INSTITUTE OF CHEMISTRY

Academic programs offered

1. BS Chemistry
2. MSc Chemistry
3. MPhil Chemistry
4. PhD Chemistry

REVISED SCHEME OF STUDIES & CURRICULUM
BS CHEMISTRY
(Semester / Term System)
(2020)

INSTITUTE OF CHEMISTRY
UNIVERSITY OF SARGODHA
SARGODHA

Revised Scheme of Studies and Curriculum for BS Chemistry with specialization in Analytical, Inorganic Chemistry, Organic Chemistry, Physical Chemistry and Biochemistry

Summary for BS 4 Year Program

BS 4 Years Chemistry program comprises of 8 semesters with 136 credit hours. Outline of the courses is as under.

Semester I – IV (For BS student with Pre-Medical Combinations in Intermediate)
Botany and Zoology courses will be offered for the students who have entered in the program with Pre-Medical combination in F.Sc. or equivalent.

Semester-I:

Course Code	Course Title	Credits
CHEM-5101*	Physical Chemistry	4(3+1)
BOTN-5101	Diversity of Plants	4(3+1)
ZOOL-5101	Animal Diversity-I (Invertebrates)	4(3+1)
URCE-5101	Grammar	3(3+0)
URCI-5105	Islamic Studies	2(2–0)
Total Credits		**17(14-3)**

Semester-II:

Course Code	Course Title	Credits
CHEM-5102*	Inorganic Chemistry	4(3+1)
BOTN-5102	Plant Systematic, Anatomy and Development/Embryology	4(3+1)
ZOOL-5102	Animal Diversity-II (Chordates)	4(3+1)
URCE-5102	Language Comprehension & Presentation Skills	3(3+0)
URCP-5106	Pakistan Studies	2(2–0)
Total Credits		**17(14-3)**

Semester-III:

Course Code	Course Title	Credits
CHEM-5103*	Organic Chemistry	4(3+1)
BOTN-5103	Cell Biology, Genetics and Evolution	4(3+1)
ZOOL-5103	Animal Form and Function-I	4(3+1)
URCE-5103	Academic Writing	3(3+0)
URCI-5109	Introduction to Information and Communication Technologies	3(3+0)
Total Credits		**18(15-3)**

Semester-IV:

Course Code	Course Title	Credits
CHEM-5104*	Chemistry Special Topics	4(3+1)
BOTN-5104	Plant Physiology and Ecology	4(3+1)
ZOOL-5104	Animal Form and Function-II	4(3+1)
URCE-5104	Introduction to English Literature	3(3+0)
CHEM-5105	Introduction to Management	3(3+0)
Total Credits		**18(15-3)**

*Chemistry courses (semester I-IV) can be rotated with subject to availability of teacher in that specialized field.

Semester I – IV (For BS student with Pre-Engineering Combinations in Intermediate)

Mathematics and Physics courses will be offered for the students who have entered in the program with Pre-Engineering combination in F.Sc. or equivalent.

Semester-I:

Course Code	Course Title	Credits
CHEM-5101*	Physical Chemistry	4(3+1)
PHYS-5161	Physics-I	4(3+1)
MATH-5120	Applications of Differentials	4(4+0)
URCE-5101	Grammar	3(3+0)
URCI-5105	Islamic Studies	2(2+0)
Total Credits		**17(15-2)**

Semester-II:

Course Code	Course Title	Credits
CHEM-5102*	Inorganic Chemistry	4(3+1)
PHYS-5162	Physics II	4(3+1)
MATH-5121	Techniques of Integration	4(4+0)
URCE-5102	Language Comprehension & Presentation Skills	3(3+0)
URCP-5106	Pakistan Studies	2(2+0)
Total Credits		**17(15-2)**

Semester-III:

Course Code	Course Title	Credits
CHEM-5103*	Organic Chemistry	4(3+1)
PHYS-5163	Physics III	4(3+1)
MATH-5122	Calculus	4(4+0)
URCE-5103	Academic Writing	3(3+0)
URCI-5109	Introduction to Information and Communication Technologies	3(3+0)
Total Credits		**18 (16-2)**

Semester-IV:

Course Code	Course Title	Credits
CHEM-5104*	Chemistry Special Topics	4(3+1)
PHYS-5164	Physics IV	4(3+1)
MATH-5125	Linear Algebra	4(4+0)
URCE-5104	Introduction to English Literature	3(3+0)
CHEM-5105	Introduction to Management	3(3+0)
Total Credits		**18(16-2)**

*Chemistry courses (semester I-IV) can be rotated with subject to availability of teacher in that specialized field.

Semester-V:
No. of Credits = 18 Credits

Course Code	Course Title	Credits
CHEM-6101	Basic Mathematics for Chemists	2(2–0)
CHEM-6102	Analytical Chemistry	4(3+1)
CHEM-6103	Inorganic Chemistry-I	4(3+1)
CHEM-6104	Organic Chemistry-I	4(3+1)
CHEM-6105	Physical Chemistry-I	4(3+1)
Total Credits		**18(14-4)**

Semester-VI:
No. of Credits = 18 Credits

Course Code	Course Title	Credits
CHEM-6106	Basic Statistics for Chemists	2(2–0)
CHEM-6107	Biochemistry	4(3+1)
CHEM-6108	Inorganic Chemistry-II	4(3+1)
CHEM-6109	Organic Chemistry-II	4(3+1)
CHEM-6110	Physical Chemistry-II	4(3+1)
Total Credits		**18(14-4)**

Semester-VII:

Every student will be offered two compulsory theory courses of five credits (3 and 2) in Semester VII. Moreover, at the beginning of VII Semester every student shall opt one field of specialization (11 credits). Some of the students will be offered research on the basis of merit while others will be offered a theory course (3 – 1 Credit) from field other than specialization in lieu of research.

List of Compulsory Courses

Course Code	Title of the Course	Credits
CHEM-6111	Forensic Chemistry	2(2+0)
CHEM-6112	Industrial Chemistry	3(3+0)

Semester with Research

	Credit Th – Pr
Two theory courses (compulsory) of (2-3) credits	5 (5-0)
One theory course of specialization (Major)	3(3+0)
One theory course of specialization (Minor)	4 (3+1)
Research	4 (4+0)
Total	**16 (15-1)**

Fields of Specializations
Every student shall opt any one of the following specializations.

- **i.** Analytical Chemistry
- **ii.** Biochemistry
- **iii.** Inorganic Chemistry
- **iv.** Organic Chemistry
- **v.** Physical Chemistry

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6114	Advanced Spectroscopy – I (Minor)	4(3+1)
CHEM-6115	Advanced Chromatographic Techniques (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6116	Instrumental Methods of Analysis	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6117	Metabolism and Bio-Energetics (Minor)	4(3+1)
CHEM-6118	Microbiology and Industrial Fermentation (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6119	Enzymes and Nutrition	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6120	Advance Inorganic Chemistry (Minor)	4(3+1)
CHEM-6121	Organometallic & Bio-inorganic Chemistry (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6122	Inorganic Polymers & Chemical Forces	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6123	Reaction Mechanism, (Major)	3(3+0)
CHEM-6124	Spectroscopic Methods in Organic Chemistry (Minor)	4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6125	Organometallics	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6126	Surface Phenomena (Minor)	4(3+1)
CHEM-6127	Molecular Spectroscopy (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6128	Statistical and Quantum Mechanics	3(3+0)

Semester without Research

	Credits Th – Pr
Two theory courses (compulsory) of 05 credits	5 (5-0)
One theory course of specialization (Major)	3 (3+0)
One theory course of specialization (Minor)	4(3+1)
One theory course (Minor) from field other than specialization	4(3+1)
Total	**16 (14-2)**

Fields of Specializations

Every student shall opt any one of the following specializations.

vi. Analytical Chemistry
vii. Biochemistry
viii. Inorganic chemistry
ix. Organic chemistry
x. Physical chemistry

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6114	Advanced Spectroscopy – I (Minor)	4(3+1)
CHEM-6115	Advanced Chromatographic Techniques (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		

CHEM-6116	Instrumental Methods of Analysis	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6117 CHEM-6118	Metabolism and Bio-Energetics (Minor) Microbiology and Industrial Fermentation (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6119	Enzymes and Nutrition	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6120 CHEM-6121	Advance Inorganic Chemistry (Minor) Organometallic & Bio-inorganic Chemistry (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6122	Inorganic Polymers & Chemical Forces	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6123 CHEM-6124	Reaction Mechanism, (Major) Spectroscopic Methods in Organic Chemistry (Minor)	3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6125	Organometallics	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6126 CHEM-6127	Surface Phenomena (Minor) Molecular Spectroscopy (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM- 6128	Statistical and Quantum Mechanics	3(3+0)

Semester-VIII
Every student will be offered one compulsory theory course of three credits in Semester VIII. Moreover the scheme of studies on behalf of VII semester will be carried over to semester VIII accordingly.

Compulsory course

Course Code	Title of the Course	Credits
CHEM-6129	Environmental Chemistry	3(3+0)

Semester with Research

		Credits Th – Pr
Research		4(4+0)
One theory course (compulsory)	3(3+0)	
One theory course of specialization (Major)		3(3+0)
One theory course of specialization (Minor)		4(3+1)
Total	**14(13+1)**	

Field of Specialization

Field of specialization will remain same as opted in semester VII

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6130	Advanced Spectroscopy – II (Major)	4(3+1)
CHEM-6131	FTIR, Raman Spectroscopy, ESR and Surface Analysis(Minor)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6132	Instrumental Methods of Analysis-II	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6133	Chemotherapy & Immunology (Major)	3(3+0)
CHEM-6134	Molecular Biology & Physical Techniques (Minor)	4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6135	Endocrine System	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6136	Homogeneous Catalysis by Transition Metal Complexes (Minor)	4(3+1)
CHEM-6137	Inorganic Reaction Mechanism(Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6138	Physical Methods in Inorganic Chemistry	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6139	Chemistry of Natural Products (Minor)	4(3+1)
CHEM-6140	Organic Synthesis (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6141	Chemistry of Protective Groups & Reactive Intermediates	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6113	Research	4(4+0)
CHEM-6142	Advanced Approaches of Homogeneous and Heterogeneous Kinetics (Minor)	4(3+1)
CHEM-6143	Polymers and Photochemistry (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6144	Elementary Group Theory	3(3+0)

Semester without Research

		Credits Th – Pr
One theory course (compulsory)		3(3+0)
One theory course of specialization (Major)		3(3+0)
One theory course of specialization (Minor)		4(3+1)
One theory course (Minor) from field other than specialization		4(3+1)
	Total	**14(12-2)**

Field of Specialization

Field of specialization will remain same as opted in semester 3rd.

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6130 CHEM-6131	Advanced Spectroscopy – II (Minor) FTIR, Raman Spectroscopy, ESR and Surface Analysis(Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6132	Instrumental Methods of Analysis-II	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6133 CHEM-6134	Chemotherapy & Immunology (Major) Molecular Biology & Physical Techniques (Minor)	3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM- 6135	Endocrine System	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6136 CHEM-6137	Homogeneous Catalysis by Transition Metal Complexes (Minor) Inorganic Reaction Mechanisms (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6138	Physical Methods in Inorganic Chemistry	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6139 CHEM-6140	Chemistry of Natural Products (Minor) Organic Synthesis (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6141	Chemistry of Protective Groups & Reactive Intermediates	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6142 CHEM-6143	Advanced Approaches of Homogeneous and Heterogeneous Kinetics (Minor) Polymers and Photochemistry (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6144	Elementary Group Theory	3(3+0)

Note: Order of the courses in semesters may be changed depending upon the available resources.

SEMESTER-I

CHEM-5101 Physical Chemistry 4 (3+1)

This course is the first part of this program, introduction to Physical Chemistry. This foundation course of physical chemistry covers basic knowledge and its application for learning chemical principles of physics to chemistry. This offer complementary approaches to the fundamental understanding of chemical systems. Students will acquire knowledge to enable themselves to understand the kinetic theory of gases, collision theory of reactions, fundamental principles and laws of thermodynamics and chemical equilibria and to investigate the physical properties of ideal/non-ideal binary solutions. Students will also be able to study the rates of reactions and perform related calculations. The general goal of learning physical chemistry is to obtain a vision of matter-energy relationship in physical and chemical systems. Learning objectives emphasized in CHEM 5101 involve developing an understanding of basic principles of physical chemistry. Students learned in class to modern physical chemistry techniques which give them opportunities to see how Physical Chemists are solving current, real-world problems.

Contents

1. Elementary Mathematics: Logarithmic, exponential and trigonometric functions, differentiation of elementary functions, methods of differentiation and integration, significance of differentiation and integration.
2. Physical States of Mater: Gases (van der Waal's equation, critical Phenomena, Critical values of T, P andV., liquification of gases, molecular collisions, collision diameter, mean free path) Liquids (viscosity, Parachor value, Refractive index, molar refraction and its applications. Dipole moment, Solids (Unit cells. Bragg crystal analysis, crystal structure of NaCl, powder method of crystal structure analysis).
3. Atomic Structure: De Brogile equation. Schrodinger wave equation, solution for particle in 1D box, quantization concept, Heisenberg Uncertainty Principle, Pauli Exclusion Principle, Hund's Rule.
4. Chemical Thermodynamics: First law of thermodynamics, state functions, isothermal and adiabatic processes in ideal gases, heat capacity, reversible and irreversible processes. Spontaneous and non-spontaneous processes, second law of thermodynamics, change of entropy with change in T, P andV.
5. Chemical Equilibrium: Law of Mass Action, equilibrium constant, relationship between Kc, Kp, Kx and Ka and LeChaterlier's Principle.
6. Solutions: composition, ideal and non-ideal solutions. Raoult's law. Colligative properties, ebullioscopy, cryoscopy, osmotic pressure, distillation and concept of azeotropes.
7. Chemical Kinetics: Zero, first and second order reaction, Arrhenius equation, activation energy, Lindemann's mechanism, collision theory and transition state theory.
8. Electrochemistry: Conductance, dependence of conductance on the nature of solvent and temperature, Kohlrausch's law and its applications, measurement of conductance strong and weak electrolytes, degree of dissociation.

Physical Chemistry Lab

1. Determination of surface tension and Parachor value by stalagmometer.
2. Determination of percent composition of liquid solutions from surface tension measurement.
3. Determination of viscosity and Rhechor value of liquids from viscosity measurement.
4. Determination of percent composition of liquid solutions viscometrically.
5. Determination of refractive index and molar refractivity by refractometer.
6. Determination of percent composition of liquid solutions by refractive index measurements.
7. Determination of heat of solution by solubility method.

8. Determination of heat of neutralization of an acid with a base.
9. A kinetic study of acid hydrolysis of ethyl acetate.
10. Kinetic study of saponification of ethyl acetate.
11. Determination of molecular weight of a compound by elevation in boiling point. (Ebullioscopic method).
12. Determination of molecular weight of a compound by lowering of freezing point (The Cryoscopic methods).
13. Determination of equilibrium constant of KI – I2 Kl3.
14. Conductometric titration of strong acid and strong base.

Recommended Texts

1. Atkins, P., Paula, J., & Keeler, J. (2017). *Atkins' Physical Chemistry* (11th ed.). UK: Oxford University Press.
2. Kuhn, H., Försterling, H., & Waldeck, D. H. (2009). *Principles of Physical Chemistry* (2nd ed.). USA: Wiley Publisher.

Suggested Readings

1. Akhtar, M. N., & Nabi, G. (2006). *Text Book of Physical Chemistry.* Lahore: Ilmi Kitab Khawna.
2. Das, R. C., & Behera, B. (2003). *Experimental Physical Chemistry.* Delhi: Tata McGraw Hill.

BOTN-5101 Diversity of Plants 4 (3+1)

This course offers an evolutionary survey of the origin and diversification of land plants through geological time. The course will start with the green algae and on how plants may have transitioned from aquatic to the land environment. Land plants that will be discussed include bryophytes, lycophytes, pteridophytes, gymnosperms and angiosperms with emphasis on representative fossil and living taxa. Lectures will emphasize on life histories, anatomical and morphological adaptations, ecology and climate change, extinction, phylogenetics, economic importance, and conservation strategies of representative taxa. Plants are one of the most successful and abundant groups of organisms on earth, comprising the majority of terrestrial biomass, being integral to ecosystem structure, and providing humans with food, shelter, and materials. The laboratory will provide ample hands-on opportunities for analysis of plant anatomy and morphology, reproductive mechanisms, evolutionary adaptations, and identification of a variety of living and preserved specimens. Plants are multi-cellular and mostly photosynthetic organisms which found essentially everywhere, both in water and on land. Plants are really important for the planet and for all living things. Plants absorb carbon dioxide and release oxygen from their leaves, which humans and animals need to breathe.

Contents

Comparative study of life form, structure, reproduction and economic significance of:

1. Viruses (RNA and DNA types) with special reference to TMV
2. Bacteria and Cyanobacteria (*Nostoc, Anabaena, Oscillatoria*) with specific reference to bio fertilizers, pathogenicity and industrial importance;
3. Algae (*Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia*)
4. Fungi (*Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus*) their implication on crop production and industrial applications.
5. Lichens (*Physcia*)
6. Bryophytes (*Riccia, Anthoceros*, *Funaria)*
7. Pteridophytes: Psilopsida (*Psilotum*) , Pteropsida (*Marsilea*), Sphenopsida (*Equisetum*) Lycopsida (*Selaginella*)
8. Gymnosperms (*Cycas, Pinus*, *Ephedra)*
9. Angiosperms: Monocot (Poaceae) , Dicot (Solanaceae)

Diversity of Plants Lab

1. Culturing, maintenance, preservation and staining of microorganisms.
2. Study of morphology and reproductive structures of the types mentioned in theory.
3. Identification of various types mentioned from prepared slides and fresh collections.

Recommended Texts

1. Bellinger, E. G. & Sigee, D. C. (2015). *Freshwater algae*. USA: Wiley Publishers.
2. Prestre, P. G. (2017). *Governing global biodiversity: the evolution and implementation of the convention on biological diversity*. UK: Routledge Publishers.

Suggested Readings

1. Şen, B., & Grillo, O. (2018) *Selected Studies in Biodiversity*. USA: Intech Open Publishers.
2. Zotz, G. (2016). *Plants on Plants: The biology of vascular epiphytes*. Germany: Springer-Verlag.
3. Cronk, J. K., & M. S. Fennessy (2016). *Wetland plants: biology and ecology*. USA: CRC Press.
4. Pullaiah T., Bahadur, B., & Murthy, K. (2015). *Plant biodiversity*. Germany: Springer-Verlag.

ZOOL-5101 Animal Diversity-I (Invertebrates) 4 (3+1)
(Foundation-I)

This course will provide the knowledge of evolutionary/phylogenetic relationship. It imparts the basic taxonomic characteristics and classification of all the invertebrate phyla. This includes more than 95% of all of the described species of animals and far more than 99% of all of the individual animals on the planet. The central theme running throughout this course will be phylogeny. It provides understanding of body organization, mode of feeding, digestion, reproduction and development of invertebrates. It delivers information to students about economic and ecological importance of invertebrates. Students will understand invertebrate organismal concepts in laboratory and field. The primary objectives for the laboratory section of this course includes; introduction of structure, function and behavior of selected invertebrate types through the observation of both living and preserved specimens, to reinforce basic laboratory skills of students like microscopy, dissection and careful observation, to provide students with the ability to recognize the major groups of invertebrate and to increasing understanding of the methods of investigating animal evolution.

Contents

1. Introduction: Classification of organisms, Evolutionary relationships and Tree diagrams: Patterns of organization.
2. Animal-like protists: the protozoa: Evolutionary perspective; Life within a single plasma Membrane, Symbiotic Life-styles, Protozoon Taxonomy, Pseudopodia and Amoeboid Locomotion; Cilia and other pellicular structure, Nutrition; Genetic Control and Reproduction; Symbiotic ciliates, Further Phylogenetic consideration.
3. Multicellular and tissue levels of organization: Evolutionary Perspective, Origins of Multicellularity; Animal Origins, Phylum Porifera, Cnidaria, Ctenophora, Characters and Classification, Maintenance functions.
4. The triploblastic and with acoelomate body plan: Phylum Platyhelminthes, Phylum Nematode, Gastrotricha, Evolutionary Perspective; Classification up to class, Body plan and functions.
5. Pseudocoelomate body plan: Phylum Aschelminths, Evolutionary perspective; General Characteristics; Classification up to order with External Features, Feeding and Digestive system; Other Organ System; Reproduction and Development including Phylum Rotifera, Phylum Nematoda and Phylum Kinorhyncha. Some important Nematode parasites of Humans.
6. Phylum Mollusca: Evolutionary perspective; Relationship to other animals; Origin of the Coelom; Characteristics, Classification up to class. The characteristics of shell and associated structures, Feeding, Digestion, Gas Exchange, Locomotion, Reproduction and Development, Other maintenance Functions and Diversity in Gastropods, Bivalves and Cephalopods.
7. Phylum Annelida: The Metameric Body Form; Evolutionary perspective; Relationship to other animals, Metamerism and Tag-matization, Classification up to Class. External Structure and Locomotion, Feeding and the Digestive system, Gas Exchange and Circulation, Nervous and Sensory Functions, Excretion, Regeneration, Reproduction and Development, Polychaeta, Oligochaeta and Hirudinea, Further Phylogenetic Consideration.
8. Phylum Arthropoda: Evolutionary Perspective: Classification and relationship to other Animals; Metamerism and Tagmatization; The Exoskeleton; Metamorphosis; Classification up to Class.
9. The Hexapods and Myriapods: Evolutionary Perspective: Classification upto class. External Structure and Locomotion, Nutrition and the Digestive system, Gas Exchange, Circulation and Temperature Regulation, Nervous and Sensory Functions, Excretion, Chemical Regulation, Reproduction and Development in Hexapoda, Insects Behavior, Insect and Human.
10. Phylum Echinoderms: Evolutionary Perspective: Relationship to other Animals; Echinoderm Characteristics; Classification up to class. Maintenance functions, regeneration, reproduction, and development in Asteroida, Ophiuroidea, Echinoidea, Holothuridea and Crinoidea.
11. Some lesser known Invertebrates: Lophorates, Entoprocts, Cycliophores, and Cheatognaths.

Animal Diversity-I (Invertebrates) lab

Note: Classification of each members of each phylum upto order with adaptions in relation to habitat of the specimen. Preserved Specimen and or colored projection slide and or CD ROM projection of computer must be used.

1. Study of Euglena, Amoeba, Endameba, Plasmodium, Trypanosome, Paramecium as representative of animal like Protists.
2. Study of representatives of Phylum Porifera and prepared slides of spicules of sponges
3. Study of principal representatives of classes of Phylum Coelenterate.
4. Study of principal representatives of classes of Phylum Platyhelminthes.
5. Study of representatives of phylum Rotifer, Phylum Nematode.
6. Study of principal representatives of classes of Phylum Mollusca.
7. Study of principal representatives of classes of Phylum Annelida.
8. Study of principal representatives of classes of groups of Phylum Arthropoda
9. Study of representatives of classes of Phylum Echinodermta.
10. Preparation of permanent mount of Leucosolenia, Obelia, Hydra, Proglottid of Tapeworm, Parapodia of Nereis and Daphnia. Drawing and labeling.
11. Preparation of permanent slide of mouthpart of insects (after dissection).
12. How to make grade-wise series for preparation of temporary and permanent slides.

Recommended Texts

1. Miller, A. S., & Harley, J. B. (1999, 2002, 2007, 2009, 2012 and2016). *Zoology (*4th, 5th, 6th, 7th, 8th, 9th and 10th ed.) Singapore: McGraw Hill.
2. Hickman, C. P., Roberts, L. C. & Larson, A. (2007). *Integrated principles of zoology* (11th and 12th ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Hickman, C. P., Roberts, L. C., & Larson, A. (2018). *Integrated principles of zoology* (15th ed.). Singapore: McGraw-Hill.
2. Pechenik, J. A. (2015). *Biology of invertebrates* (7th ed.). Singapore: McGraw-Hill
3. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill

PHYS-5161 Physics-I 4 (3+1)

Physics, the most fundamental physical science, is concerned with the basic principles of the universe. It is the foundation upon which the other sciences—astronomy, biology, chemistry and geology are based. Physics is based on experimental observations and quantitative measurements. The main objective of physics is to find the limited number of fundamental laws that govern natural phenomena and to use them to develop theories that can predict the results of future experiments. The course of "physics-I", presents often need to work with physical quantities that have both numerical and directional properties of this nature. The course is primarily concerned imperative with graphical and their algebraic properties and with some general properties of some common applications to physical situations and its associated technologies. The goals of the course is to provide tools by which students how to effectively read scientific material, identify fundamental concepts, reason through scientific questions, and solve quantitative problems. However, it can also be one of the most rewarding because it reveals the world's fundamental clockwork from which all scientific and engineering applications spring regarded the Particle's motion Earth' movements, movements of the planets, stars, and other celestial objects.

Contents

1. Vectors
2. Particle Dynamics
3. System of Particles
4. Rotational Dynamics,
5. Angular Momentum,
6. Collisions,
7. Work, Power and Energy,
8. Gravitation,
9. Fluid Dynamics,
10. Bulk Properties of Matters,
11. Special Theory of Relativity
12. Oscillations, Harmonic Oscillations,
13. Waves, Waves in Physical Media,
14. Light, Interference, Diffraction, Polarization.

Physics-I Lab

1. Modulus of rigidity by static and dynamic method (Maxwell's needle, Barton's apparatus).
2. Determination of moment of inertia of a solid/hollow cylinder and a sphere etc.
3. To study the conservation of energy (Hook's Law)
4. To determine the surface tension of water by capillary tube method.
5. To determine the value of 'g' by a compound pendulum.
6. To study the laws of vibration of stretched string-using sonometer.

Recommended Texts

1. Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics* (10th ed.). New York: Wiley.
2. Halliday, D., Resnick, R., & Krane, K. S. (2003). *Physics* (5th ed.). New York: Wiley.

Suggested Readings

1. Sear, A., & Zemansky. (2008). *University physics with modern physics* (12th ed.). USA: Pearson.

2. Ohanian, H. C., & Markert, J. T. (2006). *Physics for engineers and scientists* (3rd ed.). New York: W. W. Norton.
3. Mark, H., & Olsono, H. T. (2004). *Experiments in modern physics.* New York: McGraw-
4. Hill.
5. Musaddiq, M. H. (2008). *Experimental physics.* Lahore: Allied Book Center.

MATH-5136 Applications of Differentials 4 (4+0)

Calculus is the mathematical study of continuous change. If quantities are continually changing, we need calculus to study what is going on. Calculus is concerned with comparing quantities which vary in a non-linear way. It is used extensively in science and engineering, since many of the things we are studying (like velocity, acceleration, current in a circuit) do not behave in a simple, linear fashion. Calculus has two major branches, differential calculus (Calculus–I) and integral calculus (Calculus–II); the former concerns instantaneous rates of change, and the slopes of curves, while integral calculus concerns accumulation of quantities, and areas under or between curves. This is the first course of the sequence, Calculus-I, II and III, serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts and skills needed for mathematical manipulation. It focus on the study of functions of a single variable. Applications of differential calculus include computations involving velocity and acceleration, the slope of a curve, and optimization.

Contents

1 Functions and their graphs
2 Rates of change and tangents to curves
3 Limit of a function and limit laws, the precise definition of a limit
4 One-sided limits
5 Continuity
6 Limits involving infinity; asymptotes of graphs
7 Differentiation: tangents and derivative at a point, the derivative as a function
8 Differentiation rules, the derivative as a rate of change
9 Derivatives of trigonometric functions, chain rule, implicit differentiation
10 Related rates, linearization and differentials
11 Higher derivatives
12 Applications of derivatives: extreme values of functions
13 Rolls' theorem, the mean value theorem
14 Monotonic functions and the first derivative test
15 Convexity, point of inflection and second derivative test
16 Concavity and curve sketching
17 Antiderivatives, Integration: area and estimating with finite sums
18 Sigma notation and limits of finite sums
19 The definite integral, the fundamental theorem of calculus
20 Indefinite integrals and the substitution method
21 Substitution and area between curves
22 Applications of definite integrals: volumes using cross-sections
23 Volumes using cylindrical shells, arc length
24 Areas of surfaces of revolution
25 Transcendental functions: inverse functions and their derivatives
26 Natural logarithms, exponential functions
27 Indeterminate forms and L'Hôpital's rule
28 Inverse trigonometric functions, hyperbolic functions

Recommended Texts

1. Thomas, G. B., Weir, M. D., Hass, J. and Giordano, F. R. (2005). *Thomas' Calculus* (11th ed.). Boston: Addison Wesley.

2. Stewart, J. (2015). *Calculus* (8th ed.). Boston: Cengage Learning.

Suggested Readings

1. Anton, H., Bivens I. C., and Davis, S. (2016). *Calculus* (11th ed.). New Jersey: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I., and Asmar, N. H. (2017). *Calculus and Its Applications* (14th ed.). London: Pearson.
3. Hallett, D. H., *et al*. (2017). *Calculus Single and Multivariable* (7th ed.). New Jersey: John Wiley and Sons, Inc.
4. Larson, R., and Edwards, B. H. (2013). *Calculus* (10th ed.). Brooks Cole.

URCE-5101 Grammar 3 (3+0)

The course introduces the students to the underlying rules to acquire and use language in academic context. The course aims at developing grammatical competence of the learners to use grammatical structures in context in order to make the experience of learning English more meaningful enabling the students to meet their real-life communication needs. The objectives of the course are to, reinforce the basics of grammar, understand the basic meaningful units of language, and introduce the functional aspects of grammatical categories and to comprehend language use by practically working on the grammatical aspects of language in academic settings. After studying the course, students would be able to use the language efficiently in academic and real-life situations and integrate the basic language skills in speaking and writing. The students would be able to work in a competitive environment at higher education level to cater with the long-term learners' needs.

Contents

1 Parts of speech
2 Noun and its types
3 Pronoun and its types
4 Adjective and its types
5 Verb and its types
6 Adverb and its types
7 Prepositions and its types
8 Conjunction and its types
9 Phrases and its different types
10 Clauses and its different types
11 Sentence, parts of sentence and types of sentence
12 Synthesis of sentence
13 Conditional sentences
14 Voices
15 Narration
16 Punctuation
17 Common grammatical errors and their corrections

Recommended Texts

1. Eastwood, J. (2011). *A basic English grammar*. Oxford: Oxford University Press.
2. Swan, M. (2018). *Practical English usage* (8th ed.). Oxford: Oxford University Press.

Suggested Readings

1. Thomson, A. J., & Martinet, A. V. (1986). *A practical English grammar*. Oxford: Oxford University Press
2. Biber, D., Johansson, S., Leech, G., Conrad, S., Finegan, E., & Quirk, R. (1999). *Longman grammar of spoken and written English*. Harlow Essex: MIT Press.
3. Hunston, S., & Francis, G. (2000). *Pattern grammar: A corpus-driven approach to the lexicalgrammar of English*. Amsterdam: John Benjamins.

URCI-5105 Islamic Studies 2 (2+0)

Islamic Studies engages in the study of Islam as a textual tradition inscribed in the fundamental sources of Islam; Qur'an and Hadith, history and particular cultural contexts. The area seeks to provide an introduction to and a specialization in Islam through a large variety of expressions (literary, poetic, social, and political) and through a variety of methods (literary criticism, hermeneutics, history, sociology, and anthropology). It offers opportunities to get fully introductory foundational bases of Islam in fields that include Qur'anic studies, Hadith and Seerah of Prophet Muhammad (PBUH), Islamic philosophy, and Islamic law, culture and theology through the textual study of Qur'an and Sunnah..

Islamic Studies is the academic study of Islam and Islamic culture. It majorly comprises of the importance of life and that after death. It is one of the best systems of education, which makes an ethical groomed person with the qualities which he/she should have as a human being. The basic sources of the Islamic Studies are the Holy Qur'an and Sunnah or Hadith of the Holy Prophet Muhammadﷺ. The learning of the Qur'an and Sunnah guides the Muslims to live peacefully.

Contents

1. Study of the Qur'an (Introduction to the Qur'an, Selected verses from *Surah Al-Baqarah, Al-Furqan, Al-Ahzab, Al-Mu'minoon, Al-An'am, Al-Hujurat, Al-Saff*)
2. Study of the Hadith (Introduction to Hadith literature, Selected Ahadith (Text and Translation)
3. Introduction to Qur'anic Studies
4. Basic Concepts of Qur'an
5. History of Quran
6. Basic Concepts of Hadith
7. History of Hadith
8. Kinds of Hadith
9. Uloom –ul-Hadith
10. Sunnah and Hadith
11. Seerat ul-Nabi (PBUH), necessity and importance of Seerat, role of Seerah in the development of personality, Pact of Madinah, Khutbah Hajjat al-Wada' and ethical teachings of Prophet (PBUH).
12. Legal Position of Sunnah
13. Islamic Culture and Civilization
14. Characteristics of Islamic Culture and Civilization
15. Historical Development of Islamic Culture and Civilization
16. Comparative Religions and Contemporary Issues
17. Impact of Islamic civilization

Recommend Texts

1. Hassan, A. (1990). *Principles of Islamic jurisprudence*. New Dehli: Adam Publishers.
2. Zia-ul-Haq, M. (2001). *Introduction to al-Sharia al-Islamia*. Lahore: Aziz Publication.

Suggested Readings

1. Hameedullah, M. (1957). *Introduction to Islam*. Lahore: Sh M Ashraf Publisher.
2. Hameedullah, M. (1980). *Emergence of Islam*. New Dehli: Adam Publishers.
3. Hameedullah, M. (1942). *Muslim conduct of state.* Lahore: Sh M Ashraf Publisher.

SEMESER-II

CHEM-5102 Inorganic Chemistry 4 (3+1)

This course covers a range of general topics of inorganic chemistry. It will provide a useful supplement to the advanced courses specified in the department. This course aims to enable the students to achieve the advance knowledge about the key introductory concepts of chemical bonding, acid-base chemistry, and properties of the representative and transition elements, as well as using this knowledge for qualitative and quantitative analysis of inorganic compounds during laboratory work. Learning objectives emphasized in CHEM 5102 involve developing an understanding of basic principles of inorganic chemistry. It develop critical thinking skills enabling students to solve chemistry problems that incorporate their cumulative knowledge. Students learned in class to modern chemistry techniques which give them opportunities to upgrade their knowledge about advanced inorganic concepts. The essence of this course is to develop study skills that students need to succeed in university-level chemistry courses and preparation of students for professional positions in chemistry.

Contents

1. Periodic Table and Periodicity of Properties: Modern Periodic Table, Group trends and periodic properties, Atomic and ionic radii, ionization potentials, electron affinities and electronegativities; Redox potential, electrochemical series and its applications. Corrosion and electroplating.
2. Acid Base Equilibria: Acids and bases, relative strengths of acids, pH, pKa, pKb. Hard and soft acid and Bases. SHAB Principle and its application. Buffers, types buffer, Preparation, Buffer capacity and applications of buffers. Indicators: (Acid-base, Redox, Adsorption), Solubility product, Common ion effect and its applications.
3. Chemical Bonding: Nature of a bond, hybridization, Valence Bond Theory (VBT), The Concept of Resonance, Molecular Orbital Theory (MOT), Valence Shell Electron Pair Repulsion (VSEPR) theory. Special types of bonds such as Metallic bonds, Hydrogen Bonding, Bent bond, Ion-dipole-dipole bond, ion induced-dipole bond.
4. Chemistry of p-Block Elements: Introduction to p-block elements (Group trends in p-block elements with reference to, atomic sizes and chemical reactivities). Boranes and Boride; aluminium halides, hydrides and Alums; Silicates (Structural aspects, classifications and applications); silicones (Structural aspects, classifications and applications),Germanes; phosphazenes, Phosphides, Oxoacids of Phosphorous; Oxoacids and salts of sulphur; Noble gases (compounds of Xe, Kr, Ra; bonding and applications).Production of pure silicon chips for solar energy cells.
5. Chemistry of d-Block Elements: Electronic configuration. Characteristics. Nomenclature. Nature of bonding in coordination compounds: Werner's theory, VBT, MOT and CFT for coordination compounds. Isomerism in coordination compounds. Chelates: Classification and applications. Applications of coordination compounds (Medicinal, Industrial, Agricultural).
6. Separation Techniques: General introduction and Applications (Solvent extraction and Chromatographic techniques such as paper, Ion exchange and Column).
7. Introduction to Analytical Techniques in Inorganic Chemistry: Introduction to spectroscopic Techniques: Principle, brief instrumentation, sample handling and applications (Flame emission, Atomic Absorption, IR and UV/Vis).
8. Chemical Industries: Metallurgy of Al, Cr and U, fertilizers (Urea and Phosphate fertilizers) Cement and Sugar.

Inorganic Chemistry Lab

1. Qualitative Analysis; four radicals (cations and anions) for salt mixture.
2. Chromatographic separation of cations
3. Determination of total hardness of water using EDTA.
4. Estimation of manganese (II) using EDTA.

5. Estimation of copper (Iodometrically).
6. Determination of thiosulphate ion (lodometrically).
7. Determination of ferricyanide using KI solution.
8. Determination of chloride by Volhard's and Mohr's methods.
9. Estimation of chloride ions using adsorption (Fluorescein) indicator.
10. Estimation of bromide ions using adsorption (Eosin) indicator.
11. Estimation of percentage of ferrous ions in the Mohr's salt using $KMnO_4$.
12. Percentage determination of ferric ions in ferric alum using $KMnO_4$ solution.
13. Determination of purity of commercial potassium oxalate using $KMnO_4$ solution.
14. Estimation of ferrous ions using $K_2Cr_2O_7$ solution.

Recommended Texts

1. Iqbal, M. Z. (2015). *Text book of inorganic chemistry.* Lahore: Ilmi Kitab Khana
2. Lee, J. D. (1996). *Concise inorganic chemistry.* (5th ed.). UK: Chapman and Hall
3. Vogel, A. I. (1995). *A text book of macro and semi micro qualitative inorganic analysis.* New York: Longman Green and Co.
4. Skoog, D. A., West, D.M., & Holler, F. J. (1994). *Analytical chemistry* (6th ed.). UK: Saunders College Publications.

Suggested Readings

1. Graham, H., & Man, H. (2000). *Chemistry in context* (5th ed.). UK: Thomas Nelson Ltd.
2. Philp, M. (1996). *Advance chemistry*. UK: Cambridge Publishing.
3. David, H. (2000). *Modern analytical chemistry*. New York: McGraw Hil.

BOTN-5102 Plant Systematics, Anatomy and Development/Embryology 4 (3+1)

Plant systematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. It divides plants into taxonomic groups, using morphological, anatomical, embryological, chromosomal and chemical data. However, the science differs from straight taxonomy in that it expects the plants to evolve, and documents that evolution. Determining phylogeny -the evolutionary history of a particular group; is the primary goal of systematics. The study systematics gives the order and relationships among the organism. This order and relationship arise from evolutionary processes. These studies also give description of the new species. It organizes the animals into groups and grouping is based on degree of evolutionary relatedness. The modern classification system has been given by Carolus Linnaeus. Plant anatomy is the study of the shape, structure, and size of plants and a typical plant body consists of three major vegetative organs: the root, the stem, and the leaf, as well as a set of reproductive parts that include flowers, fruits, and seeds. As a living thing, all of a plant's parts are made up of cells and this course will also lead towards the developmental processes that how they took place.

Contents

Plant Systematic

1. Introduction to Plant Systematic: aims, objectives and importance.
2. Classification: Brief history of various systems of classification with emphasis on Takhtajan.
3. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to ICBN/ ICN for plants.
4. Morphology: A detailed account of various morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
5. Diagnostic characters, economic importance and distribution pattern of the following families: Ranunculaceae, Brassicaceae (Cruciferae), Fabaceae (Leguminosae), Rosaceae Euphorbiaceae, Cucurbitacea, Lamiaceae (Labiatae), Apiaceae (Umbelliferae), Asteraceae (Compositae), Liliaceae (Sen. Lato)

Anatomy

a) Cell wall: structure and chemical composition
b) Concept, structure and function of various tissues like:Parenchyma Collenchyma Sclerenchyma, Xylem, Phloem, Epidermis (including stomata and trichomes)
c) Meristem: types, stem and root apices
d) Vascular cambium
e) Structure and development of root, stem and leaf.
f) Primary and secondary growth of dicot stem, periderm
g) Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.

Development/Embryology

h) Early development of plant body*: Capsella bursa-pastoris*
i) Structure and development of Anther (microsporogenesis, microgametophyte)
j) Structure and development of Ovule (megasporogenesis, megagametophyte)
k) Endosperm formation
l) Parthenocarpy
m) Polyembryony

Plant Systematics, Anatomy and Development/Embryology Lab

Anatomy and Embryology

a) Study of stomata and epidermis.
b) Tissues of primary body of plant.
c) Study of xylem 3-dimensional plane of wood.
d) T. S of angiosperm stem and leaf.
e) Anatomy of germinating seeds
f) Study of pollens

Taxonomy
g) Identification of families given in syllabus with the help of keys.
h) Technical description of common flowering plants belonging to families mentioned in theory.
i) Field trips shall be undertaken to study and collect local plants.
j) Students shall submit 40 fully identified herbarium specimens.

Recommended Texts

1. Clive A., Stace, C. A., & Crawley, M. J. (2015). *Alien plants*. USA: Harper Collins Publishers.
2. Hather, J. G. (2016). *Archaeological parenchyma*. USA: Routledge Publishers.

Suggested Readings

1. Steeves, T. A., & Sawhney, V. K. (2017). *Essentials of developmental plant anatomy*. UK: Oxford University Press.
2. Spichiger, R. E. (2019). *Systematic botany of flowering plants: A new phytogenetic approach of the angiosperms of the temperate and tropical regions*. USA: CRC Press.
3. Hickey, M., & King, C. (2015). *The Cambridge illustrated glossary of botanical terms,* UK: Cambridge University Press.
4. Lyons-Sobaski, S., Richard, C., & Robert, W. (2018). *Plant anatomy*. Germany: Springer-Verlag.

ZOOL-5102 Animal Diversity-II (Chordates) 4 (3+1)

This course will enable students to understand the taxonomic characteristics of protochordates and chordates. It provides knowledge about the phylogenetic relationships of protochodates and various classes of chordates. Students will understand the phylogenetic relations, physiological adaptations, behavior and diversity of Pisces, amphibians, reptiles and mammals and able to analyze the process of micro evolution within chordates. After this course the students will understand what the chordates are, can recognize different categories of chordates, understands the level of organization in chordate subphylum, can comprehend the general characters of chordates and know about the origin and evolutionary relationship in different subphylum of chordates. Upon successful completion of this subject students will be able to describe unique characters of urochordates, cephalochordates and fishes, can recognize life functions of urochordates to fishes, will understand the ecological role of different groups of chordates and understand the diversity of chordates and can identification of the morphological and anatomical structure for the major groups of vertebrates from an evolutionary point of view.

Contents

1. Protochordates: Classification of protochordates. Structure, anatomy and organ systems of Acorn worms, Urochodates and Cephalochodates, Reproduction; life histories and metamorphosis ofprotochodates. Phylogenetic relationships.
2. Fishes: Vertebrate Success in Water. Phylogenetic relationships of Pisces. Classification of Chondrichthyes, Osteichthyes, Dipnoi and Holocephalli Locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development of Chondrichthyes (Scoliodon) and Osteichthyes (*Cyprinus carpio*and *Wallagoattu*).
3. Amphibians: The first terrestrial vertebrates. Characteristics ofamphibians Phylogenetic relationships. Classification of amphibians and characteristics of order Caudata, Gymnophiona, and Anura. Structure and locomotor adaptations, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and Osmoregulation, reproduction, development, and metamorphosis of caudate, anura and Gymnophiona.
4. Reptiles: The First Amniotes and cladistic interpretation of the amniotic lineage. General characteristics of reptiles. Characteristics of Order Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development of chelonia, squamata, Rhynchocephalia and crocodilian. Further phylogenetic considerations.
5. Birds: Classification, feathers, flight and endothermy. Phylogenetic relationships; ancient birds and the evolution of flight. Diversity of modern birds. Adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development. Migration and navigation.
6. Mammals: Classification, Specialized teeth, endothermy, hair and viviparity. Diversity of mammals. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Animal Diversity-II (Chordates) Lab

1. Classification and study of lab specimens of hemichordates, fishes, amphibians, reptiles, birds and mammals.
2. Visit to PMNH for the study of diversity of chordates.

Recommended Texts

1. Campbell, N.A., (2011). *Biology* (9th ed.). California: Benjamin Cummings.
2. Miller, S. A., & Harley, J. B. (2010). *Zoology* (8th ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Miller, S. A. (2002). *General zoology laboratory manual* (5th ed.). Singapore: McGraw-Hill
2. Hickman, C. P. Roberts, L. C., & Larson, A. (2009). *Integrated principles of zoology* (14th ed.). Singapore: McGraw-Hill
3. Pechenik, J. A. (2000). *Biology of invertebrates* (4th ed.). Singapore: McGraw-Hill

PHYS-5162 Physics-II 4 (3+1)

Physics, the most fundamental physical science, is concerned with the basic principles of the universe. It is the foundation upon which the other sciences—astronomy, biology, chemistry and geology—are based. Physics is based on experimental observations and quantitative measurements. The main objective of physics is to find the limited number of fundamental laws that govern natural phenomena and to use them to develop theories that can predict the results of future experiments. The course of "physics-II", presents the fundamental aspects of flow and behavior of charges and basic concepts of the strength of electrically and magnetically interaction of particle with objects around it. The subject of "electricity and magnetism" is an overview of electromagnetic field and forces quite literally dominate our everyday experience. However, it can also be one of the most rewarding because it reveals the world's fundamental clockwork from which all scientific and engineering applications regarded industries. The course objectives are to enable the students about the ideas of electric field, electric potential, capacitor, resistance, magnetic field, some concepts of basic electronics and to get a deeper inside laws of electricity, magnetism and energy conservation.

Contents Course

1. Electric Field
2. Gauss's Law
3. Electric Potential
4. Current and Resistances
5. Direct Current and Circuits
6. Capacitors and Dielectrics
7. Inductance
8. Alternating Current and Circuits
9. Basic Electronics,
10. Magnetic Field, Field Effects and Magnetic Properties of Matter,
11. Electro-Magnetic Waves (Maxwell's Equations)

Physics-II Lab

1. Conversion of a galvanometer into Voltmeter and an Ammeter.
2. To determine the frequency of A.C mains by using a sonometer.
3. To determine the frequency of A.C by Meld's experiment.
4. Resonance frequency of an acceptor circuit
5. Resonance frequency of a rejector circuit.
6. To set up and study various logic gates (OR, AND, NOT, NAND etc.) using diode and to develop their truth table.
7. Study the characteristics of a transistor.

Recommended Texts

1 Halliday, D., Resnick, R., & Walker, J. (2014). Fundamentals of physics (10th ed.). New York: Wiley.
2 Halliday, D., Resnick, R., & Krane, K. S. (2003). Physics (5th ed.). New York: Wiley.

Suggested Readings

1. Sear & Zemansky. (2008). *University physics with modern physics.* (12th ed). USA: Pearson.
2. Ohanian, H. C., & Markert, J. T. (2006). *Physics for engineers and scientists* (3rd ed.). New York: W. W. Norton.
3. Mark, H., & Olsono, H. T. (2004). *Experiments in modern physics.* New York: McGraw-Hill.
4. Musaddiq, M. H. (2008). *Experimental physics.* Lahore: Allied Book Center.

MATH-5137 Techniques of Integration 4 (4+0)

Calculus demonstrates the beauty of math and the agony of math education. It relates the topics in an elegant, brain bending manner. Calculus II is a prerequisite for many popular college majors, including pre-med, Engineering, and Physics. This is the second course of the sequence, Calculus-I, II and III. MATH–5137 continues the study of the calculus begun in MATH-5136. The course focuses on definite integrals, which allow exact calculation of surface areas, volumes, the length of curves, and solutions of practical and theoretical problems. Applications of integral calculus include computations involving area, volume, arc length, center of mass, work, and pressure. More advanced applications include power series and Fourier series. Students learned in this course different math which give them opportunities to see how these techniques are solving current subject problems. This offer complementary approaches to the fundamental understanding of math systems. Students will acquire knowledge to enable themselves to understand the different theories.

Contents

1 Techniques of integration
2 Integrals of elementary, hyperbolic and trigonometric function
3 Logarithmic and exponential functions
4 Integration by parts, substitution rule
5 Partial fractions, improper integrals
6 Applications of integrals
7 Area between curves
8 Average value of a function
9 Volumes of Solids, arc length
10 Area of a surface of revolution
11 Infinite series, Sequences and series
12 Convergence and absolute convergence
13 Tests for convergence, divergence test
14 Integral test, p series test, comparison test
15 Limit comparison test, alternating series test
16 Ratio test, root test
17 Power series, convergence of power series
18 Representation of functions as power series
19 Differentiation and integration of power series
20 Taylor and McLaurin series
21 Conic section
22 Parameterized curves and polar coordinates
23 Curves defined by parametric equations
24 Calculus with parametric curves
25 Tangents, areas, arc length, polar coordinates
26 Polar curves
27 Tangents to polar curves
28 Areas and arc length in polar coordinates

Recommended Texts

1. Thomas, G. B., Weir, M. D., Hass, J., and Giordano, F. R. (2005). *Thomas' Calculus* (11th ed.). Boston: Addison Wesley.
2. Stewart, J. (2015). *Calculus* (8th ed.). Boston: Cengage Learning.

Suggested Readings

1. Anton, H., Bivens I. C., & Davis, S. (2016). *Calculus* (11th ed.). New Jersey: Wiley.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I., & Asmar, N. H. (2017). *Calculus and Its Applications* (14th ed.). London: Pearson.
3. Hallett, D. H., *et al*. (2017). *Calculus Single and Multivariable* (7th ed.). New Jersey: John Wiley and Sons, Inc.
4. Larson, R., & Edwards, B. H. (2013). *Calculus* (10th ed.). USA: Brooks Cole.

URCE-5102 Language comprehension and presentation skills 3 (3+0)

The course aims at developing linguistic competence by focusing on basic language skills in integration to make the use of language in context. It also aims at developing students' skills in reading and reading comprehension of written texts in various contexts. The course also provides assistance in developing students' vocabulary building skills as well as their critical thinking skills. The contents of the course are designed on the basis of these language skills: listening skills, pronunciation skills, comprehension skills and presentation skills. The course provides practice in accurate pronunciation, stress and intonation patterns and critical listening skills for different contexts. The students require a grasp of English language to comprehend texts as organic whole, to interact with reasonable ease in structured situations, and to comprehend and construct academic discourse. The course objectives are to enhance students' language skill management capacity, to comprehend text(s) in context, to respond to language in context, and to write structured response(s).

Contents

1 Listening skills
2 Listening to isolated sentences and speech extracts
3 Managing listening and overcoming barriers to listening
4 Expressing opinions (debating current events) and oral synthesis of thoughts and ideas
5 Pronunciation skills
6 Recognizing phonemes, phonemic symbols and syllables, pronouncing words correctly
7 Understanding and practicing stress patterns and intonation patterns in simple sentences
8 Comprehension skills
9 Reading strategies, summarizing, sequencing, inferencing, comparing and contrasting
10 Drawing conclusions, self-questioning, problem-solving, relating background knowledge
11 Distinguishing between fact and opinion, finding the main idea, and supporting details
12 Text organizational patterns, investigating implied ideas, purpose and tone of the text
13 Critical reading, SQ3R method
14 Presentation skills, features of good presentations, different types of presentations
15 Different patterns of introducing a presentation, organizing arguments in a presentation
16 Tactics of maintaining interest of the audience, dealing with the questions of audience
17 Concluding a presentation, giving suggestions and recommendations

Recommended Texts

1 Mikulecky, B. S., & Jeffries, L. (2007). *Advanced reading power: Extensive reading, vocabulary building, comprehension skills, reading faster*. New York: Pearson.
2 Helgesen, M., & Brown, S. (2004). *Active listening: Building skills for understanding*. Cambridge: Cambridge University Press.

Suggested Readings

1 Roach, C. A., & Wyatt, N. (1988). *Successful listening*. New York: Harper and Row.
2 Horowitz, R., & Samuels, S. J. (1987). *Comprehending oral and written language*. San Diego: Academic Press.

URCP-5106 Pakistan Studies 2 (2+0)

The course is designed to acquaint the students of BS Programs with the rationale of the creation of Pakistan. The students would be apprised of the emergence, growth and development of Muslim nationalism in South Asia and the struggle for freedom, which eventually led to the establishment of Pakistan. While highlighting the main objectives of national life, the course explains further the socio-economic, political and cultural aspects of Pakistan's endeavours to develop and progress in the contemporary world. For this purpose, the foreign policy objectives and Pakistan's foreign relations with neighbouring and other countries are also included. This curriculum has been developed to help students analyse the socio-political problems of Pakistan while highlighting various phases of its history before and after the partition and to develop a vision in them to become knowledgeable citizens of their homeland. It tends to examine a range of important issues in national history and use these theoretical frameworks to provide better understanding of these events.

Contents

1. Contextualizing Pakistan Studies
2. Geography of Pakistan: Geo-Strategic Importance of Pakistan
3. Freedom Movement (1857-1947)
4. Pakistan Movement (1940-47)
5. Muslim Nationalism in South Asia
6. Two Nations Theory
7. Ideology of Pakistan
8. Initial Problems of Pakistan
9. Political and Constitutional Developments in Pakistan
10. Economy of Pakistan: Problems and Prospects
11. Society and Culture of Pakistan
12. Foreign Policy Objectives of Pakistan and Diplomatic Relations
13. Current and Contemporary Issues of Pakistan
14. Human Rights: Issues of Human Rights in Pakistan

Recommended Texts

1. Kazimi, M. R. (2007). *Pakistan studies.* Karachi: Oxford University Press.
2. Sheikh, J. A. (2004). *Pakistan's political economic and diplomatic dynamics.* Lahore: Kitabistan Paper Products.

Suggested Readings

1. Hayat, S. (2016). *Aspects of Pakistan movement.* Islamabad: National Institute of Historical and Cultural Research.
2. Kazimi, M. R. (2009). *A concise history of Pakistan.* Karachi: Oxford University Press.
3. Talbot, I. (1998). *Pakistan: A modern history*. London: Hurst and Company.

SEMESTER-III

CHEM-5103 Organic Chemistry 4 (3+1)

The students will acquire knowledge about the basic concepts of organic chemistry, chemistry of hydrocarbons, functional groups and the mechanism of organic reactions. It will be useful for the qualitative analysis and synthesis of organic compound. Understanding and knowledge of new and advanced field of organic and also significances the importance of application of advanced techniques. This course is a foundation course for Organic Chemistry major courses of higher semester. The main objectives emphasized in this course involve developing an understanding of basic principles of organic chemistry. It develop critical thinking skills enabling students to solve general chemistry problems that incorporate their cumulative knowledge. Students learned in class to advanced organic chemistry concepts which give them opportunities to upgrade their knowledge about advanced organic concepts. The essence of this course is to develop study skills that students need to succeed in university-level chemistry courses and preparation of students for professional positions in the field of synthesis chemistry.

Contents

1. Basic concepts: atomic, molecular and hybrid orbitals: multiple localized and delocalized bonds, properties of bonds, inductive effect, dipole moment. The concept of resonance, rules of resonance, resonance energy, stearic inhibition of resonance, hyperconjugation, resonance effect, hydrogen bonding, tautomerism.
2. Introduction to spectroscopy with special reference to the infrared, ultraviolet/visible spectroscopy.
3. Hydrocarbons: classification of hydrocarbons. Nomenclature. Methods of preparation, physical characteristics and chemical reactions of alkanes, alkenes and alkynes. Source of aromatic hydrocarbons. Structure of benzene and the concept of aromatic hydrocarbon. Aromatic electrophilic substitution.
4. Stereoisomerism: conformational analysis of ethane and butane. Optical isomerism, optical activity, chiral carbon atom and optical isomerism, relative and absolute configuration, creation of chiral carbon and racemization. Optical isomerism in compounds containing two chiral carbons atom, diastereoisomer, elements of symmetry, resolution of racemic mixture, geometric isomerism, cis/trans isomerism, designation of isomerism, determination of configuration.
5. Alkyl halide: nomenclature, method of preparation and chemical reaction with special reference to the nucleophilic substitution and elimination reaction of alkyl halide. Preparation, structure and synthetic application of grignard reagent.
6. The hydroxyl group and ether: nature of hydroxyl group in phenol and alcohol.
7. Alcohol: classification and nomenclature, preparation method and chemical reaction, distinction between primary, secondary and tertiary alcohol, polyhydric alcohols. Phenol: preparation method, acidity of phenol, chemical reaction.
8. Ether: preparation and reactions.
9. The carbonyl group: nature and its reactivity, nomenclature of aldehyde and ketone, aldehyde and ketone preparation and reactions along with distinction between them. Carboxylic acid and their derivatives: nomenclature, preparation and chemical reactions, strength of acid and factors affecting it, formation and hydrolysis of acid anhydrides, acid halides, acid amides, esters including glycerides. Introduction to amino acid.
10. Nitrogen compounds: amines; classification, nomenclature, preparation and chemical reactions, distinction between primary, secondary and tertiary amines. Preparation and reaction of aniline. Basicity of aromatic and aliphatic amines and factors affecting it. Diazzonium salts and their synthetic applications.

Organic Chemistry Lab.

1. Qualitative organic analysis; systematic identification of organic compounds containing group like COOH, OH, NH_2, C=O.
2. Purification techniques viz solvent extraction distillation and recrystallization, etc.
3. Preparation of simple organic compounds viz, Ethyl benzoate, benzoic acid, tribromophenol, aspirin, nitrobenzene.

Recommended Texts

1. Younas, M. (2006). *Organic spectroscopy*. Lahore: A. H. Publisher
2. Solomons, T. W. G. (2016). *Fundamentals of organic chemistry*. (12th ed.). New York: Wiley.
3. Vogel, A. I. (1996). *A text book of practical organic chemistry*. New York: Prentice Hall.

Suggested Readings

1. Kemp, W. (1990). *Organic spectroscopy*. London: Macmillan
2. Chughtai, F. A. (1995). *Organic reactions*. Lahore: Majid Book Depot.
3. Streitwieser, A. Heathcock, C. & Kosower, E. M. (2017). *Introduction to organic chemistry*. (4th ed.). New York: Macmillan.

BOTN-5103 Cell Biology, Genetics and Evolution 4 (3+1)

Cell biology, genetics and evolution are fundamental to an understanding of the processes of life. In this unit, students will be able examine the structure and function of prokaryotic and eukaryotic cells, including a discussion of the energy flow in photosynthesis, respiration and metabolism. A brief introduction to DNA structure and function from molecular to organism levels and current applications of DNA technology will be studied. This will also enlighten and introduce with classical genetic and evolutionary theory as unifying explanations of life. This course is intended for the student interested in understanding and appreciating common biological topics in the study of the smallest units within biology: molecules and cells. There are thousands of opportunities within the medical, pharmaceutical, agricultural, and industrial fields for a person with a concentrated knowledge of molecular and cellular processes. This course will give you a general introduction of cell organelles, cell division and enzymes which are involved in the process of metabolism. Evolution is the process of change in all forms of life over generations, and evolutionary biology is the study of how evolution occurs. Laboratory practicals will investigate enzyme function, cytogenetics and the genetic analysis of populations.

Contents

Cell Biology

1. Structure and Function of Bio-molecules (Carbohydrates, Lipids, Proteins, Nucleic Acids)
2. Cell: Cell theory, cell types (prokaryotes, eukaryotes), basic properties of cell.
3. Brief description of structure and function of the following cell organelles (Cell wall, Cell membrane, Nucleus, Endoplasmic reticulum, Plastids, Mitochondria, Ribosomes, Dictyosomes, Vacuoles)
4. Reproduction in somatic and embryogenic cell, mitosis, meiosis and cell cycle

Genetics

5. Introduction, scope and brief history of genetics. Mendelian inheritance; Lawsof segregation and independent assortment, back cross, test cross, dominance and incomplete dominance
6. Molecular genetics; DNA replication, nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. lac operon).
7. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and Euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.
8. Evolution: Introduction and theories.

Cell Biology, Genetics and Evolution Lab

1. Study of cell structure using compound microscope and elucidation of ultra structure from electron microphotographs
2. Measurement of cell size.
3. Study of mitosis and meiosis by smear/squash method and from prepared slides.
4. Study of chromosome morphology and variation in chromosome number.
5. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.

Genetics

6. Genetical problems related to transmission and distribution of genetic material.
7. Identification of chromosomes in plant material. Carmine/orcein staining.
8. Determination of blood groups

Recommended Texts

1. Templeton, N.C. (2015). *Gene and cell therapy* (4th ed.). Germany: Taylor and Francis

Publications.
2. Sybille, M., & Shoshan, M. (2015). *Tumor cell metabolism*. Germany: Springer Publications.

Suggested Readings

1. Verma P. S., & Agarwal, V. K. (2016). *Cell Biology* (*Cytology*, *Biomolecules and Molecular Biology*). India: S. Chand Publishing.
2. Milo, R., & Phillips, R. (2015). *Cell biology by the numbers* (1st ed.). Germany: Taylor and Francis publications.
3. Bradshaw, R., & Stahl, P. (2015). *Encyclopedia of cell biology*. Amsterdam: Elsevier Publications.

ZOOL 5103 Animal Form and Function- I (*A Comparative Perspective*) 4 (3+1)

This course teaches about animal's diversity adapted in different strategies for performance of their similar functions through modifications in body parts in past and present times. It impart understanding of diverse strategic structural adaptations in each of the functions of integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory and respiratory systems for effective survival in their specific conditions. The course mainly aims to teach the students about animal's diversity adapted in different ways for their functions through modifications in body parts, about the diversity in integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory, respiratory, nutritive, excretory, osmoregulatory and reproductive systems according to strategies to survive in their specific conditions. It will also introduce about organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body along with the basic structure of each system that determines its particular function of animal body.

Contents

1. Protection, Support, and Movement: Protection: the integumentary system of invertebrates and vertebrates; Movement and support: the skeletal system of invertebrates and vertebrates; Movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates
2. Communication I: Nerves: Neurons: structure and function.
3. Communication II: Senses: Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates Lateral line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air and water, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.
4. Communication III: The Endocrine System and Chemical Messengers: Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action, Hormones with principal function each of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals
5. Circulation and Immunity: Internal transport and circulatory systems in invertebrates Characteristics of invertebrate coelomic fluid, hemolymph, and blood cells, transport systems in vertebrates; characteristics of vertebrate blood, blood cells and vessels; the hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; the human heart: blood pressure and the lymphatic system; immunity: nonspecific defenses, the immune response

Animal Form and Function- I (A Comparative Perspective) Lab

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
2. Study and notes of skeleton of Labeo (Labeo rohita), Frog (Hoplobatrachus tigerinus), Varanus (Varanus bengalensis), fowl (Gallus gallus domesticus) andrabbit (Oryctola guscuniculus).

Note: Exercises of notes on the adaptations of skeletons to their function must be done.

3. Earthworm or leech; cockroach, freshwater mussel, Channa or Catla catla or Labeo or any other local fish, frog, pigeon and rat or mouse and rabbits dissections as per availability.
4. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

Recommended Texts

1. Pechenik, J. A. (2013). B*iology of invertebrates* (4th ed.). Singapore: McGraw-Hill.
2. Hickman, C. P., Roberts, L. S., & Larson, A. (2004). *Integrated principles of zoology, (*11th ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Campbell, N. A. (2002). *Biology* (6th ed.). California: Benjamin Cummings.
2. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.

PHYS-5163 Physics-III 4 (3+1)

Physics, the most fundamental physical science, is concerned with the basic principles of the universe. It is the foundation upon which the other sciences—astronomy, biology, chemistry, and geology—are based. Physics is based on experimental observations and quantitative measurements. The main objective of physics is to find the limited number of fundamental laws that govern natural phenomena and to use them to develop theories that can predict the results of future experiments. The course of "physics-III", presents the fundamental aspects of flow and behavior of heat and basic concepts of the asset of thermodynamically interaction of matter with other objects around it. Thermodynamics literally means heat in motion. Statistical mechanics deals with average effects of large number of individuals. However, it can also be one of the most rewarding because it reveals the world's fundamental clockwork from which all scientific and engineering applications regarded industries. It is widely used in the design of heat engine, steam turbines, refrigerator, physical chemistry and chemical physics. The main objectives of this course are to provide the student with a clear and logical presentation of basic concepts and principles of thermodynamics and statistical mechanics

Contents

1 Heat and Temperature
2 Kinetic theory of gases
3 Microscopic and macroscopic states
4 The Van der Waals equation
5 Thermodynamics and Thermodynamic equilibrium
6 Laws of Thermodynamics
7 Heat engine
8 Carnot cycle and efficiency measurements
9 Entropy, Entropy for reversible and irreversible process
10 Low temperature Physics
11 Thermodynamic Potentials, Tds Equation, Third Law of Thermodynamics
12 Statistical Mechanics
13 Mean Free Path, Maxwell distribution of molecular speeds and Energies
14 Phase space
15 Partition function and Relations with thermo-dynamical variables.

Physics-III Lab

1 Measurement of resistance using a Neon flash bulb and condenser
2 Determination of ionization potential of mercury.
3 To determine the stopping potential by photo cell.
4 Measurement of low resistance of a wire by using Carey Foster Bridge.
5 Calibration of a thermocouple by potentiometer.
6 Determination of temperature coefficient of resistance of a given wire.

Recommended Texts

1. Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics* (10th ed.). New
2. York: Wiley.
3. Halliday, D., Resnick, R., & Krane, K. S. (2003). *Physics* (5th ed.). New York: Wiley.

Suggested Readings

1. Garg, S. C., Bansal, R. M., & Ghosh C. K. *Thermal Physics Kinetic theory, thermodynamics and statistical mechanics* (2nd ed.). USA: McGraw-Hill Education Private Limited.
2. Ohanian, H. C., & Markert, J. T. (2006). *Physics for engineers and scientists* (3rd ed.). New York: W. W. Norton.
3. Mark, H., & Olsono, H. T. (2004). *Experiments in modern physics.* New York: McGraw-Hill

MATH-5138 **Calculus** **4 (4+0)**

This course in calculus is intended to further develop practical skills in differential and integral calculus. As well, it is intended to illustrate various applications of calculus to technical problems. The rules of differentiation will be introduced, and methods of differentiating various algebraic and transcendental functions will be developed. Applications of differential calculus to finding roots of equations by Newton's method, to finding maxima and minima, and to developing power series representation for functions will be studied. Methods of algebraic integration will be introduced, with both definite and indefinite integrals being determined for a variety of functions. The use of tables of integrals for finding solutions for difficult integrals will be introduced. Numerical integration using Simpson's rule will also be developed. Various applications of integration will be studied including Fourier series. First and second order differential equations will be introduced, and methods of solving will be developed. These methods will include Laplace transforms.

Contents

1. Parametric Equations: Curves defined by Parametric Equations
2. Calculus with Parametric Curves
3. Polar Coordinates: Introduction
4. Areas and Lengths in Polar Coordinates
5. Conic Sections, Conic Sections in Polar Coordinates
6. Infinite Sequence and Series: Sequences, Series
7. The Integral Test and Estimates of Sums
8. The Comparison Tests, Alternating Series
9. Absolute Convergence and the Ratio and Root Test
10. Strategy for Testing Series, Power Series
11. Functions as Power Series
12. Taylor and Maclaurin Series.

Recommended Texts

1. Thomas, G. B. (2015). *Calculus* (12th ed.). India: Pearson
2. Stewart, J. (2015). *Calculus early transcendentals* (7th ed.). New York: Brooks/Cole.
3. Anton, H., Calculus. (2001). *A new horizon* (7th ed.). New York: John Wiley.

Suggested Readings

1. Laurence, D. H., & Gerald, L. (2010). *Calculus* (10th ed.). New York: McGraw-Hill.
2. Thomas, G.B., & Finny, R. L. (1995). *Calculus and analytic geometry* (9th ed.). New Jersey: Addison Wesley.

URCE-5103 Academic Writing 3 (3+0)

Academic writing is a formal, structured and sophisticated writing to fulfill the requirements for a particular field of study. The course aims at providing understanding of writer's goal of writing (*i.e.* clear, organized and effective content) and to use that understanding and awareness for academic reading and writing. The objectives of the course are to make the students acquire and master the academic writing skills. The course would enable the students to develop argumentative writing techniques. The students would be able to the content logically to add specific details on the topics such as facts, examples and statistical or numerical values. The course will also provide insight to convey the knowledge and ideas in objective and persuasive manner. Furthermore, the course will also enhance the students' understanding of ethical considerations in writing academic assignments and topics including citation, plagiarism, formatting and referencing the sources as well as the technical aspects involved in referencing.

Contents

1 Academic vocabulary
2 Quoting, summarizing and paraphrasing texts
3 Process of academic writing
4 Developing argument
5 Rhetoric: persuasion and identification
6 Elements of rhetoric: Text, author, audience, purposes, setting
7 Sentence structure: Accuracy, variation, appropriateness, and conciseness
8 Appropriate use of active and passive voice
9 Paragraph and essay writing
10 Organization and structure of paragraph and essay
11 Logical reasoning
12 Transitional devices (word, phrase and expressions)
13 Development of ideas in writing
14 Styles of documentation (MLA and APA)
15 In-text citations
16 Plagiarism and strategies for avoiding it

Recommended Texts

1 Swales, J. M., & Feak, C. B. (2012). *Academic writing for graduate students: Essential tasks and skills* (3rd ed.). Ann Arbor: The University of Michigan Press.
2 Bailey, S. (2011). *Academic writing: A handbook for international students* (3rd ed.). New York: Routledge.

Suggested Readings

1 Craswell, G. (2004). *Writing for academic success*. London: SAGE.
2 Johnson-Sheehan, R. (2019). *Writing today*. Don Mills: Pearson.
3 Silvia, P. J. (2019). *How to write a lot: A practical guide to productive academic writing*. Washington: American Psychological Association.

URCI-5109 Introduction to Information and Communication Technologies 3 (2+1)

The course introduces students to information and communication technologies and their current applications in their respective areas. Objectives include basic understanding of computer software, hardware, and associated technologies. They can make use of technology to get maximum benefit related to their study domain. Students can learn how the Information and Communications systems can improve their work ability and productivity. How Internet technologies, E-Commerce applications and Mobile Computing can influence the businesses and workplace. At the end of semester students will get basic understanding of Computer Systems, Storage Devices, Operating systems, E-commerce, Data Networks, Databases, and associated technologies. They will also learn Microsoft Office tools that includes Word, Power Point, and Excel. They will also learn Open office being used on other operating systems and platforms. Specific software's related to specialization areas are also part of course. Course will also cover Computer Ethics and related Social media norms and cyber laws.

Contents

1. Introduction, Overview and its types.
2. Hardware: Computer Systems and Components, Storage Devices and Cloud Computing.
3. Software: Operating Systems, Programming and Application Software,
4. Introduction to Programming Language
5. Databases and Information Systems Networks
6. The Hierarchy of Data and Maintaining Data,
7. File Processing Versus Database Management Systems
8. Data Communication and Networks.
9. Physical Transmission Media and Wireless Transmission Media
10. Applications of smart phone and usage
11. The Internet, Browsers and Search Engines.
12. Websites Concepts, Mobile Computing and their applications.
13. Collaborative Computing and Social Networking
14. E-Commerce and Applications.
15. IT Security and other issues
16. Cyber Laws and Ethics of using Social media
17. Use of Microsoft Office tools (Word, Power Point, Excel), mobile apps or other similar tools depending on the operating system.
18. Other IT tools/software specific to field of study of the students if any

Recommended Texts

1. Vermaat, M. E. (2018). *Discovering computers: digital technology, data and devices.* Boston: Course Technology Press.

Suggested Readings

1. Timothy, J., O'Leary & Linda, I. (2017). *Computing essentials*, (26th ed.). San Francisco: McGraw Hill Higher Education.
2. Schneider, G. M., & Gersting, J. (2018). *Invitation to computer science*. Boston: Cengage Learning.

SMESTER-IV

CHEM-5104 Chemistry Special Topics 4 (3+1)

This course covers a range of specialized topics in chemistry which provide a useful supplement to the advanced courses specified in the department. Student will be able to learn the basic knowledge of biomolecules, simple heterocycles and introductory organic spectroscopy, is helpful in identification of organic compounds. In addition to it, basics of surface chemistry, modern material and detail study of unit operations in chemical industry and metallurgy can be a beneficial for new learners who are ambitious for specialized area of chemistry. The main objectives emphasized in this course involve developing an understanding of basic principles of different branches of chemistry. It develop critical thinking skills enabling students to solve general chemistry problems that incorporate their cumulative knowledge. Students learned in class to advanced chemistry concepts which give them opportunities to upgrade their applicable knowledge. This course is to develop study skills that students need to succeed in university-level advanced chemistry courses and preparation of students for professional positions in this field and their industrial skill.

Contents

1. Bio-molecules and Simple Heterocycles: (carbohydrates, proteins, lipids, nucleic acids, their importance, nomenclature, properties, synthesis and reactions of simple heterocycles).
2. Introduction to Spectroscopy: (IR and UV/Vis).
3. Surface Phenomena and Colloids: (Physisorption and chemisorption, isotherms, types, properties, preparation and applications of colloids).
4. Nuclear Chemistry: (radioactivity; stability of nuclei, nuclear transformation, measurement of nuclear radiation, nuclear reactions, fission and fusion, nuclear reactor, uses of radioisotopes, nuclear hazards and safety measures).
5. Modern Materials: (Introduction to liquid crystals, Inorganic polymers, Ceramics, Fiber glass, Thin films, Semiconductors and Composite materials).
6. Chemical Industries: (Metallurgy of Al, Manufacturing of sulphuric acid, nitric acid, fertilizers, cement and glass).

Chemistry Special Topics Lab

1. Percentage determination of barium in barium nitrate by gravimetric method.
2. Gravimetric determination of nickel.

3. Estimate the glucose content in the sample by titration method
4. Determination of adsorption parameters using Langmuir adsorption isotherm of acetic acid on charcoal.
5. To determine the wavelength of maximum absorption of compounds using spectrophotometer.
6. To determine the concentration of Cr in water sample by using spectrophotometer.
7. To determine the concentration of Mn in water sample by using spectrophotometer.
8. To determine the concentration of the Sucrose, glucose and dextrose in samples by using polarimeter.
9. To determine the Iodine value of the oil and fat
10. Estimate the glucose content in the sample by titration method
11. Identification Al^{3+}, Cr^{3+} and F^{3+} in samples by TLC
12. Determine the partition coefficient of iodine between water and carbon tetrachloride
13. Qualitative analysis of lipids, proteins, carbohydrates

Recommended Texts

1. Voet, D. R. & Voet, J. G. (2001). *Biochemistry*. New York: John Wiley and Sons

2. Younas, M. (2005). *Organic spectroscopy*. Lahore: A. H. Publisher
3. Solomons, T. W. G. (2016). *Fundamentals of organic chemistry* (12th ed.). New York: Wiley,

Suggested Readings

1. Kent, J. A. (1997). *Riegal's hand book of industrial chemistry*. New Delhi: CBS Publishers and Distributors.
2. Arnikar, H. J. (1998). *Nuclear chemistry*. India: Krishna Prakashan Media (P) Ltd.
3. Gurdeep, R. (2002). *Advanced physical chemistry*. India: Krishna Prakashan Media (P) Ltd.

BOTN-5104 Plant Physiology and Ecology 4 (3+1)

This course is designed to provide students with comprehensive exposure to the subject of plant physiology and ecology and will give know how about physiological adaptation; limiting factors; resources acquisition/allocation; photosynthesis, carbon, energy balance; water use and relations; nutrient relations; linking physiology, stable isotope applications ecophysiology; stress physiology; life history, physiology; evolution of physiological performance; physiology population, community, ecosystem levels. The goal in teaching this course is to give students a greater appreciation of the plant world we depend on and to stimulate student learning of basic concepts in plant and biological science. Plant physiology helps to study a wide range of processes and functions that plants use to live and survive and its very important to know the functions of a living organism or any of its parts while Plant Ecology is the study of the interactions of living things with their environment. It helps to ask questions across four levels of biological organization—organismal, population, community, and ecosystem. The laboratory exercises provide hands-on experiences with experiments and training in instrumental skills on the topics: water relations, photosynthesis, inorganic nutrition, metabolism of organic materials, and plant growth regulation, with emphasis on environmental factors in the physiology of plants.

Contents

Plant Physiology

1. Water relations: (water potential, osmotic potential, pressure potential, matric potential). Absorption and translocation of water. Stomatal regulation.
2. Mineral nutrition: Soil as a source of minerals. Passive and active transport of nutrients. Essential mineral elements, role and deficiency symptoms of macronutrients.
3. Photosynthesis: Introduction, oxygenic and non-oxygenic photosynthesis. Mechanism: light reactions (electron transport and photophosphorylation) and dark reactions (Calvin cycle). Differences between C_3 and C_4plants.Factors affecting this process. Products of photosynthesis.
4. Respiration: Definition and respiratory substrates. Mechanism of Glycolysis, Krebscycle. Electron transport and oxidative phosphorylation. Anaerobic respiration. Energy balance in aerobic and anaerobic respiration, respiratory quotients.

Ecology

5. Introduction: Aims and applications of ecology.
6. Soil: Physical and Chemical properties of soil (soil formation, texture. pH, EC, organism and organic matter etc.) and their relationships to plants.
7. Light and Temperature: Quality of light, diurnal and seasonal variations. Ecophysiological responses.
8. Water: Field capacity and soil water holding capacity. Characteristics of xerophytes and hydrophytes. Effect of precipitation on distribution of plants.
9. Wind: Wind as an ecological factor and its importance.
10. Population Ecology: Introduction. A brief description of seed dispersal and seed bank.
11. Community Ecology. Ecological characteristics of plant community ii. Methods of sampling vegetation (Quadrat and line intercept) iii. Major vegetation types of the local area.
12. Ecosystem Ecology. Definition, types and components of ecosystem. ii. Food chain and Food web.
13. Applied Ecology: Causes, effects and control of water logging and salinity with respect to Pakistan.

Plant Physiology and Ecology Lab

Plant Physiology

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.
3. Measurement of leaf water potential by the dye method.
4. Determination of the temperature at which beet root cells lose their permeability.
5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a photometer/cobalt chloride paper method.
6. Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram. Study of absorption spectra using spectrophotometer.
7. Estimation of oxygen utilized by a respiring plant by Winkler's method.

Ecology

8. Determination of physical and chemical characteristics of soil.
9. Measurements of various population variables
10. Measurement of vegetation by Quadrat and line intercept methods.
11. Field trips to ecologically diverse habitats.
12. Measurements of wind velocity.
13. Measurement of light and temperature.
14. Effect of light and temperature on seed germination.

Recommended Texts

1. Sharma, H., & Singh, P. K. (2018). *Laboratory manual for bioinstrumentation, biochemistry, microbiology, cell biology and enzyme technology for PG and UG students*. New Delhi, India: Excellent Publishing House
2. Jugulam, M. (2017). *Biology, physiology and molecular biology of weeds*. Germany: CRC Press.

Suggested Readings

1. Keddy, P. A. (2017). *Plant ecology origins, processes, consequences*. (2nd ed.). UK: Cambridge University Press.
2. Canadell, J. G., Diaz, S., Heldmaier, G., Jackson, R. B., Levia, D.F., Schulze, E. D., & Wardle, D. A. (2019). *Ecological studies*. Germany: Springer.
3. Taiz, L., & Zeiger, E. (2019). *Plant physiology*.(7th ed.). Germany: Sinnauers Publ. Co. Inc.

ZOOL-5104 Animal Form and Function-II 4 (3+1)

This course will enable students to understand the diverse forms adapted to perform the same functions are because of the different past and present conditions. Students will also be able to solve that emergence of diversity of forms for the performance of similar function. It also demonstrates that a form is successfully adapted to perform a function like temperature regulation adequately and successfully. Upon successful completion of course students will have knowledge about nutrition and digestion process among animal groups, temperature regulation strategies adapted by animals and different modes of reproduction adapted by several groups for their successful stay on planet. The practical section will let them to study the excretory system in invertebrate and vertebrate model animals, can study nutritive canal in an invertebrate and a vertebrate animals through dissection and will be able to study the male and female reproductive system of an invertebrate and a vertebrate animal model.

Contents

1. Nutrition and Digestion: Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion, Animal strategies for getting and using food, diversity in digestive structures of invertebrates., The mammalian digestive system: gastrointestinal motility and its control, Oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gallbladder in digestion.
2. Temperature and Body Fluid Regulation : Homeostasis and Temperature Regulation; The Impact of Temperature on Animal Life; Heat Gains and Losses; Some Solutions to Temperature Fluctuations; Temperature Regulation in Invertebrates, Fishes, Amphibians, Reptiles, Birds and Mammals; Heat Production in Birds and Mammals , Control of Water and Solutes (Osmoregulation and Excretion); Invertebrate and Vertebrate , Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions. Reproduction and Development
3. Reproduction: Asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction, Sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes; The human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function; The human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; hormonal regulation in gestation; prenatal development and birth: the placenta; milk production and lactation.

Animal Form and Function-II Lab

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of dissection system in invertebrate and a vertebrate representative (Dissection).
3. Dissection and study of male and female reproductive system in vertebrates and invertebrates.
   Note: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.

Recommended Texts

1. Pechenik, J. A. (2013). *Biology of invertebrates* (4th ed.). Singapore: McGraw-Hill.

2. Hickman, C. P., Roberts, L. S., & Larson, A. (2004). *Integrated principles of zoology* (11th ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Campbell, N. A. (2002). *Biology* (6th ed.). California: Benjamin Cummings.
2. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.
3. Hickman, C. P., & Kats, H. L. (2000). *Laboratory studies in integrated principles of zoology*. Singapore: McGraw-Hill.

PHYS-5164 Physics-IV 4 (3+1)

Physics, the most fundamental physical science, is concerned with the basic principles of the universe. It is the foundation upon which the other sciences—astronomy, biology, chemistry, and geology—are based. Physics is based on experimental observations and quantitative measurements. The main objective of physics is to find the limited number of fundamental laws that govern natural phenomena and to use them to develop theories that can predict the results of future experiments. The course of "physics-IV", is intended for use with one semester-courses in "Modern Physics" (Quantum mechanics, Laser physics, Plasma physics. Atomic physics, Nuclear physics and Cosmology.). A framework for understanding the physics of atoms and nuclei and elementary particles are provided. The deliberately leans more toward ideas and practical applications, because the beginning student is better served by a conceptual framework than by a mass of individual details. The main objectives of this course are twofold: to provide the student with a clear and logical presentation of basic concepts and principles of modern physics, and to strengthen an understanding of the concepts and principles through a broad range of interesting applications to the real world.

Contents

1 Relativistic mechanics
2 Origin of Quantum Theory
3 Wave nature of matter
4 Quantum Mechanics, Introduction to Quantum Optics, Laser and Plasma Physics
5 Atomic Physics
6 Bonding in Solids, Band theory of solids
7 Fundamental forces in nature
8 Nuclear structure
9 Fundamental particles
10 Nuclear transmutation (Alpha-Beta and Gamma decays)
11 Radioactivity
12 Half-life and Mean life
13 Fission and Fusion reactions
14 Introduction to cosmology

Physics-IV Lab

1 Determination of e/m of an electron.
2 Characteristics of a semiconductor diode.
3 Setting up of half and full wave rectifier and study of following factors.
   i. Smoothing effect of a capacitor.
   ii. Ripple factor and its variation with load.
   iii. Study of regulation of output voltage with load.
4 Study of the parameter of wave i.e. amplitude, phase and time period of a complex signal by CRO.
5 To determine Horizontal/Vertical distance by Sextant.
6 The determination of wavelength of Sodium D lines by Newton's ring.
7 The determination of wavelength of light/laser by diffraction grating.

Recommended Texts

1. Halliday, D., Resnick, R., & Walker, J. (2014). *Fundamentals of physics* (10th ed.). New York: Wiley.
2. Krane, Y. (2008). *Introductory nuclear physics.* New York: Wiley.

Suggested Readings

1. Beiser, A. (2003). *Concepts of modern physics.* (6th ed). USA: McGraw Hill.
2. Sear, A., & Zemansky. (2008). *University physics with modern physics* (12th ed.). New York: Pearson.
3. Mark, H. & Olsono, H. T. (2004). *Experiments in modern physics.* New York: McGraw-Hill.
4. Musaddiq, M. H. (2008). *Experimental physics.* Lahore: Allied Book Center.

MATH–5139 Linear Algebra and Differential Equation 4 (4+0)

This course gives a working knowledge of systems of linear equations, matrix algebra, determinants, eigenvectors and eigenvalues, finite-dimensional vector spaces, matrix representations of linear transformations, matrix diagonalization, changes of basis, Separable and first-order linear equations with applications, 2nd order linear equations with constant coefficients, method of undetermined coefficients, Systems of linear ODE's with constant coefficients, Solution by eigenvalue/eigenvectors, Non homogeneous linear systems and its applications in solving chemical problems. Computer software and graphing calculators will be used to enhance the learning and teaching of topics and techniques covered and also describe the chosen scientific method and communicate their findings in a written scientific report using precise language and set up numerical experiments and interpret the results and able to implement the algorithms in a chosen programming language. The main objectives of this course is to provide the student with a clear and logical presentation of basic concepts and principles of Algebra and Differential Equation, and to strengthen an understanding of the concepts and principles through a broad range of their interesting applications.

Contents

1. Algebra of matrices
2. Types of matrices
3. Operations of matrices
4. Determination and its properties
5. Echelon form
6. Reduced Echelon form
7. Adjoint, inverse rank of a matrix
8. Solution of homogeneous liner algebraic system of equations by use of matrices
9. Solution of non- homogeneous liner algebraic system of equations by use of matrices
10. De Formation of differential equation
11. Different methods of solving first order
12. Bernoulli ' s Equation,
13. Cauchy - Euler differential equation
14. Second and higher order linear differential equations with constant co-efficient

Recommended Texts

1. Yusuf, S. M. Majeed. A. & Amin. M. (2002). *Mathematical methods* (3rd ed.). Lahore: Ilmi Kitab Khana.
2. Dennis, Z. & Michael, C. (1993). *Differential equations and boundary value problems* (3rd ed.). Boston: PWS-KENT.

Suggested Readings

1. Curtis, W. (2004). *Linear Algebra*. Berlin: Springer.
2. Apostol, T. (1997). *Multi variable calculus and linear algebra.* (2nd ed.). New York: John Wiley and Sons
3. Friedberg, S. & Insel A. (2003). *Linear algebra.* Canada: Pearson Education
4. Grossman, S. I. (2004). *Elementary linear algebra*,.(5th ed.). USA: Cengage Learning.

URCE-5104 Introduction to English Literature 3 (3+0)

The course is designed to provide the familiarity and comprehension of English literary pieces. The students may not be familiar or well-versed in the various genres of literature prior to taking this course. The course provides training and skills necessary to engage, understand, critically analyze, and enjoy the literary genres of literature: short story, poetry, novel and drama. The students will explore the basic concepts of literary technique, narrative, poetic, and dramatic structures and innovations to engage with the more advanced cognitive aspects of literature. In addition to these theoretical skills, students will also read below the surface of the texts for their historical, ethical, psychological, social, and philosophical value by developing insights in how literature gives us a window into both the experiences of others and wider appreciation for the human condition. The course explores literary production in English against local context in particular, by emphasizing shifts in thought as well as genre innovation, i.e. medieval to modern. It provides an introduction to key texts, authors and literary periods, exploring the relationship of texts to their contexts and considering multiple perspectives in the different literary genres.

Contents

1. Poems, Milton: *Book IX*, lines 897–959.
2. Shakespeare: All the World is a Stage.
3. Browning: My Last Duchess
4. Wordsworth: The Leech Gatherer
5. Keats: Ode to Autumn
6. Walter De La Mare: Tartary
7. Short Stories, *The Necklace*
8. The Woman Who had Imagination
9. Shadow in the Rose Garden
10. Essays, *My Tailor*
11. Whistling of the Birds
12. One Act Play, *Riders to the Sea*
13. Novel, *Animal Farm*

Recommended Readings

1. Kennedy, X. J., & Gioia, D. (2014). *Literature: An introduction to fiction, poetry, drama, and writing*. Boston: Pearson.
2. Mays, K. J. (2014). *The Norton introduction to literature*. New York: Norton.

Suggested Readings

1. Bausch, R., & Cassill, R.V. (2006). *The Norton anthology of short fiction*. New York: Norton and Company.
2. Gardner, J. E., Lawn, B., Ridl, J., & Schakel, p. (2016). *Literature: A portable anthology*. Boston: Bedford St. Martins.

CHEM-5105 Introduction to Management 3 (3+0)

This is an introductory course about the management of organizations. It provides instructions on principles of management that have general applicability to all types of enterprises; basic management philosophy and decision making; principles involved in planning, organizing, leading, and controlling; and recent concepts in management. Have you ever wondered what qualities billionaire Warren Buffet, visionary Steve Jobs, or Jeff Bezos all have in common? After you finish studying business practices in this course, you may discover that you have some of the same qualities as other successful entrepreneurs. This course is designed as a survey course that will expose you to business terminology, concepts, and current business issues. The intent is to develop a viable business vocabulary, foster critical and analytical thinking, and refine your business decision-making skills. These skills will be acquired by the reading materials, exercises, and research assignments in this course that simulate the workplace today. The principles learned in this course will allow the student to effectively work with and through others in an organization. The course will also encourage the students to explore and inquire the applicability of western management principles and theories in local settings.

Contents

1. Introduction to management the management process
2. Importance of management for a business
3. Organizational theories
4. Nature and types of organizations
5. The organizational culture and the management
6. The external environment and the manager
7. The internal environment and the manager
8. The manager's role as decision maker
9. Decision making process
10. Type of decision-making processes
11. Basics of strategic management
12. Organizational structure, types of organizational structure
13. Human Resource Management
14. Important of human resource for a business
15. Motivation its theories, team work and group behavior,
16. Leadership and its characteristics, leadership style and behavior
17. The process of control, case of controlling

Recommended Texts

1. Stephen, P. R., & Mary, A. C. (2017). *Management* (14th ed.). New York: Pearson Publication.

Suggested Readings

1. Hannaway, J. (1989). *Managers managing: The workings of an administrative system* (3rd ed.). New York: Oxford University Press.
2. Eccles, R. G., and Nohria, N. (1992). *Beyond the Hype*: *rediscovering the essence of management*. Boston: The Harvard Business School Press.

SEMESTER-V

CHEM-6101 Basic Mathematics for Chemist 2(2+0)

This course introduces students with basic mathematics that is used in chemistry. This is the fundamental course of serving as the foundation of mathematics for its use in chemistry and chemical calculation during the lab experiments and research. The course , equally, emphasizes basic concepts and skills needed for mathematical manipulation. It focus on the study of functions of a logarithmic and exponential functions, single variables, differential equations and their use in chemical problems, and use of Integration, Determinants and Matrices. Applications of differential equations include computations involving velocity and acceleration, the slope of a curve, and optimization. Student are also expected to learn solutions of linear equations (simple, determinant and matrices methods), operator theory, differentiation, integration and matrices. This course will also provide applications of eigen value problem and curve fitting in chemistry. Upon successful completion of course students will be able to derive basic mathematics equations use in chemistry and apply them to seek solution for related problems in the experiments.

Contents

1. Introduction
2. Review of basic algebra
3. Graphs and their significance in chemistry
4. Trigonometric
5. Logarithmic functions
6. Exponential functions
7. Differentiation
8. Partial differentiation
9. Differential equations and their use in chemical problems
10. Concept of maxima and minima
11. Integration
12. Determinants
13. Matrices
14. Their properties and use in chemical problems.
15. Solutions of linear equations (simple, determinant and matrices methods)
16. Operator theory,
17. The eigen value problem
18. Curve fitting.

Recommended Texts

1. Paul, M. (2006). *Mathematics for chemistry.* (1st ed.). Oxford, United Kingdom: Oxford University Press
2. Ghram, D. (1996). *Mathematics in chemistry*. (1st ed.). New York, USA: Prentice Hall Publishing.

Suggested Readings

1. Tebutt, P. (1998). *Basic mathematics for chemists*. (2nd ed.). New York, USA: John Wiley & Sons.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I., & Asmar, N. H. (2017). *Calculus and Its Applications* (14th ed.). London: Pearson.

CHEM-6102 Analytical Chemistry 4 (3+1)

This course is aimed to build foundation of Analytical Chemistry among the beginners, introducing them with the basic terminology and phenomenon of Analytical Chemistry, methods and precautions in collection and preservation of different type of samples for chemical analysis. It provides fundamental to deep insight about characterizing a material into its constituents as well as proportion of different ingredients in given sample. All the techniques and precautions for sample collection, and preparation are included in this course. Accuracy of this information is influenced by mode of sampling. This course provides a comprehensive skill development for preparation of solutions for measurements, calibration of volumetric glassware, and measurement of reagents with different types of balances. Skill about data analysis is also included in this course. Besides, basic principle, operational mechanism and applications of three different chromatographic techniques is contained in this course. For advanced information, overview of spectroscopic techniques, with comprehensive focus on UV/Visible spectrophotometry is also included in this course. After studying this course, students will be able to work independently in any quality control laboratory of any industry.

Contents

1. Data Handling: introduction to analytical chemistry
2. Sampling; types of samples, techniques/ steps involved in sample preparation
3. Drying and ignition
4. Weighing, analytical balance, its construction working
5. volumetric glassware; errors in measurements, calibration of glassware
6. Steps involved in chemical analysis, system for units of measurements and their interconversion
7. Chemical concentration and preparation of solutions
8. Calibration and calibration curves (construction and interpretation), Standard addition and internal standard methods
9. Statistical treatment of analytical data; Precision, accuracy and types of errors, sample, population, mean, average, median, range, standard deviation, variance, significant figures
10. Chemical equilibrium ant its types
11. Separation techniques: chromatography (introduction, classification) TLC, column & ion exchange chromatography (with reference to principles & applications), electrophoresis & solvent extraction

Analytical Chemistry Lab – I

1. Calibration of glassware (Pipette, Burette, Flask) used for volumetric Analysis.
2. Use of Analytical balance and calculation of standard deviation.
3. Use of pH meter for plotting acid - base titration curve and assay of commercial caustic soda.
4. Plotting of first differential curve for titration of acetic acid and commercial soda.
5. Measurement of solubility products of sparingly soluble salts.
6. Determination of HCl by titrating with NaOH and plotting of a titration curve.
7. Packing of chromatographic column and separation of mixture of dyes.
8. Separation of various components of plant extract by column chromatography.
9. Separation of mixture of dyes by Radial chromatography.
10. Separation of mixture of Amino acids by paper chromatography.
11. Coating of TLC plates and separation of mixture of dyes.
12. Separation of mixture of Amino acids by TLC.

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical chemistry.* (4th ed.). New York, John Wiley & Sons.

CHEM-6103 Inorganic Chemistry – I 4(3+1)

The students will be able to learn the detailed concept of d-block elements, inner transition elements, non-aqueous solvents and structural elucidation of compounds. Nature of chemical bonding in coordination compounds is included in the course, which enables the students to understand the color and magnetic properties of compounds. The examples of salts with some properties different from those of double-salts enable us to think about the introduction and nomenclature of coordination compounds. The earlier knowledge of the electronic configuration of elements belonging to d-block elements makes the learning easier about f-block Lanthanides and Actinides. Further, non-aqueous chemistry provides information about reactions which otherwise cannot take place in aqueous polar environment. Moreover, different methods for the analysis of halide ions and transition metals ions will also be studied in lab work. Estimation of different metal ions in the water and biological samples is necessary to explain the properties and nature of such samples.

Contents

1. Survey of Inorganic Structures and Bonding: Structures of molecules having single bonds
2. Resonance and formal charge, Complex structures-a preview of coming attractions
3. Electron-deficient molecules, Structures having unsaturated rings and Bond energies
4. Chemistry of Lanthanides and Actinides: Structure, occurrence and preparation
5. Separation, electronic configuration and oxidation states
6. Spectral and magnetic properties and Complex formation and their applications
7. Chemistry of Coordination Compounds: Introduction of d–block elements
8. Nomenclature, Werner's theory, Valence bond theory, Crystal field and Ligand field theory
9. Molecular orbital theory and Jahn-Teller Theorem
10. The spectrochemical series, color, isomerism and stereochemistry of metal complexes
11. Geometry of complexes having coordination number 2 to 6
12. Applications of coordination compounds in chemistry, life and industry
13. Composition and Stability of Complexes.
14. Non – aqueous Solvents: Introduction and classification of solvents
15. Types of reactions in non-aqueous solvents
16. Effect of physical and chemical properties of solvents
17. Study of reactions in liq. NH_3 and liq. SO_2
18. Reactions in Liq. HF and liq. BrF_3 and in molten salt system

Inorganic Chemistry Lab-I

1. Qualitative Analysis of inorganic mixture (six radicals) by micro and semi-micro techniques.
2. Estimation of Halide ions (Cl^-, Br^-, I^-) by adsorption indicator.
3. Complexometric titrations using EDTA for Ni, Ca (II) and Mg (II) in a mixture.
4. Complexometric titrations using EDTA for Mg (II), Mn (II) and Zn (II) in a mixture.

Recommended Texts

1. Cotton, F.A., & Wilkinson, G. (2015). *Advanced inorganic chemistry*. (7th ed.). New York: John Wiley & Sons.
2. Greenwood, N.N., & Earnshaw, A. (1984). *Chemistry of the elements.* (2nd ed.). U.K.: Elsevier.

Suggested Readings

1. De Lavis, R. (1997). *Principles of quantitative chemical analysis*. (1st ed.). New York, USA: WCB/McGraw Hill.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

CHEM-6104 Organic Chemistry–I 4 (3+1)

It is a course designed to deliver fundamental concepts in organic chemistry for core understanding of forthcoming courses (CHEM-6209, CHEM-6223 and CHEM-6240) of organic chemistry specialization. The nomenclature of organic molecules (both carbocycles and heterocycles), involvement of electronic (*–I*, *+I*)/resonance (*–R*, *+R*)/steric factors in reactions and stereochemical aspects are major focus of this course. The major part of this course is associated with the study of stereoisomers. Stereochemistry spans the entire spectrum of organic, inorganic, biological, physical and especially supramolecular chemistry. It includes methods for determining and describing these relationships; the effect on the physical or biological properties these relationships impart upon the molecules in question, and the manner in which these relationships influence the reactivity of the molecules in question (dynamic stereochemistry). A basic concept on 3D structures, conformations of molecules, asymmetric synthesis, other stereochemical principles and attributes are essential. The completion of this course shall enable the students to apply fundamental concepts in organic chemistry and stereoisomerism.

Contents

1. IUPAC nomenclature of polyfunctional aliphatic, alicyclic, aromatic, heterocyclic, multicyclic organic compounds, spiro and allenes.
2. Inductive effect, resonance, hyperconjugation, aromaticity & tautomerism. The effect of structure, medium and steric factor on the strength of acids, bases and on acid-base equilibria. Introductory linear free energy relationship.
3. Geometrical Isomerism: *cis/trans, E/Z &syn/anti* conventions, optical isomerism
4. Chirality and symmetry, elements of chirality and elements of symmetry.
5. Optical isomerism of compounds up to three asymmetric centers, configuration *vs* conformation.
6. Wedge-head, saw-horse, Newman & Fischer projections. Baeyer's Strain theory.
7. Conformational isomerism in acyclic, alicyclic compounds (cyclobutane, cyclopentane, cyclohexane), mono / di-substituted cyclohexanes and condensed rings, locking groups.
8. Configurational isomerism, relative (*D/L* convention) and absolute configuration (CIP rule &*R/S*, *r/s*, *aR*/*aS* conventions).
9. Configurational isomerism in biphenyls, allenes and spiro compounds.
10. Racemization, resolution of racemic modification and introductory asymmetric synthesis.
11. Stereospecificity *vs* stereoselectivity. Determination of configuration (ORD/CD).

Organic Chemistry Lab. – I

Separation & identification of two and three component mixture of organic compounds by physical and chemical methods.

Recommended Texts

1. Clayden, J., Greeves, N., and Warren, S. (2012). *Organic chemistry*. (2nd ed.). Oxford, London.
2. Solomons, T. W. G. (2016). *Fundamentals of organic chemistry*. (12th ed.). New York: Wiley.
3. Hendrickson, J. B., Cram, D. J., and Hammond, G. S. (1980), *Organic chemistry*. New York: McGraw-Hill Book Co.

Suggested Readings

1. Streitwieser, A., Heathcock, C. and Kosower, E. M. (2017). *Introduction to organic chemistry*. (4th ed.). New York: Macmillan.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (4th ed.). London: Longman Publisher.

CHEM-6105 Physical Chemistry – I 4(3+1)

This course is designed to have basic concepts and strong foundation of Physical Chemistry. This course will cover laws of thermodynamics, Nernst heat theorem and its applications and knowledge of entropy in detail. Moreover, Maxwell's law and its derivation, Barometric formula, effect of altitude, temperature and molecular mass on vertical distribution of particles and kinetics of third order, opposing reactions, parallel and consective reactions is also part of this course. Kinetics of thermally excited chain reactions and theories of reactions will also be focused. As course covers main directions of physical chemistry i.e. kinetics and thermodynamics so it provides a sound foundation to the students in the field of physical chemistry. It makes the students capable of understanding the laws of thermodynamics and their applications. Intensive knowledge of chemical kinetics is very useful for the students to make them understand the dynamics of a chemical reactions and the ways to increase yield at lab and industrial scale.

Contents

1. Review of first law of thermodynamics
2. Second law of thermodynamics and its applications.
3. Clausius inequality. Nernst heat theorem and its applications.
4. Third law of thermodynamics and determination of absolute entropy.
5. Entropy of mixing. Partial molal quantities.
6. Maxwell's law of distribution of velocities and derivation of average velocity, most probable velocity and root mean square velocity from the law.
7. Significance of Maxwell's law.
8. Derivation of Maxwell's distribution for kinetic energy.
9. Barometric formula, effect of altitude, temperature and molecular mass on vertical distribution of particles.
10. Concept of order of reaction.
11. Kinetics of third order reactions with different concentration and molecular identity.
12. Kinetics of opposing, reversible, consecutive and parallel reactions.
13. Kinetics of thermally excited chain reactions.
14. Theories of reactions.

Physical Chemistry Lab – I

1. Determination of specific and molar rotations of optically active substance in solution polarimetrically.
2. Percentage by refractometer.
3. Verification of Beer–Lambert's law, and determination of unknown concentration of $KMnO_4$ and $K_2Cr_2O_7$ solution by colorimeter.
4. Determination of distribution coefficient of I_2 between H_2O and CCl_4.
5. Preparation of buffer solution and measurement of exact pH-value by pH meter.

Recommended Texts

1. Marin, G. B., Yablonsky, G. S. (2011). *Kinetics of chemical reactions: decoding complexity.* Wiley-VCH Verlag GmbH.
2. Koretsky, M. D. (2010). *Engineering and chemical thermodynamics.* John Wiley & Sons Inc.

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.) Meerut Krishna Prakashan Media (P) Ltd.
2. Atkins P.W. (2017). *Physical chemistry.* (11th Ed.) UK: ELBS Oxford University Press.
3. Bhatti, H. N. (2019). *Modern physical chemistry.* Pakistan: Caravan Book House Lahore.

SEMESTER-VI

CHEM-6106 Basic Statistics for Chemists 2 (2+0)

This course aims at providing students basic knowledge of statistics. Student will be able to use Simple linear regression, multiple regression (for two independent variables), and Correlation in terms of chemistry. Students will be provided with the theoretical concepts, tools and methods of statistics as well as the opportunity to work through example problems. This course also provides basic statistical concepts for measuring the central tendency and dispersion, probability distributions, the central limit theorem, sampling, estimation, hypothesis testing, analysis of variance, correlation and regression analysis, multiple regression and statistical forecasting. Upon the completing this course the students will be able to compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, for forecasting and also perform ANOVA and F-test. This will further enhance student knowledge to understand both the meaning and applicability of a dummy variable and the assumptions which underline a regression model. Be able to perform a multiple regression using computer software.

Contents

1. Statistics- Introduction.
2. Definition, Descriptive and inferential statistics, Population, Sample, Data collecting. Use of Microsoft Excel for data analysis
3. Applications of statistics in chemistry.
4. Graphical Representation.
5. Simple Bar chart, Multiple Bar chart
6. Rectangle Sub-divided Chart, Histogram
7. Frequency Polygon, Histogram, Pi- Chart
8. Central Tendencies (A.M., G.M. Median, Mode, H.M. for Ungrouped Data.
9. Quantiles with Interpretation (for ungrouped data)
10. Quartiles, Percentiles, Deciles
11. Measures of dispersion (Mean Deviation, Variance, Standard Deviation, Coefficient of Variation).
12. Basic Probability Theory.
13. Regression, Definitions of Simple linear regression
14. Multiple regression (for two independent variables), and Correlation.
15. Estimation: Point estimate, interval estimates
16. Confidence Interval for Single Mean, Difference of Mean.
17. Testing of Hypothesis: t- test for single mean for paired samples and for Independent samples.
18. ANOVA, Multiple Comparison Test, (LSD and DUCANSAN).
19. Chi Square for Association.

Recommended Texts

1. Navidi, J. (2010). *Statistics for engineers and scientists.* (1st ed.). New York, USA: John Wiley.
2. Schuenemeyer, J. (2011). *Larry drew statistics for earth and environmental scientists*. New York, USA: John Wiley.

Suggested Readings

1. Miller, C. J. & Miller, N. J. (1993). *Statistics for analytical chemistry*. New York: Ellis Horwood Ltd.
2. Miller, N. J. & Miller, C. J. (2001) *Statistics and chemometrics for analytical chemistry*. (4th ed.). New York: Prentice Hall.

CHEM-6107 Biochemistry 4 (3+1)

This is a basic biochemistry course designed to provide the fundamental concepts about biomolecules, their classifications, functions and significance. This course demonstrate a broad knowledge of the fundamental introductory concepts of biochemistry where students will gain a deep understanding of function of biomolecules with respect to chemical and molecular processes that occur in and between cells. Students will learn about proteins, carbohydrates, lipids and nucleic acids and their types. Lab experiments related to qualitative and quantitative estimation of biomolecules are also part of this course. Upon the successful completion of course, students will be able to show a deep understanding of fundamental principles of biochemistry along with scientific reasoning to solve problems. Students will demonstrate a comprehensive understanding of the theory and practice of modern instrumentation and apply it to appropriate chemical problems. Students will also be able to perform basic biochemistry laboratory procedures with good standard lab practices and accurate record keeping. This compulsory course is followed by advance biochemistry courses in next semesters.

Contents

1. History and Scope of Biochemistry. Origin and nature of biomolecules.
2. Proteins: Amino acids, classification and properties of amino acid. Stereochemistry,
3. Primary, Secondary, Tertiary and Quaternary protein structures.
4. Motif and domains in proteins. Biological functions of proteins and peptides,
5. Enzymes: Chemical Nature, Nomenclature and Classification.
6. Enzyme activity. Coenzymes and immobilized enzymes, Specificity of Enzymes,
7. Enzyme Inhibition. Regulation of Enzyme activity.
8. Carbohydrates: Definition and Classification, Monosaccharides:
9. Pyranose and Furanose ring structures. Stereoisomerism and Optical isomerism.
10. Disaccharides; Structures, Polysaccharides; starch, Glycogen and Cellulose.
11. Modified carbohydrates, Glycoproteins and Glycolipids.
12. Derived sugars, Hemiacetal, Acetal and Glycosidic linkages,
13. Glycosaminoglycans and Glycoconjugates.
14. Lipids: Structures and classification of Fatty Acids, essential and non-essential fatty acids
15. Phospholipids, Fats and oils; Hydrogenation, Oxidation and Rancidity
16. Steroids, Eicosanoids, Fats and oils, Waxes
17. Nucleic Acids: Purines and pyrimidines, nucleosides and nucleotides
18. Structural and functional differences between DNA and RNA.
19. Types of DNA and RNA, their functions in biological systems.
20. Vitamins: A basic introduction, classification and significance

Biochemistry Lab I

1. Safety Lab Practices – Safety signs and significance
2. Operation and use of micropipettes – types and uses
3. Standard Buffer preparation and use of pH meter
4. Qualitative Tests for carbohydrates
5. Molisch's Test, Fehling's Test, Benedict's Test, Barfoed's Test, Seliwanoff's Test, Bial's Test, Osazone Test
6. Effect of Alkalis on Sugars
7. Quantitative Determination of Reducing Sugars by using Calorimetric Method (Spectrometric)

8. Enzymatic Hydrolysis of Glycogen and Starch
9. Qualitative tests for Amino Acids;
10. Xanthoproteic acid Test, Millon's Test, Hopkins-Cole Test, Sakaguchi Test
11. Estimation of protein by Bradford and Lowery methods
12. Separation of Amino Acids using Paper Chromatography and Thin Layer Chromatography (TLC)
13. Qualitative tests for fats, Sterols and Phospholipids
14. Determination of Ascorbic acid in Lemon Juice.
15. Saponification Tests and Iodine Values of Fat
16. Use of online available Protein Databases to get protein and DNA sequence
17. Use of online software to visualize Secondary structure of Proteins.

Recommended Texts

1. Nelson, D. L. & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D. & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
3. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.

Suggested Readings

1. Murray, R. K., Grammer, D. K., Mayes, P. A., & Rodwell, V.W. (2000). *Harper's biochemistry*. (25th ed.). New York, USA: Appleton & Lange.
2. Stryer, L. (2010). *Biochemistry*. (7th ed.). New York, USA: Freeman & Co.
3. Ausubel, F. M. (2010). *Short protocols in molecular biology.* (5th ed.). New Jersey, USA: John Wiley & Sons.

SEMESTER-VII

CHEM-6108 Inorganic Chemistry – II 4(3+1)

Basic concept of dipole moments, intermolecular forces and effect of intermolecular forces on properties of solvent and solute will be discussed in detail in this course. The physical properties like dipole moment measure polarity of the molecules. The geometries and shapes of covalent compounds which possess single and double bonds are determined by Valence Shell Electron Repulsion Theory. The Valence Bond Theory in combination with hybridization approach makes it easy to closely know structures of proposed compounds. Further, the pi-acceptor ligands will be discussed in detail emphasizing the nature of bonding in coordination compounds and their chemical applications in industrial processes. Different organic reagents used in inorganic analysis will also be discussed and analysis will be performed in lab to estimate the inorganic species in different types of samples. Some inorganic compounds will also be prepared in the lab work to understand the basic preparation methods of compounds. After the successful completion of this course, students will be able to learn the properties and bonding in metal complexes as well as intermolecular forces.

Contents

1. Dipole Moments and Intermolecular Interactions: Introduction & measurements.
2. Implications of dipole moment in inorganic molecules and dipole-dipole forces.
3. Dipole-induced dipole forces, London (dispersion) forces & other intermolecular forces: hydrogen bonding.
4. VSEPR model followed by VB Theory: for determination of geometries of molecules and ions containing sigma bond as well as pi-bonds.
5. Band theory of metallic bonding Conductors, Insulators and Semiconductors.
6. pi – acceptor Ligands: Transition metal carbonyls (Mononuclear, Binuclear, Polynuclear).
7. The eighteen-electron rule as applied to metal carbonyls.
8. Evaluation of structures based on spectroscopic evidence and Chemistry of metal carbonyls.
9. Applications of metal carbonyls and their derivatives to catalysis and organic synthesis.
10. Organic Reagents used in Inorganic Analysis: Types of reagents, their specific nature and methods of applications with specific examples.
11. Complexometric titrations involving various reagents (EDTA etc).
12. Chelates and chelate effect: Role of organic reagents in different analytical techniques.
13. Gravimetric Estimations (Barium ions and Oxalate ions).
14. Redox titrations (Cu (II) by Potassium iodate, Fe (II) by Ceric sulphate).
15. Preparation of four inorganic compounds in pure state using different techniques of synthesis
    a. *tris* – Etylenediamine Ni(II) chloride dihydrate
    b. Pot. Trioxalatoaluminate (III)
    c. Ammonium Ni(II) sulphate
    d. Hexa aquochromium (III) chloride

Recommended Texts

1. Greenwood, N.N., & Earnshaw, A. (1984). *Chemistry of the elements.* (2nd ed.). U.K.: Elsevier.
2. Sharpe, A. G. (2012). *Inorganic chemistry*. (4th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Kotz, J. C., & Treichel, P. (2018). *Chemistry and chemical reactivity*. (10th ed.). New York: Saunders College Publishing.
2. Cotton, F.A., & Wilkinson, G. (2015). *Advanced inorganic chemistry*. (7th ed.). New York: John Wiley & Sons.

CHEM-6109 Organic Chemistry–II 4 (3+1)

This course (Organic Chemistry-II) focuses on the classification, methods of determination, kinetic and stereochemical aspects of reaction mechanisms of organic reactions. It includes addition (to >C=C<, –C≡C–, >C=O), substitution (nucleophilic & electrophilic) at sp^3&sp^2 hybridized C and elimination reactions. This course is a foundation course for Reaction Mechanism (CHEM-6223, Organic Chemistry major course of semester-VII), Organic Synthesis (CHEM-6240, Organic Chemistry major course of semester-VIII) and Advance Organic Synthesis (CHEM-7146) of MSc and MPhil with organic chemistry specialization. Synthetic organic chemists have the power to replicate some of the most intriguing molecules of living nature in the laboratory and apply their developed synthetic strategies and technologies to construct variations of them. Such molecules facilitate biology and medicine, as they often find uses as biological tools and drug candidates for clinical development. In addition, by employing sophisticated catalytic reactions and appropriately designed synthetic processes, they can synthesize not only the molecules of nature and their analogues, but also myriad other organic molecules for potential applications in many areas of science, technology and everyday life. The practical work involves single step synthesis of small molecules followed by workup, isolation and purification of product.

Contents

1. Introduction and classification of reaction mechanism on different basis. Benefits of thermodynamic and kinetic data towards reaction mechanism.
2. Kinetic *vs* thermodynamic control. Isotopic labeling and trapping of intermediates.
3. Selectivity (Regio-, Chemo- and Stereoselectivity) *vs* Stereospecificity.
4. Addition reactions involving C=C, C≡C and C=O, MOT of C=C and C=O additions.
5. *Syn vs anti* additions, factors affecting addition reactions. Conjugate (1,4-) *vs* direct (1,2-) additions.
6. Electrophilic and nucleophilic substitution reactions at aromatic sytems, Mechanisms involved (Arenium ion, S_E1, simultaneous attack & departure etc.).
7. Nucleophilic substitution reactions (S_N1, S_N2, S_Ni, S_N1', S_N2', S_Ni', S_N1cA, S_N2cA, neighboring group participation / anchimeric assistance etc.) at aliphatic C, Td mechanism.
8. Enol, enolate & enolization, acid/base catalyzed aldol condensations.
9. Alkylation, arylation and acylation of acitve methylene compounds.
10. Conditions, mechanism and synthetic applications of Claisen, Claisen–Schmidt, Knovenagel, Perkin, Reformatsky reactions, Stobbe's condensation, Darzen's glycidic ester synthesis, Mannich and Wittig reactions.
11. Classification of elimination reactions. *Syn* / *anti* and E_1cB eliminations.
12. E_1*vs* E_2, factors affecting eliminations.
13. Free radicals (generation, detection and reactions), application of free radical in industry, role of free radicals in nature and environment.

Organic Chemistry Lab.–I

Estimation of phenol (PhOH) & acetone (Me_2CO), amino (NH_2) groups, synthesis of azodyes, iodobenzene (PhI), iodoform ($CHCl_3$), sulphanilic acid, cinnamic acid, benzil & benzilic acid, ethyl benzene (PhEt).

Recommended Texts

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Pine, S. H. (1987). *Organic chemistry*. New York: McGraw-Hill.
3. Clayden, J., Greeves, N., and Warren, S. (2012). *Organic chemistry*. (2nd ed.). Oxford, London.

Suggested Readings

1. Hendrickson, J. B., Cram, D. J., and Hammond, G. S. (1980). *Organic chemistry.* New York: McGraw-Hill Book Co.
2. Streitwieser, A., Heathcock, C. and Kosower, E. M. (2017). *Introduction to organic chemistry*. (4th ed.). New York: Macmillan.
3. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6110 Physical Chemistry – II 4 (3+1)

Physical chemistry-II is designed to make the students capable of learning in 3 important fields (Quantum Chemistry, Statistical Thermodynamics & Electrochemistry) of Physical Chemistry. The objective includes to make the students understand the foundation of Quantum Chemistry along with derivation of Schrodinger Wave Equation, interpretation of wave function and its mathematical requirements and the application of knowledge to understand the structure of atom & molecules and a glance into sub-atomic phenomenon, properties and occurrences. The Boltzmann distribution law and partition function, partition function and thermodynamics functions like internal energy and entropy and Debye-Huckel Theory are important part of the syllabus to be covered. As course covers three main directions i.e. Quantum Chemistry, Statistical Thermodynamics & Electrochemistry so studying this course will make students capable of applying their knowledge to solve the issue related to the mentioned fields. Students will be able to understand this basic knowledge understand the properties of molecules and their reactions, energetics and probability of an electron to exist. Knowledge will be guiding torch about electrochemical processes and cells too.

Contents

1. Schrodinger's wave equation, postulates of quantum theory.
2. Operators, Eigen value, Eigen function, orthogonality and normalized wave functions.
3. Motion of particle in three-dimensional box and idea of degeneracy.
4. Mathematical treatment of rigid rotator and calculation of bond length of simple molecule
5. Stirling approximation. probability, statistical treatment of entropy. The Boltzman distribution law and partition function.
6. Partition function and thermodynamics functions like internal energy and entropy.
7. Translational, rotational, vibrational and electronic partition function and their comparison).
8. Concept of conductance of electrolytes. Debye–Huckle equation and limiting law.
9. Ionic strength, weak electrolytes and Debye–Huckle theory.
10. Activity and activity coefficients of electrolytic solutions.
11. Determination of activities. Concentration cells. Determination of e.m.f. of concentration cells with and without transference. Fuel cells and hydrocarbon fuel cells.

Physical Chemistry Lab – II

1. Determination of pK_a and K_a value of a weak acid.
2. Molecular mass determination of non-electrolyte solute by cryoscopic method.
3. Determination of number of associated molecule of Benzoic acid in Benzene and to determine the Distribution coefficient of Benzoic acid between H_2O and Benzene.
4. Determination of unknown concentrations of $KMnO_4$ and $K_2Cr_2O_7$ solution spectrophotometrically.
5. Determination of percentage purity of an optically active compound.

Recommended Texts

1. Atkins P.W. (2017). *Physical chemistry.* (11th Ed.) UK: ELBS Oxford University Press
2. Lehigh S.M. *Electrochemistry.* Volume 15. UK: Craig Banks Manchester

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.) Meerut Krishna Prakashan Media (P) Ltd.
2. Polkinghorne, J. (2002). *Quantum theory: a very short introduction.* UK: Oxford University Press.

SEMESTER-VII

a) Compulsory Papers (Total 05 credits)

CHEM-6111 Forensic Chemistry 2 (2+0)

This course provide a comprehensive knowledge about applications of forensic procedures in chemistry. Student will learn about types of evidences and methods to collect them. This course will also provide a detailed knowledge about toxicology and forensic biology. This course explains the principles of operation for common chemistry laboratory instrumentation used in forensic science, using knowledge of chemical structure and properties and instrument design. Furthermore, it will also allow to understand the role of law, ethics, courtroom testimony, quality assurance and professional practice in forensic science. The importance and evidential value of separation and identification techniques, and the scope and limitations of these techniques, is also emphasized in relation to the analysis of forensic samples. Upon successful completion of the course, students will be able to understand the fundamental principles utilized in forensic science and can demonstrate a knowledge of the applications of chemistry and criminal justice in forensic science.

Contents

1. History of Forensic science/forensic chemistry
2. Applications of forensic chemistry in relation to other sciences e.g. Botany, Zoology, Geology, Odontology, Pathology etc
3. Types and classification of evidence, Physical, chemical biological evidence, Classifications of forensic evidences
4. Fingerprint analysis, history, types, latent vs visible fingerprints
5. Chemical tests for latent and visible fingerprints
6. AFIS, fingerprint database.
7. Hair as a forensic physical evidence, composition and structure of hair, differences between human and animal hair and identification.
8. Fiber as a forensic evidence, composition, chemical composition of fiber, microscopic analysis, chemical tests for fiber analysis.
9. Glass as a forensic evidence, Physical and chemical properties of glass, chemical analysis
10. Trace evidences, Physical and chemical properties, qualitative and quantitative
11. Metal analysis
12. Microscopic analysis
13. Trace evidence types, characterization, chemical tests, collection, analysis, exhibiting in court. Analysis of paints, vehicles, fire, bullet and cartridge analysis,
14. Tests for explosive residues, glass comparisons. Anthropometry, body measurement.
15. Toxicology, History, relation with other sciences
16. Introduction to drugs, narcotics, toxins, laws related to poisons
17. Classification of poisons, organic, inorganic and mechanical poisons,
18. Corrosives, irritants, neurotics, and miscellaneous poisons
19. Mechanisms of poisons, methods of administration, routes of excretion. Diagnosis of poisons. Analytical chemistry techniques for drug and poison analysis, narcotics analysis.
20. Serology, forensic analysis of blood patterns, and chemical tests for identifications.
21. Forensic biology and DNA analysis; DNA CODIS databases, PCR, blotting, RE digestion, RFLP, STRs, VNTRs analysis, DNA Fingerprinting, paternity tests.
22. Example cases in forensic chemistry related to above-mentioned topics

Recommended Texts

1. Bell, S. (2012). *Forensic chemistry.* (2nd ed.). New York, USA: Prentice Hall.
2. Jackson, A. R. W. & Jackson, J. M. (2016). *Forensic science.* (4th ed.). New York, USA: Prentice Hall.

Suggested Readings

1. Khan, J. Kennedy, T.J. & Christian, D.R. Jr. (2012). *Basic principles of forensic chemistry*. New Jersey, USA: Humana Press.
2. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.

CHEM-6112 Industrial Chemistry 3(3+0)

Industry is backbone of the economy of any country and among different industries; chemical industries have versatile novelties in their operation. This course is aimed to provide understanding about upgradation of laboratory processes to commercial scale, installation of industrial units, quality assurance and quality control of a process. Parameters to determine feasibility for installation of an industrial unit, its impact on living organisms and vegetation are also contained in this course. Treatment of industrial effluents, sludge, and smoke are important segments of this course. Significance of research and development in an industry and its need in domestic industries is part of this course. Safety measures including fire extinguishing, saving from toxic chemicals and first-aids in an industry are also part of the course. Chemical reactions, raw materials, process conditions and scope of different industries listed in contents are part of the course. After studying this course, students will have sufficient knowledge about working in any industrial unit as well as one will be able to work at his own.

Contents

1. Chemical processes
2. Unit operations, unit process
3. Chemical process control and instrumentation
4. Safety; Hazards such as fire or toxic materials
5. Research and development
6. Important modern industries, their chemistry and technology
7. Pharmaceutical industry
8. Paper and pulp industries; kraft reaction
9. Oil, fats and waxes
10. Soap and detergent industries
11. Water conditioning
12. Flavors and food additives
13. Sugar and starch, steel
14. Cement industries

Recommended Texts

1. Shreve, R.N., & Brink, J.A. (1977). *Chemical process industries*. New York: McGraw Hill.
2. Witcoff, H.A., & Reuben, B.G. (2012). *Industrial organic chemicals*. (3rd ed.). New York: Wiley.

Suggested Readings

1. Smith, R. (2016). *Chemical process design. (*2nd ed.). New York: McGraw Hill.
Relevant research articles

b) Specialization (Total 11 credits)
i) Analytical Chemistry

CHEM-6114 Advanced Spectroscopy – I 4(3+1)

This course is aimed to provide an advanced knowledge about three spectroscopic techniques, which are widely used in different industries for analytical characterization of samples. Atomic absorption spectrometry is used for elemental analysis of different samples, while atomic emission spectroscopy is used for elemental analysis of hard materials like refractory and ceramics. Among both of these techniques, different atomizers are used to ensure the accurate determination of analyte at low concentrations. Flame emission spectroscopy uses flame as source of excitation and is used for identification of common salts, usually of alkali metals. UV/Visible spectrophotometry is used for analysis of molecular species and is rapid, economical preliminary technique. These techniques are widely used in different industrial units to analyze a wide range of products of daily use, ranging from soil, fertilizer, food, cosmetic and material objects. After learning this course, students will be able to work in any research or industrial laboratory with comprehensive background-knowledge based operational skill.

Contents

1. Atomic Spectrometry: Atomic Absorption and Flame Emission Spectrometry, instrumentation and applications
2. Emission Spectrometry with plasma and electrical discharge sources
3. UV/Visible Spectrophotometry: basic principle, instrumentation and applications.

Analytical Chemistry Lab. III
1. Measurement of λ_{max} and calculation of Molar absorptivity of potassium permanganate.
2. Plotting of calibration graph and measurement of unknown sample concentration.
3. Use of standard addition method in Spectrophotometry.
4. Determination of iron (II) using 1,10-phenanthroline method.
5. Determination of iron (III) using thiocyanate method involving solvent extraction.
6. Determination of phosphate by Spectrophotometry using molybdenum blue method.
7. Determination of Sodium in tap water sample by using Flame photometer.
8. Determination of Potassium in tap water sample by using Flame photometer.
9. Determination of Calcium in chalk sample by using Flame photometer.
10. Determination of Calcium in drinking water by EDTA.
11. Identification of free salicylic acid in aspirin by using TLC.
12. Determination of Methylene blue value of activated charcoal.
13. Determination of iron in tap water by AAS.
14. Determination of copper content in milk samples by AAS.

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). Analytical chemistry. (4th ed.). New York, John Wiley & Sons.

CHEM-6115 Advanced Chromatographic Techniques 3 (3+0)

This course is aimed to provide an advanced level information for students opting analytical chemistry as field of specialization. It provides comprehensive overview of two commonly used chromatographic techniques ranging from fundamental principles, instrumentation and applications for analysis of different types of samples. Gas chromatography is used for analysis of gaseous samples like petroleum products, air samples, dust, industrial smoke, and perfumeries. High performance liquid chromatography is used for analysis of liquid samples or solutions like foods, pharmaceuticals. Students will be able to learn optimization of different parameters affecting the quality of separation. Van-Deemter equation gives insight about all the factors contributing towards plate height and decrease efficiency of separation. By learning the course, students would be able to predict the material to be used as stationary phase, mobile phase, length and width of chromatographic column. This will be able to develop cost-effective methods saving time and cost of analysis, which is fundamental target of any industry.

Contents

1. Gas–Liquid chromatography
2. Concepts of theoretical plates
3. Van–deemter equation
4. High–performance liquid chromatography, instrumentation and applications of these techniques

Recommended Texts

3. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
4. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). Analytical chemistry. (4th ed.). New York, John Wiley & Sons.

CHEM-6116 Instrumental Methods of Analysis 3 (3+0)

This course is aimed to provide a comprehensive overview of different instrumental techniques of industrial significance. For rapid, economical and accurate analysis, electroanalytical techniques are the techniques of choice; amongst which potentiometry is an economical technique with comparable results. Ion-selective electrodes are used for determination of any specific ions in a sample without any interference of matrix. In this course, significance of different electrodes used in potentiometry, methods for development of new electrodes and their representative applications are included. Fluorescence and phosphorescence spectroscopic techniques are electromagnetic techniques used for analysis of atomic and molecular species, on the basis of luminescence characteristics of sample. Efficiency and applications of these luminescence techniques will be compared with UV/Visible spectroscopic techniques. Basic principles, instrumentation, recent advances, limitations, domains and scope of each of these techniques is contained in this course. After studying this course, students will be able to work on these instruments in any of the research or industrial laboratories.

Contents

1. Potentiometry: Nernst equation, reference electrodes, Ion-selective electrodes, Glass electrodes for pH measurements, Potentiometric titrations
2. Fluorescence and Phosphorescence spectrometry: Atomic and Molecular Fluorescence, basic principles and applications, Structural factors, measurements
3. Comparison of Luminescence and UV–Visible absorption methods.

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). Analytical chemistry. (4th ed.). New York, John Wiley & Sons.

ii) Biochemistry

CHEM-6117 Bioenergetics and Metabolism 4 (3+1)

This course aims at providing a better understanding of metabolic pathways, their control mechanisms and disorders. This course include both theory and practical modules that are offered to the students who have adapted Biochemistry as a major or minor subject. This course focuses on the metabolic pathways in living cells from prokaryotes to Eukaryotes, and how these pathways are regulated and disturbed in disease state, and how metabolic energy is obtained and transduced to meet a cell's requirements. This focus will allow calculations of bioenergy produced and assimilate in the metabolic pathways and will enhance the knowledge of students about how these pathways are integrated. Students will learn about enzymes involved in metabolic reactions and their reaction mechanisms, regulation of metabolic routes for energy production in form of ATP and diseases related to metabolic dysfunctions. Student will also be able to enhance their knowledge about metabolic diseases and their treatments.

Contents

1. Principles of Bioenergetics and Biochemical, Types of reaction involved in metabolism,
2. Carbohydrate Metabolism: Glycolysis; mechanism of reactions of enzymes.
3. Regulation of glycolysis. Reaction energy calculations.
4. Net ATP consumption.
5. Gluconeogenesis; dedicated reaction, regulations and net energy calculations.
6. Fermentation
7. Pentose Phosphate Pathway; relationship to glycolysis, gluconeogenesis
8. Metabolism of carbohydrates other than glucose; fructose, galactose, mannose starch and Glycogen.
9. The Citric Acid Cycle; regulations, reaction mechanism.
10. Fatty Acid Metabolism; Beta oxidation of even and odd chain fatty acids, Lipid Biosynthesis
11. Oxidative Phosphorylation, Electron transport chain and Photophosphorylation.
12. Protein Metabolism; amino Acid Oxidation and production of Urea,
13. Biosynthesis of Amino Acids
14. Nucleotide metabolism, Synthesis and degradation.
15. Integration and Hormonal Regulation of Mammalian Metabolism

Biochemistry Lab. II

1. Isolation of serum and plasma from human blood
2. Estimation of fasting/random glucose levels in human serum by colorimetric methods (DNS method, glucose peroxidase method).
3. Estimation of Hemoglobin in human blood.
4. Estimation of total protein serum/urine proteins by Colorimetric method.
5. Estimation of nitrogen content by microkjeldahl method.
6. Estimation of urea, creatinine triglycerides Glutathione, ammonia and cholesterol in human serum/urine.
7. Liver function tests using human serum/urine and chicken liver sample.
8. Determination of antioxidant and lipid profiles of human serum
9. Determination of vitamin contents i.e. Ascorbic acid in food samples

10. Estimation of Sodium (Na+), Potassium (K+) and Chloride (Cl-) from serum using flame photometer.
11. Estimation of heavy metals in human serum using atomic absorption.
12. Isolation and enzymatic hydrolysis of Glycogen from Liver
13. Sterilization and Preparation of culture media i.e use of autoclave
14. Steak, pour and spread plate methods sing a wire loop and spreader
15. Testing sensitivity to antimicrobial substances, Preparing serial dilutions of cultures
16. Use of microscope and differential staining: Gram's staining method
17. Online resources for metabolic pathways i.e. KEGG, MetaCyc

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
3. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.

Suggested Readings

1. Swaminathan, R. (2011). *Handbook of clinical biochemistry.* (2nd ed.). Singapore: World Scientific Publishing Company.
2. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.

CHEM-6118 Microbiology & Industrial Fermentations 3 (3+0)

This course is offered to the students who have adapted Biochemistry as a major subject and provides a comprehensive understanding of industrial applications of microorganisms in production and fermentation processes. This course also provides technical information on fermenter design, operation and growth kinetics of microbes involved in the fermentation processes. Types of fermentations and the commercial products derived from microbes are also discussed in this course. Students will get hands on experience in the microbial production of biopolymer, enzymes, bioactive compounds and biomass. Based on the skills acquired in this course, graduate students would have a mini project / review writing/ assignment as an additional component. Upon the completion of course, students will be able to have a better understanding of microorganisms, their classification, identification and characterization techniques. Students will also learn about industrial fermentation processes involved in production of Cheese, Alcohol, Citric acid, Acetic acid and Antibiotic synthesis. The students will also be able to discuss the role of microorganisms in industry, as well as to carry out experiments to produce microbial metabolites.

Contents

1. Definitions and Scope of Microbiology and fermentation.
2. Classification, methods of isolation, microscopic examination, general morphology and cytology of microorganisms.
3. General effects of environments on microorganisms.
4. Nutrition of microorganisms.
5. Growth (Normal growth Cycle and Continuous Culture) and Reproduction, Pure culture Study.
6. Introduction to industrial microbiology and chemical biology.
7. Industrial Uses of Bacteria, Molds ,Yeast and viruses.
8. Microbial production of Cheese, Alcohol, Citric acid, Acetic acid, Antibiotic, enzyme production, Fermented Foods, Vinegar production, Amino Acid.
9. Petroleum Microbiology and Deterioration of Materials.(Paper, Textile and Cordage, Painted Surface).
10. Microbial assays

Recommended Texts

1. Willey, J. Sherwood, L. & Woolverton, C. J. (2017). *Prescott's microbiology.* (10th ed.). New York, USA: Prescott Publishers.
2. Dawis, B. D., Dulbecco, R., Eisen, H. N., & Ginsbery, H. S. (2002). *Microbiology.* New York, USA: Harper & Row.

Suggested Readings

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

CHEM-6119 Enzymes and Nutrition 3 (3+0)

This course provides insight about the function, classification and characterization of enzymes in terms of kinetics and reaction mechanism. Studying the enzyme kinetics provide a better understanding of enzyme catalytic efficiency and inhibition. This course also provide structural and functional characteristics of macronutrients (carbohydrates, lipids, proteins) and micronutrients (vitamins) in food consumed by humans. Students will learn about the biochemical mechanisms associated with the digestion and assimilation of macronutrients, and are introduced to analytical techniques in food biochemistry. Enzymes involved in food metabolism will also be explained to the students. Upon the completion of this course, students will be able to have a better understanding of classification of food, metabolic rates, micro- and macro- nutrients and their deficiencies. Students will obtain the basic knowledges about the relationship between properties and structure of the enzymes, their mechanism of action and kinetics of enzymatic reactions. Students will obtain basic knowledges about the relationship between properties and structure of the enzymes, their mechanism of action and kinetics of enzymatic reactions.

Contents

1. Enzyme Structure and Functions: Chemical nature, nomenclature and classification of enzymes
2. Cofactors, effect of different factors on enzyme activity
3. Kinetics Studies of substrate reactions. (Michaelis- Menten Equation and Lineweaver-Burke Plot)
4. Quantitative assay of enzyme activity, substrate specificity
5. Enzyme substrate interactions and nature of the active site
6. Models of enzyme substrate complex
7. Mechanism of enzyme action with specific reference to Chymotrypsin and nuclease
8. Inhibition, Competitive, uncompetitive, non-competitive and irreversible inhibition
9. Regulatory enzymes: Allosteric enzymes, Multi-enzyme systems, Zymogens
10. Isoenzymes Non-Protein Bio-catalysis Ribosome's, (RNA as Enzyme)
11. Enzymatic control of metabolic pathways
12. Therapeutic uses of Enzyme and Immobilized enzymes.
13. Nutrition: Classification of Food, Source of Nutrients, Respiration
14. Caloric value of food, Calorimetry, Respiratory Quotient, Basal metabolic rate (BMR)
15. General Factor, chemical composition, functions
16. Deficiency symptoms and requirements of Nutrients and their biological values
17. Balanced diet, Role of nutrition in growth, development and Chronic disease.

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

Suggested Readings

1. Murray, R. K., Grammer, D. K., Mayes, P. A., & Rodwell, V.W. (2000). *Harper's biochemistry*. (25th ed.). New York, USA: Appleton & Lange.
2. Stryer, L. (2010). *Biochemistry*. (7th ed.). New York, USA: Freeman & Co.

iii) Inorganic Chemistry

CHEM-6121 Organometallic & Bio-inorganic Chemistry 3 (3+0)

Bioinorganic chemistry is a field that examines the role of metals in biology. Bioinorganic chemistry includes the study of both natural phenomena such as the behavior of metalloproteins as well as artificially introduced metals, including those that are non-essential, in medicine and toxicology. Interaction of various inorganic compounds with the biological species enables the scientist to design and formulate medicines for different diseases. Preparation of organometallic compounds by using different reaction conditions will also be discussed to lead a new era of research for preparation of stable metal complexes having metal-carbon bonding. Moreover, the role and interaction of different metal ions will also be discussed in living organisms. Further, the metal--carbon bonding unlike carbon-carbon bonding provides basis for catalysis. Starting from polymerization of ethylene by Zeigler and Natta leading to industrial revolution, the recent M-C bond chemistry has been studied in detail to materialize those reactions which otherwise are not possible. The fundamental rules like Eighteen-electron-rule explain the stability of organometallic compounds.

Contents

1. Nature of metal-carbon bonds
2. Compounds with metal-carbon single bonds
3. Compounds with metal-carbon π- bonds
4. Classification of organometallic compounds
5. Compounds of transition metals: single, double and triple bonds to carbon
6. Compound and types of acyls, alkylidene complexes
7. Compound of alkylidyne complexes
8. Delocalized hydrocarbon systems (alkene, olefins, allyl and butadienes)
9. Alkyne complexes and cyclic π complexes (four, five and six member rings)
10. Fundamental processes in reactions of organotransition metal complexes
11. Ligand coordination and dissociation
12. Oxidative addition
13. Reductive eliminations
14. Insertion & extrusion reactions: reaction of coordinated ligands
15. Applications of organometallic compounds in synthetic chemistry
16. Applications of organometallic compounds in industry.
17. Bio-inorganic chemistry: introduction
18. Bio-inorganic chemistry : Environmental intrusion
19. Role of inorganic species in vivo
20. main group ions (Na^+, K^+, Ca^{++}, Mg^{++})
21. Trace elements: general roles, lanthanides & actinides, Zn, Cu, Cr, Mo, W, Co, Si, Se, Sn, I.
22. Storage and transport of iron
23. Metalloenzymes

Recommended Texts

1. Huheey, J.E., Keiter, E.A., Keiter, R.L., & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.
2. Roat-Malone, R. M. (2007). *Bioinorganic chemistry: a short course*. New York: John Wiley & Sons.

Suggested Readings

1. Hill, A.F., & Hill, A. (2002). *Organotransition metal chemistry*. Cambridge, U.K.: Royal Society of Chemistry.
2. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin, Germany: Springer.

CHEM-6122 Inorganic Polymers & Chemical Forces 3 (3+0)

This course aims to understanding of general concept of polymerization, types of polymerization, inorganic polymers, their properties, stability and applications. Inorganic polymers are polymers with a skeletal structure that does not include carbon atoms in their backbone. Polymers containing inorganic and organic components are sometimes called hybrid polymers, and most so-called inorganic polymers are hybrid polymers. Most of the ceramic material in use in routine life has its origin from inorganic polymers. Blending of metal cluster compounds with carbonates, borates or phosphates gives rise to a wide range of tensile material equally applicable in ceramic appliances and other industrial reaction vessels. The material strength is governed more by a study of the forces responsible within substances for inter- and intra-molecular bonding. After the successful completion of this course, students will be able to synthesize the inorganic polymers of desired properties, elaborate the stability and structure of inorganic polymers and the factors affecting their properties.

Contents

1. Inorganic Polymers: Molecular species
2. Polymeric sulphur and nitrogen compounds
3. Borazines
4. Phosphazines
5. Types and applications of phosphazines
6. Boranes
7. Carboranes
8. Silicones
9. Classification of silicones
10. Polyionic species: Isopropyl ions
11. Heteropoly anions of transition elements
12. Polysilicates
13. Polyphosphates
14. Metal cluster compounds
15. Chemical Forces: Internuclear distances and atomic radii
16. Types of chemical forces
17. Effects of chemical forces on physical properties
18. Hydrogen bond
19. Bonding in Clathrates
20. Urea adducts
21. Effects of Chemical forces

Recommended Texts

1. Miessler, G.L. and Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York: Pearson Education, Inc.
2. Jordan, R.B. (1998). *Reaction mechanisms of inorganic and organometallic systems*. (2nd ed.). U.K.: Oxford University Press.
3. Sharpe, A.G. (2012). *Inorganic chemistry*. (4th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Huheey, J.E., Keiter, E.A., Keiter, R.L., & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.
2. Hill, A.F., & Hill, A. (2002). *Organotransition metal chemistry*. Cambridge, U.K.: Royal Society of Chemistry.
3. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin, Germany: Springer.

iv) Organic Chemistry

CHEM-6123 Reaction Mechanism 3 (3+0)

This course is the continuity of study of organic reaction mechanisms (CHEM-6209) in which rest of the polar mechanism (redox, molecular rearrangements and pericyclic cyclization) are addressed. The chemistry of reactive intermediates (carbenes, nitrenes, arynes) are also focused in this course. This course is a foundation course for Organic Synthesis (CHEM-6240, Organic Chemistry major course of semester-VIII) and Advance Organic Synthesis (CHEM-7146) of MSc and MPhil, respectively, with organic chemistry specialization. The reaction mechanism of a chemical reaction is a step-by-step description of the course on which the starting materials are converted into the products. The course is described on a molecular level and contains information about the position of all atoms and electrons of the reactants (including the solvent, etc.) at each point of the reaction course (called reaction coordinate) and, thus, about all the shiftings and movements of electrons and atoms. At the end of this course the student's shall be able to predict the mechanism of reaction and the synthetic methodologies of small organic molecules.

Contents

1. Oxidation state of organic compounds. Oxidation of C=C. Mild oxidation of 1º-ols → CHO, 2º-ols → ketone.
2. Harsh oxidation of alcohols, amines, nitriles.
3. Reduction involving metal/metal complexes (Wilkinson's *vs* Crabtree catalysts), hydride ($NaBH_4$, $LiAlH_4$, DIBAlH, Red-Al and their derivatives) reductions and reductions involving single electron transfer (SET).
4. Classification of molecular rearrangements.
5. Mechanism of intramolecular 1,2–shifts involving migration of a group from C to C, C to N, N to C, C to O and O to C.
6. Mechanism and examples of Wagner–Meerwein, Pinacol–Pinacolone, Benzidine–Benzillic acid, Favorski, Wolf, Beckmann, Hofmann, Curtius, Lossen, Schmidt, Steven, Baeyer–Villiger, Dakin and Fries rearrangements.
7. Introduction and classification, Hoffman, Fukii, Mobius–Huckle approaches of electrocyclization and cycloadditions involving 4n/4n+2 π electrons
8. Diels-Alder, Alder-ene and 1,3-dipolar additions
9. Sigma tropic reactions, Ireland-Claisen rearrangement.
10. Structure, methods of generation, detection, reactions and synthetic applications of carbenes, nitrenes and arynes.

Recommended Texts

1. Smith M. B. and March, J. (2019). *March's advanced organic chemistry*. (8th ed.). John Wiley, NY.

2. Morrison, R. T. and Boyd, R. N. (1987). *Organic chemistry*, Allyn & Bacon, Boston.

3. Clayden, J., Greeves, N., and Warren, S. (2012). *Organic chemistry*. (2nd ed.). Oxford, London.

Suggested Readings

1. Streitwieser, A., Heathcock, C. and Kosower, E. M. (2017). *Introduction to organic chemistry*. (8th ed.). New York: Macmillan.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.
3. House, H. O. (1972). *Modern synthetic reactions*. California: Benjamin.

CHEM-6124 Spectroscopic Methods in Organic Chemistry 4 (3+1)

This course (Spectroscopic Methods in Organic Chemistry) focuses on the physical methods of characterization of isolated natural products (animal, fungal, marine and terrestrial sources), derivatives of natural products, bio/synthetic polymers and synthetic organic molecules of pharmacological importance. The new molecular entities isolated/synthesized are studied by these methods, which require only 5-10 mg quantity of the analyte as compare to chemical methods of analyses, to elucidate their molecular structure. This course does not cover the medical aspects of spectroscopy (commonly called Radiology) in broader spectrum. In fact, this course is a foundation course for Advance NMR (CHEM-7140) and advance MS (CHEM-7147) courses of MPhil with organic chemistry specialization.
The practical work involves the synthesis of a few small molecules in the laboratory by a reported protocol followed by workup, purification (involving crystallization, partitioning, solvent extraction, chromatography etc.) and comparative study of IR, UV, NMR and MS spectra of substrate and product(s).

Contents

1. Basic principle & EMR, spectral regions (bands), allowed and forbidden transitions, spectrum.
2. Application of Schrödinger wave equation to rotational and vibrational transitions.
3. Basic principle, instrumentation and interpretation of IR spectroscopy. Classification of IR band on the basis of functional groups, applications of IR spectroscopy.
4. Mathematical relationship between absorbance (A) and transmittance (T) in UV-Vis spectroscopy. Bathochromic and hypsochromic shifts, factors affecting λ_{max}.
5. Woodward-Fieser rule for calculating λ_{max} of conjugated dienes, carbonyls and acyclic systems. Absorption by aromatic compounds. Applications of UV-Visible spectroscopy
6. Difference between spectroscopy and spectrometry, radical cations, radical anions and cabonium ion.
7. Parts of a mass spectrometer (MS); basic principle, instrumentation, different methods of ionization in MS (EI, APCI, FAB(+), FAB(-), ESI, MALDI).
8. Modes of fragmentation of various functional groups of organic molecules, Low resolution and high-resolution mass spectrometry, radioactive abundance and ratio of isotopes of C, Cl, Br, S & P.
9. Determination of molecular mass, molecular formula and molecular structure, Interpretation of a mass spectrum.
10. NMR active nuclei, basic principle (Spin flipping, Spin relaxation)
11. Chemical shift (δ in ppm), factors affecting it
12. Coupling constant *(J* in Hz), factors affecting it
13. Spin-spin splitting, multiplicity (*s, d, t, q, dd, ddd, dddd*) of ^{1}H signals. Interpretation of ^{1}H-NMR spectra.
14. Structure elucidation of organic compounds by joint applications of IR, UV, ^{1}H-NMR spectroscopy and Mass spectrometry.

Spectroscopic Methods in Organic Chemistry Lab.

1. Experimental techniques e.g. distillation, solvent extraction, chromatography etc.
2. Multi-step synthesis of some organic compounds
3. Estimation of glucose and number of acetyl groups

Recommended Texts

1. Williams, D. and Fleming, I. (1995). *Spectroscopic methods in organic chemistry*. New York: McGraw-Hill.
2. Younas, M. (2005). *Organic spectroscopy*. Lahore: A. H. Publisher.

Suggested Readings

1. Anderson, R. J., Bendell, D. and Groundwater, P. (2004). *Organic spectroscopic analysis – a tutorial chemistry texts (serial-22)*. Cambridge: RSC Publisher.
2. Kemp, W. (1990). *Spectroscopy*. London: Macmillan.
3. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6125 Organometallics 3 (3+0)

The Inorganic Chemistry-I (CHEM-6103/6203) of BS/MSc curricula is the foundation course for having a keen understanding of this course. The organometallic chemistry is the study of organometallic compounds, chemical compounds containing at least one chemical bond between a carbon atom of an organic molecule and a metal, including alkaline / alkaline earth / transition metals and sometimes broadened to include metalloids like boron, silicon and tin as well. Some related compounds such as transition metal hydrides and metal phosphine complexes are often included in discussions of organometallic compounds but they are not necessarily organometallic
This course shall highlight the important transformations of organoboranes, ylides (organophosphorous & organosulphur only) in addition to organotransition-metal (Li^{+}, Mg^{2+}, Cu^{+}, Zn^{0}, Zr^{0}, Sn^{4+}, Pd^{0}, Pd^{2+}, Ru^{3+} etc.) species with an emphasis on their synthesis, basic mechanism of action/catalysis, structure-reactivity relationships and applications in organic synthesis. This course shall serve as foundation course for core understanding of a postgraduate course (Organometallic Chemistry, CHEM-7149).

Contents

1. Historical perspective of organometallics
2. The eighteen-electron rule, classification of organometallics
3. Compounds with M–C & M=C
4. Ligand coordination & dissociation, oxidative addition and reductive elimination
5. Transmetallation recations
6. Carbonylation reactions
7. Insertion and extrusion reactions
8. Preparation and applications of s-block organometallics; organoLi, organoMg (Grignard's reagent)
9. Preparation of organoCu, orgnaoZn and organoPd in synthetic organic chemistry with special focus on stereochemical outcome.
10. Applications of organoCu, orgnaoZn and organoPd.
11. Brief introduction to organoSn, organoB, organoSi, organoS and organoP chemistry.

Recommended Texts

1. Huheey, J. E., Keiter, E. A. and Keiter, R. L. (2016). *Inorganic chemistry: principles of structure and reactivity*. (4th ed.). New York: Harper and Row.
2. Hill, A. F. (2012). *Organotransition metal chemistry*. New York: Wiley-Interscience.
3. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin: Springer-Verlag.

Suggested Readings

1. Spessard, G. O. and Miessler, G. L. (1997). *Organometallic chemistry*. Prentice Hall PTR.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

v) Physical Chemistry

CHEM-6126 Surface Phenomena 4(3+1)

This course is about the colloids and surfactants. In this course, main focus is on surface tension, adsorption isotherms, Freundlich, Langmuir and BET isotherms, surfactants, micellization, methods of preparation of gels and emulsions, precipitation in gels, Liesegang rings, emulsifiers and breaking of emulsions. Moreover, orientation theory, sols and their preparation, properties of sols, optical properties of sols, determination of particle size, kinetic properties of sols, sedimentations of suspensions, electrical properties of sols electrophoresis and electroosmosis and stability of suspensions, molecular wt. determination of macromolecules are also part of this course. Course is designed in a way that student may be able to prepare colloids (sols, emulsions and gels) by different physical and chemical methods and use them in research and application fields. Knowledge about different adsorption isotherms and the factors affecting adsorption process gives detailed understanding of sorption mechanism which leads their command to prepare efficient sorbents to remove pollutants and contaminations and to purify water etc.

Contents

1. Surface tension, adsorption isotherms, Freundlich, Langmuir and BET isotherms
2. Adsorption at liquid surface
3. Surfactants, micellization
4. Methods of preparation of gels and emulsions, Classification structure of gels. Thixotropy
5. Precipitation in gels. Liesegang rings. Emulsifiers, Breaking of emulsions
6. Orientation theory. Emulsification and wetting, Significance
7. Sols and their preparation, properties of sols, optical properties of sols
8. Determination of particle size.
9. Sedimentations of suspensions,
10. Electrical properties of sols electrophoresis and electro osmosis
11. Stability of suspensions. Precipitation of sols
12. Molecular wt. determination of macromolecules
13. The cause of semi-permeability
14. Mechanism of osmotic pressure.
15. Determination of the molecular weight by osmometry

Surface Phenomena Lab

1. Determination of heat of solution of a substance by solubility method.
2. Determination of empirical formula of Ferric-salicylic acid complex calorimetrically.
3. Determination of order of reaction and the rate constant of a given reaction.
4. Verification of Freundlich isotherm for organic acids.
5. To prepare As_2S_3 sol.
6. Determination of activity coefficients by measuring electromotive force.
7. Determination of Molar extinction coefficient.

Recommended Texts

1. Kontogeorgis, G. M. & Kiil, S. (2016). *Introduction to applied colloid and surface chemistry.* John Wiley & Sons Inc.
2. Thomas, J. M. & Thomas, W. J. (2015). *Principles and practice of heterogeneous catalysis.* Germany: Wiley-VCH Verlag GmbH.

Suggested Readings

1. Somorjai, G. A., Yimin, L. (2010). *Introduction to surface chemistry and catalysis.* John Wiley & Sons Inc.
2. Cosgrove, T. (2010). *Colloid science: principles, methods and application.* John Wiley & Sons Inc.
3. Pashley, R., Karaman, M. (2004). *Applied colloid and surface chemistry.* John Wiley & Sons Inc.

CHEM-6127 Molecular Spectroscopy 3 (3+0)

The objective of this course is to comprehend the basics of spectroscopic techniques in a precise and compact way and to understand its foundation based on equations of quantum mechanics. Course focuses on classification of spectroscopy, rotational spectra of rigid linear molecules, harmonic and inharmonic oscillator models for the energy of a diatomic molecule, types of vibrational modes, interpretation of IR spectra of simple molecules. Moroever, a comprehensive and detailed knowledge about fermi resonance, applications and sampling techniques, H–atom spectrum, energies of atomic orbital, electronic angular momentum and the fine structure, Raman & Rayleigh scattering and vibrational Raman spectrum and nuclear magnetic resonance spectroscopy will be discussed in detail. The student will learn about updated skills of analysis at laboratory as well as at industry. Analysis by different techniques and the deep insight of interaction of electromagnetic radiation with matter reveals the phenomena occurring and the interpretation of meaningful signals to conclude quantitative and qualitative analyses is a part of this course. After studying this course students will be able to analyze samples through different spectroscopic techniques and they will be able to understand the way to interpret the meaning of signals for qualitative and quantitative analysis.

Contents

1. Classification of spectroscopy.
2. Rotational spectra of rigid linear molecules
3. Determination of bond lengths
4. The stark-effect
5. Harmonic and inharmonic oscillator models for the energy of a diatomic molecule
6. Types of vibrational modes
7. Interpretation of IR spectra of simple molecules
8. Fermi resonance, applications and sampling techniques
9. Types of electronic transition
10. H–atom spectrum, energies of atomic orbital
11. Electronic angular momentum and the fine structure
12. Idea of Raman scattering
13. Rayleigh scattering and molecular polarizability
14. Rotational Raman spectra of linear molecules
15. Symmetric top molecules and spherical top molecules
16. Vibrational Raman spectra
17. Nuclear magnetic resonance spectroscopy

Recommended Texts

1. Castellan G. W. (2004). *Physical chemistry* (3rd ed.). Dehli, India: Norasa Publishing House.
2. Banwell, C. N. & McCash, E. M. (1994). *Fundamentals of molecular spectroscopy*. (2nd ed.). UK: The Bath Press Avon.

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd ed.). Meerut Krishna Prakashan Media (P) Ltd.
2. Related Research Papers

CHEM-6128 Statistical and Quantum Mechanics 3(3+0)

This course is designed for the students opting Physical Chemistry as a part of their field of specialization to teach the students the detailed objectives, theory, mathematical calculations of Statistical and Quantum mechanics. It enables the students to apply the concepts of Quantum chemistry on very simple and some of the complex molecules. Quantum chemistry is a very powerful tool for studying the properties of molecules and phenomena involved during the reactions taking place between the molecules. The recent years, development in quantum chemistry methods, especially in theoretical methods has made it possible for quantum chemistry calculations to reach accuracies comparable to those obtained in experiments for molecules of moderate sizes. This is further facilitated by the rapid development of computer technologies that has greatly encouraged the chemists to use quantum chemistry to understand, simulate model, and predict molecular properties and their reactions, properties of nanometer materials and processes taking place in biological systems. While doing so the statistical mechanics plays the role of a bridge between the two concepts.

Contents

1. Statistical ensembles
2. Probability
3. Description of various systems
4. Concept of states
5. Accessible states and distribution
6. Maxwell's Boltzmann's statistics (MBS) of the systems of independent particles
7. Applications of partition functions of two chemical equilibrium and chemical kinetics
8. Bose-Einstein statistics (BES)
9. Fermi-Dirac statistics (FDS)
10. Operators and their properties, angular momentum
11. Central field problem, Hydrogen like atoms
12. Approximate methods
13. Perturbation method and variation principle
14. Valence bond theory (VBT)
15. Molecular Orbital theory (MOT)

Recommended Texts

1. Bogolubov, N. N. & Bogolubov, N. N. Jr. (2009). *Introduction to quantum statistical mechanics*. (2nd ed.). Russia.
2. Atkins P.W. & Friedman, R. S. (2010). *Molecular quantum mechanics.* UK*:* Oxford University Press.

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.) Meerut Krishna Prakashan Media (P) Ltd.
2. Atkins P.W. (2017). *Physical chemistry.* (11th Ed.) *ELBS Oxford University Press*
3. William C. Schieve, W. C. (2009). *Quantum satistical mechanics*. UK: Cambridge University Press.
4. Polkinghorne, J. (2002). *Quantum theory: a very short introduction.* UK: Oxford University Press**.**

SEMESTER-VIII

a) Compulsory Courses

CHEM-6129 Environmental Chemistry 3 (3+0)

This course is aimed to familiarize the students about components of environment, their origin, composition, chemical reactions, fate, and sink. Distribution of water, chemistry of surface, fresh, marine and underground water is part of hydrosphere. Lithosphere deals with the ores, mines, and minerals contained in soil; their determination and extraction are part of this course. Types of soil, chemical composition and reactivity of soil components is also included in this course. Composition of Origin and sources of different pollutants, their reactivity and toxicity in environment, measures to control them are also included in the course. Role of different pollutants in causing acid rain and its impact on quality of life is also part of the course. Source of gases imparting greenhouse effect, its significance, impact on vegetation and environment and artificial greenhouse are part of the course. After studying the course, students will be able to work with any environmental protection organization or sanitation agency. Different techniques for characterization of environmental samples are also included. The acquired knowledge will be helpful for skill development and career building of students, especially in environmental sciences.

Contents

1. The Human Environment
2. The litho, bio and hydrosphere
3. The nature and composition of natural waters
4. Water pollution
5. Chemistry of soil
6. Composition of the atmosphere
7. Oxides of carbon, sulphur and nitrogen in air pollution
8. Atmospheric Monitoring
9. Instrumental methods of environmental chemistry
10. Ozone demolition
11. Acid rain
12. Green House Effect

Recommended Texts

1. Manahan, S.E. (2017). Environmental Chemistry. (7th ed.). New York: CRC press.
2. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th ed.). New York: Marcel Dekker.
3. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th ed.) New York: W.H. Freeman and Company.
4. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th ed.). New York, John Wiley & Sons.

Suggested Readings

5. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th Ed.) Philadelphia: Saunders College Publishing.

b) Specialization

i) Analytical Chemistry

CHEM-6130 Advanced Spectroscopy –II 4 (3+1)

This course gives comprehensive overview about principle, instrumentation and applications of two important spectroscopic techniques. Mass spectrometry is used for determination of elemental composition of samples as well as for molecular analysis, determination of exact molecular mass of a compound using isotopic masses and is ultimate technique for structure elucidation of a compound. Components and operational skills of high-resolution mass spectrometers providing very accurate information are also part of this course. Spectroscopic techniques based on X-rays include X-ray diffraction, X-ray fluorescence, X-ray absorption, X-ray emission and X-ray crystallography; each of these have their typical applications with different detection devices. X-rays find wide application in medical diagnostics, internal structure of large molecules, security check of packed baggage. X-ray crystallography is used for 3-D structure determination of single crystals. X-ray fluorescence spectrometers are used in cement industry. After studying this course, students will be able to work on these instruments in any research or industrial laboratory, independently.

Contents

1. Mass Spectroscopy: Principle of Mass spectroscopy, Instrumentation in details
2. Quantitative and Qualitative application in analytical chemistry
3. X-rays Spectroscopy: Nature and production of X-rays
4. X-rays absorption, X-rays emission, Instrumentation
5. X-rays fluorescence analysis, Diffraction studies single crystal analysis

Analytical Chemistry Lab

1. Verification of deviations from Beer-Lambert's law.
2. Determination of chloride content in drinking water samples by mercury(II) thiocyanate spectrophotometric method.
3. Determination of copper in various food samples by diethyldithiocarbamate spectrophotometric method.
4. Determination of aspirin in pharmaceutical preparation and caffeine in tea and coffee by U.V Visible Spectrophotometry involving extraction.
5. Analysis of analgesic by HPLC.
6. Quantitative and qualitative analysis of different fruit juices for vitamin C by HPLC.
7. Estimation of Sodium and Potassium in biological fluids by flame photometry.
8. Determination of calcium in milk samples by flame photometry.
9. Determination of Magnesium in tap water, food, leaves etc by AAS.
10. Determination of manganese content in tea leaves by AAS.
11. Determination of sulphate and phosphate in commercial samples by complexometric titrations using EDTA.
12. Determination of iron in pharmaceutical samples by redox titration.
13. Determination of Sodium bicarbonate contents in baking Soda powder by conductometric titration with HCl.

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.

2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). Analytical chemistry. (4th ed.). New York, John Wiley & Sons.

CHEM-6131 FTIR, Raman Spectroscopy, ESR and Surface Analysis 3 (3+0)

This course is aimed to provide a comprehensive overview about four spectroscopic techniques, based on different modes of analysis; mentioned in title. Basic principle, detailed instrumentation, applications, limitations, scope and domain of each of these techniques is part of this course. Infrared spectroscopy gives fast, economical, and reliable information about identification of functional groups of sample components. Raman spectroscopy is based on principle of light scattering and is complement to infrared spectroscopy and can analyze those samples, which could not be analyzed by infrared spectroscopy. Electron spin resonance spectroscopy is based on spinning of nuclei and gives very authentic information about presence of certain compounds in sample. Surface analysis finds wide scope in corrosion resistance, paints, thin films, pharmaceutical coatings and medicines. Auger electron spectroscopy, photoelectron spectroscopy and electron spectroscopy for chemical analysis are the techniques of choice for the characterization of surface of any material. These techniques are widely used in different industries including food, pharmaceutical and fabrics industries. Students after having these instrumental skills will be well versed in handling these machines either in their future research activities or professional career spheres.

Contents

1. Origin of Molecular spectra
2. Origin of infrared and Raman spectra
3. Normal coordinate and normal vibrations
4. Symmetry of normal vibration and selection rules
5. Selection rule for infrared and Raman spectra
6. Metal isotope spectroscopy
7. Vibrational spectra in gaseous phase and inert gas matrices
8. Comparison of Raman with Infrared spectroscopy
9. Quantitative/Qualitative analysis, Instrumental detail and their use as analytical tool
10. Electron spin resonance spectroscopy: Instrumentation, Samples and sample holder
11. ESR spectra and Hyperfine interaction
12. Applications, Spin labels and spin traps
13. Surface Analysis: Introduction, Electron spectroscopy techniques
14. X-Rays photoelectron spectroscopy, Instrumentation for XPS
15. Sample introduction and handling for surface analysis
16. Analytical applications of XPS

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). Analytical chemistry. (4th ed.). New York, John Wiley & Sons.

CHEM-6132 Instrumental Methods of Analysis-II 3 (3+0)

This course is aimed to provide an overview about an important spectroscopic technique, i.e. nuclear magnetic resonance spectroscopy and number of techniques based on thermal methods of anlaysis. Nuclear magnetic resonance spectroscopy is and electromagnetic technique, based on spinning of nuclei and is recognized as an ultimate technique for structure elucidation of compounds with different spatial arrangement of atoms in a molecule. Nuclear reactions linked with radioactive decay gives an important in-depth information about nuclear characteristic of sample; used for identification of sample molecules. Nuclear reactors, accelerators and sources of neutron generation are also contained in this course. Thermogravimetry, differential thermal analysis, differential scanning calorimetry are the techniques based on thermal modes of analysis. These techniques give information about stability of molecules, pyrolysis reactions, kinetics, thermodynamics, and decomposition rates of polymers, medicines and food materials. Energetics of molecule as function of termperature are also included in this course. Students studying this course will be able to work in any hi-tech laboratory at their own with good background troubleshooting skills.

Contents

1. Nuclear Magnetic Resonance
2. Nuclear emission Alpha particles, Beta particles, Gamma – rays
3. Neutron activation analysis
4. Nuclear reactors; materials and working
5. Nuclear reactions
6. Radiochemical decay and activity
7. Necessary instrumentation including sources, accelerators and detectors
8. Thermal method of Analysis
9. Thermogravimetric analysis (TGA), Differential thermal analysis (DTA) and differential scanning Calorimetry (DSC)
10. Thermogravimetric curves and interpretation of thermograms
11. Pyrolysis and thermometric titration, type of measurements and applications of these techniques

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical chemistry.* (4th ed.). New York, John Wiley & Sons.

ii) Biochemistry

CHEM-6133 Chemotherapy and Immunology 3 (3+0)

This course provides insights about classification, characterization and diagnosis of various types of cancers and its therapies in respect to theoretical knowledge of the disease process. It will examine the concepts of epidemiology, aetiology and pathology of cancer along with contemporary and emerging treatment modalities and their effects. The course serves as an ideal primer for students who seek an entry point to the domain of cellular transformation, carcinogenesis and immune surveillance. This course will also examine cancer vaccine development (dendritic, genetic, anti-idiotypic, use of adjuvants) as well as the use of vaccination to counter microbial causes of cancer. Students will learn about chemical structures, mechanism of action and mechanism of drug resistance of various classes of antibacterial, antifungal, antiviral, antipyretic, analgesic and antimalarial drugs. The course will also provide basic concepts about immune system, its functioning, principles of Innate, adaptive, cell-mediated and humoral immunity.

Contents

1. Cancer: Reasons, Types and definition of various terms
2. Metastasis, Benign and malignant tumors, Oncogenes, Proto-oncogenes, hyperplasia
3. Chemotherapy: Definition, different treatment strategies
4. Problems associated with chemotherapy, mechanism of drug resistance
5. Chemotherapeutic Agents: Chemical structure
6. Mechanism of action and mechanism of drug resistance of various classes
7. Antitumor-antibiotics, Antimetabolites, Alkylating agents, Microtubule Inhibitors
8. Steroids and their Antagonists, Aromatase inhibitors
9. Monoclonal antibodies, Platinum based drugs, Irinotecan and topotecan
10. Etoposide, L-Asparaginase, Interferons and Imatinib.
11. Chemical structures, mechanism of action and mechanism of drug resistance of various classes of antibacterial, antifungal, antiviral, antipyretic, analgesic and antimalarial drugs.
12. Immunology: Fluid systems of the body, Blood groups (A, B, O and Rh system)
13. Components of Immune system, Definitions and Principles of Innate, adaptive, cell-mediated and humoral immunity, and the complement system.
14. Antibodies: Classes, biochemical structures, characteristics and functions.
15. Mechanism of allergy, hypersensitivity, acquired immunity, Immunodeficiencies and antigen-antibody reaction.

Recommended Texts

1. Sharma, A. K. (2019). *Immunology: an introductory textbook*. Singapore: Jenny Stanford Publishing.
2. Gadebusch, H. (2019). *Chemotherapy of infectious Disease.* (1st ed.). Florida, USA CRC Press.

Suggested Readings

1. Kuby, (2002). *Immunology.* (5th ed.). New York, USA: Macmillan Publishing Co.
2. Dawis, B. D., Dulbecco, R., Eisen, H. N., & Ginsbery, H.S. (2002). *Microbiology.* New York, USA: Harper & Row.

CHEM-6134 Molecular Biology & Physical Techniques 4 (3+1)

This course provides a deep understanding of molecular biology central phenomenon including DNA replication, transcription and translation with respect to their functionality at the molecular leve and including the flow of information from genes to proteins, and regulation of cellular processes, signaling and proliferation in eukaryotic cells. This course is designed as a theory and practical course and introduces some of the major ideas and experimental approaches in molecular biology using biophysical methods and techniques. Student will learn basic concepts about physical techniques that are involved in characterization of biomolecules in the theory portion, while same techniques will also be performed in the lab. Students will also learn to understand and apply general concepts of cell and molecular biology to relevant, specific problems and will be able to describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function.

Contents

1. Molecular dogma; DNA as a genetic material
2. DNA replication in prokaryotes and Eukaryotes
3. Type of DNA polymerases and functions
4. DNA damage; types of mutations. DNA repair; NER, MMR, homologous DNA repair.
5. Virus DNA/RNA replication and its protein regulation
6. Transcription in prokaryotes and Eukaryotes
7. Differences and types of DNA polymerases, operons
8. Splicing; introns, exons and ribozymes. Gene regulation
9. Translation; protein synthesis, regulation
10. Metabolism of RNA and DNA nucleosides
11. Structure of Chromatin and its functions.
12. Protein expression, purification and characterization using different biophysical methods
13. UV/Vis Spectrophotometry, FT-IR, Circular Dichroism (CD)
14. Surface Plasmon Resonance (SPR)
15. Gel electrophoresis (SDS-PAGE, agarose gel electrophoresis and capillary electrophoresis)
16. Ultra-, analytical and gradient centrifugation
17. Cryo-electron microscopy, protein NMR, X-ray crystallography/Diffraction.
18. DNA amplification by PCR and real time PCR.
19. Applications of DNA sequencing
20. Mass spectrometry and isotopes in molecular biology.

Biochemistry Lab III

1. Methods for the isolation of proteins from plant and animal samples i.e. liver/plasma protein, Salivary and Barley amylase using various cell disruption methods.
2. Protein precipitation by NH_4SO_4 method, using acid and organic solvent methods.
3. Protein dialysis and ultrafiltration methods.
4. Estimation of proteins using UV, Braford and Lowry's methods.
5. Characterization of proteins i.e. Amylase activity by enzyme assays, plasma proteins by characterization by SDS PAGE and Western blotting, analysis of a Protein from Egg White
6. Chromatographic separation/purification of proteins
7. Characterization of protein secondary structure using UV, FT-IR and circular dichroism spectroscopy.

8. Estimation and Isolation of total DNA/RNA from plant/animal tissues/cells
9. Preparation of genomic/plasmid DNA from bacteria.
10. Phenol/chloroform extraction of DNA. Mini- and Maxi- preparation of DNA
11. Isolation of RNA from mammalian cells
12. Characterization of DNA by Agarose Gel Electrophoresis and Southern blotting
13. Primer design and amplification of target DNA by PCR
14. Restriction enzyme digestion
15. Preparation of competent cells and gene cloning
16. Preparation of sequencing gels and DNA sequencing
17. PCR primer designing by online resources
18. Characterization of proteins using online tools.

Recommended Texts

1. Nelson, D. L. & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
3. Boyer, R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.

Suggested Readings

1. Swaminathan, R. (2011). *Handbook of clinical biochemistry.* (2nd ed.). Singapore: World Scientific Publishing Company.
2. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.
3. Lodish, H., Berk, A. Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Martin A. A. (2016). *Molecular cell biology*. (8th ed.). New York USA: W. H. Freeman.

CHEM-6135 Endocrine System 3 (3+0)

This course provide details for functions and control of signaling pathway using the hormone that are chemical substance secreted by a ductless gland into blood that is transported to a distant target organ. This course also covers the endocrine system from the standpoints of anatomic and histologic structure, hormones including their structures, functions, mechanisms of action receptors, and their metabolism in addition to the endocrinologic disorders including hyperactivity or hypoactivity, immune-mediated diseases, benign and malignant tumours and pharmacological properties of hormones and drugs used in the treatment of endocrine diseases. Hormones specifically control the certain pathways in the cell by binding to their specific receptors. This course also overview various diseases related to endocrine dysfunctions. Upon the successful completion of course, students will be able to identify the location, blood supply, innervation and anatomical relations of the endocrine glands and will have better understanding of the development and histological features of the endocrine glands.

Contents

1. Introduction, Chemical nature of Hormones
2. Common characteristics of hormones
3. Mode of action of Hormones, Chemistry and mechanism
4. Hormonal receptors
5. Metabolism and biological functions of Pituitary, Adrenal, Thyroid, Parathyroid, Pancreatic and gonadal hormones.
6. Biochemistry and body fluids
7. Composition and function of Blood, blood plasma
8. Blood proteins, Red blood cells, Hemoglobin
9. White blood cells, Platelets
10. Blood coagulation, Blood pressure
11. Antibodies, Antigens and blood groups
12. Composition of Urine
13. Extra- cellular fluid like cerebrospinal fluid, Lymph sweats tears
14. Synovial fluid and interstitial fluid.

Recommended Texts

1. Guyton, A. C., & Hall, J. E. (2010). *Text book of medical physiology.* (12th ed.). Philadelphia, Pennsylvania, USA: W. B. Saunders Company.
2. Bolander, F. F. (2012). *Molecular endocrinology.* (5th ed.). Cambridge, USA: Academic Press.

Suggested Readings

1. Jameson, J. L., Kasper, D. L., Fauci, A. S., Braunwald, E. Longo, D. L. & Hauser, S. L. (2006). *Harrison's endocrinology.* New York, USA: McGraw Hill.
2. Gardner, D. & Shoback, D. (2007). *Greenspan's basic & clinical endocrinology.* (8th ed.). New York, USA: McGraw Hill Medical.

iii) Inorganic Chemistry

CHEM-6136 Homogeneous catalysis by transition metal complexes 4 (3+1)

This course aims to the understanding of homogeneous catalysis by transition metal complexes of different ligands to synthesize different compounds having useful applications. Catalysis is responsible to economize processes and revolutionize the industrial era. Beginning with the polymerization of ethylene to produce polythene, an important commercial product of daily use in life at room temperature and normal atmospheric pressure, to the state-of-the art production of silicon from sand for solar technology, all are the fruitful outcomes of catalysis. Transition metals play a pivotal role in bringing about all the dreams to come true. Different analytical techniques such as conductometry, spectrophometry and potentiometry will be studied for the estimation and identification of chemical species in lab work. Accurate and precise determination of different hazardous species in biological and lab samples is very important for the health of workers and consumers. After the successful completion of course, students will be able to explain the concept of catalysis carried out by the metal complexes formed by inorganic ligands or hybrid lgands.

Contents

1. Reaction of CO and Hydrogen: Hydroformylation and Reductive Carbonylation,
2. Reduction of CO by hydrogen,
3. Synthesis of water gas and the water gas shift reactions
4. Carbonylation reactions: Synthesis of methanol and methyl acetate
5. Adipic ester, Carbonylation reactions and Decarbonylation reactions
6. Catalytic addition of molecules to C – C multiple bonds
7. Homogeneous hydrogenation
8. Hydroxylation and Hydrocynation

Inorganic Chemistry Lab-IV

a. Conductometry
   1. Titration of Strong acid and Weak acid with a Strong base
   2. Precipitation Titration involving $AgNO_3$ and KCl
   3. Determination of Dissociation Constant (K_a) for Acetic Acid

b. Spectrophotometry (Colorimetry)
   1. Microdetermination of Cr (III) by diphenylecarbazide
   2. Determination of Fe (II) by I:10 - Phenanthroline
   3. Determination of Nitrites
   4. Determination of Fe (III) by 8 – hydroxyquinoline

c. Potentiometry
   1. Determination of K_1, K_2, and K_3 for H_3PO_4
   2. Determination of Chloride in the presence of Iodide and evaluation of K_{sp} of AgI and AgCl
   3. Determination of Co (II) and Fe (II)

Recommended Texts

1. Kotz, J.C., Treichel, P.M., & Townsend, J. (2012). *Chemistry and chemical reactivity*. Boston, USA: Cengage Learning.
2. Angelici, R.J. (1986). *Synthesis and technique in inorganic chemistry*. (1st ed.). California, USA: University Science Books.

Suggested Readings

1. Miessler, G.L., & Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York, USA: Pearson Education, Inc.

CHEM- 6137 Inorganic Reactions Mechanism 3 (3+0)

This course aim to the understanding of kinetics and mechanism of different inorganic reactions. The mechanism of a chemical reaction is the most important part which is normally not visible to the chemist. However, the pace of a chemical reaction is controlled by the kinetic parameters that govern these changes. Geometry of the transition state of metal catalyst is always important because it guides the reaction pathway in the forward or backward direction. The two most significant steps in a typical catalysis are the oxidative addition and the reductive elimination. Moreover, different types of effects such as cis-effect, trans-effect, steric effects of inert ligand etc. also govern the synthesis of different types of products. After the successful completion of this course, students will be able to learn the factors affecting the kinetics and stability of inorganic products. Moreover, they will also be able to carry out different oxidative and reductive reactions.

Contents

1. Kinetics and mechanisms of inorganic reactions: rate law
2. Stationary state approximation,
3. Inert and labile complexes
4. Substitution reaction
5. Octahedral complexes
6. Acid hydrolysis and acid catalyzed equation
7. Anation reactions
8. Base hydrolysis
9. Attack on ligands
10. Steric effects of inert ligand
11. Square planar complexes
12. Nucleophilic reactivity
13. Trans effect
14. Cis effect
15. Effect of leaving group
16. Electron transfer processes: outer and inner sphere reactions
17. Complimentary and non - complimentary reactions
18. Mechanism of oxidative
19. Addition and reductive eliminations
20. Oxidative addition, one electron oxidative addition
21. Addition of oxygen
22. Addition of bimetallic species
23. Hydrogen addition and hx addition
24. Organic halides
25. Reductive elimination

Recommended Texts

1. Jordan, R.B. (1998). *Reaction mechanisms of inorganic and organometallic systems*. (2nd ed.). U.K.: Oxford University Press.
2. Kotz, J.C., Treichel, P.M. & Townsend, J. (2012). *Chemistry and chemical reactivity*. Boston, USA: Cengage Learning.

Suggested Readings

1. Miessler, G.L., & Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York: Pearson Education, Inc.
2. Purcell, K.F., & Kotz, J.C. (1980). *An introduction to inorganic chemistry.* (1st ed.). Philadelphia, USA: Saunder College Press.

CHEM-6138 Physical Methods in Inorganic Chemistry 3 (3+0)

This course aims to the understanding of different physical methods used for the analysis of inorganic products such as thermogravimetric analysis. Analysis of the product formed in a chemical reaction is an important step in chemical laboratory preparations. Different analytical techniques are used for this purpose ranging sensitivity from mg level to as low as Nano gram level. Isolation and purification of a product from the reaction mixture is accomplished by techniques like solvent extraction, thin layer chromatography, column chromatography etc. After the successful synthesis of a new compound the most important is now to find out its applications. Certain physical techniques are meant for thepurposeof analysis of product like TGA, DTA, DSC, chromatography, conductometry and potentiometry etc. After the successful completion of this course, students will be able to understand the different techniques used for the purification, isolation and determination of inorganic specie from the reaction mixture as well as the importance of physical methods of analysis.

Contents

1. Thermogravimetric Analysis
2. Applications in lab and industry
3. Thermogravimetry (TG)
4. Differential Thermal Analysis (DTA)
5. Instrumentation of DTA
6. Differential Scanning Calorimetry (DSC)
7. Separation Methods
8. Solvent Extraction
9. Solid phase micro extraction
10. Applications of SPME
11. Column chromatography
12. TLC
13. Analytical applications and instrumentation of TLC
14. Ion Exchange Chromatography
15. Types of ICE
16. Industrial applications of IEC
17. Potentiometry
18. Applications of potentiometry
19. Conductometry
20. Applications of conductometry

Recommended Texts

1. Jordan, R.B. (1998). *Reaction mechanisms of inorganic and organometallic systems*. (2nd ed.). U.K.: Oxford University Press.
2. Kotz, J.C., Treichel, P.M., & Townsend, J. (2012). *Chemistry and chemical reactivity*. Boston, USA: Cengage Learning.
3. Skoog, D.A., West, D.M., & Holler, F.J. (1994). *Analytical chemistry*. (6th ed.). Philadelphia, USA: Saunders College Publications.

Suggested Readings

1. Miessler, G.L., & Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York: Pearson Education, Inc.
2. Purcell, K.F., & Kotz, J.C. (1980). *An introduction to inorganic chemistry.* (1st ed.). Philadelphia, USA: Saunders College Press.
3. Harris, D.C. (2006). *Quantitative chemical analysis.* (ed.). New York: Freeman.

iv) ORGANIC CHEMISTRY

CHEM-6139 Chemistry of Natural Products 4 (3+1)

This course is a foundation course for Natural Product Chemistry (CHEM-7148) and Steroids (CHEM-8108) courses of MPhil and PhD classes, respectively, with Organic Chemistry specialization. Natural products have high structural diversity and unique pharmacological or biological activities due to the natural selection and evolutionary processes that have shaped their utility over hundreds of thousands of years. In fact, the structural diversity of natural products far exceeds the capabilities of synthetic organic chemists within the laboratory. Thus, natural products have been utilized in both traditional and modern medicine for treating diseases.
This course focuses on the biosynthesis, isolation of new natural products, rational structural modifications of known natural products scaffolds for new lead discovery, total synthesis of complex natural products and green chemistry. Special emphasis is given to the development of synthetic methodologies to facilitate generation of diversity around the scaffolds, which can be utilized as key intermediates for total synthesis. The new molecular entities generated are screened for pharmacological activities with focus on cancer and anti-bacterial properties. The practical work involves the purification of selected natural products and the synthesis of a few small sized natural products.

Contents

1. Primary and secondary metabolites, introduction to natural products and classification on different basis;
2. Hormones (endocrines, exocrines, paracrines), pheromones (chemical communication) and allomones (chemical defense)
3. Isolation, biosynthesis, laboratory synthesis and structure elucidation of alkaloids (ephedrine, atropine, indole, quinine, morphine etc.) by chemical, spectroscopic and spectrometric methods of analyses
4. Isolation, biosynthesis, laboratory synthesis and structure elucidation of terpenoids (lemonenes, carvones, pinenes, menthol, camphor, tritepenoids) by chemical, spectroscopic and spectrometric methods of analyses
5. Isolation, biosynthesis, laboratory synthesis and structure elucidation of steroids (ecdysteroids, corticocoids, gonadal & neuro steroids, phytosteroids, brassinoloids, withanolides etc.) by chemical, spectroscopic and spectrometric methods of analyses
6. Isolation, classification, biosynthesis, laboratory synthesis and structure elucidation of vitamins (A, B, C, D, E and K) by chemical, spectroscopic and spectrometric methods of analyses
7. Isolation, classification, biosynthesis, laboratory synthesis and structure elucidation of flavonoids by chemical, spectroscopic and spectrometric methods of analyses.

Chemistry of Natural Products Lab.

1. Multistep synthesis of different types of organic compounds. Purification of the products by chromatographic and other techniques.
2. Isolation and purification of some natural products.
3. Conformation of natural products by different techniques e.g., elemental analysis, spectroscopy

Recommended Texts

1. Finar, I. L. (2001). *Natural product chemistry*. Vol-I, London: Longman.
2. Clayden, J., Greeves, N., Warren, S. and Wothers, P. (2012). *Organic chemistry*. (2nd ed.). Oxford University Press.
3. Dewick, P. M. (2008). *Medicinal natural products - a biosynthetic approach*. (3rd ed.). England: Wiley.

Suggested Readings

1. Bhat, S. V. (2005). *Chemistry of natural products*. (1st ed.). Berlin: Springer.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6140 Organic Synthesis 3 (3+0)

This course is a foundation course for Advance Organic Synthesis (CHEM-7146) of MPhil class, with Organic Chemistry specialization. This course focuses on general methods and strategies for the synthesis of complex organic molecules. Emphasis is on strategies for stereoselective synthesis, including stereocontrolled synthesis of complex acyclic compounds. The transformation of functional groups by substitution reactions, protecting groups, dummy groups, electrophilic addition to C-C double and triple bonds, hydroboration, reactions with organoboranes, reduction of carbonyl, C-C double and triple bonds, hydrogenation, hydride reductions are included in this course. The stereocontrol in pericyclic reactions (cycloadditions, sigmaotroptic rearrangements, electrocyclic reactions), group transfer reactions are also part of this course including introduction to retro synthesis. After the end of course the students are supposed to be able to:plan syntheses of organic molecules by proper choice of starting materials, reagents and reaction conditions and shall be able to predict competing reactions and plan simple synthetic routes based on retrosynthetic synthesis strategy.

Contents

1. Introduction to reterosynthesis, retrosynthetic analysis
2. Protective groups (protection of alcohols, amines, carboxylic acids, aldehydes and ketones)
3. Dummy groups and umpulong
4. Functional group inter-conversion (FGI)
5. Methods for C–C, C–N and C–O bond formation
6. Applications to the synthesis of a variety of target molecules.
7. Difunctionalized compounds
8. Role of crown others and quaternary ammonium salts in organic synthesis
9. Recent trends in organic synthesis.

Recommended Texts

1. Clayden, J., Greeves, N., Warren, S. and Wothers, P. (2012). *Organic chemistry*. (2nd ed.). Oxford University Press.
2. Smith, M.B. and March, J. (2019). *March's advanced organic chemistry*. (8th ed.). New York: John Wiley.
3. Warren, S. (2008). *Organic synthesis*. New York: Wiley.

Suggested Readings

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6141 Chemistry of Protective Groups and Reactive Intermediates 3 (3+0)

Protecting groups are used in synthesis to temporarily mask the characteristic chemistry of a functional group because it interferes with another reaction. A good protecting group should be easy to put on, easy to remove and in high yielding reactions and inert to the conditions of the reaction required. In many preparations of delicate organic compounds, some specific parts of their molecules cannot survive the required reagents or chemical environments. Then, these parts, or groups, must be protected. For example, $LiAlH_4$ is a highly reactive but useful reagent capable of reducing esters to alcohols. It will always react with carbonyl groups, and this cannot be discouraged by any means. Neutral reactive intermediates (radicals, carbenes, nitrenes, and aryenes) occupy a fascinating place in the history of organic chemistry. First regarded as mere curiosities, neutral reactive intermediates ultimately came under the intense scrutiny of physical organic chemists from a mechanistic point-of-view. This concise text concentrates on how these electron-deficient species now play a key role in synthetic chemistry research. Important reactions are clearly and simply laid out with carefully chosen examples that illustrate their use in organic synthesis.

Contents

1. Important protective groups of different organic functional groups involved in organic synthesis including alcohols/phenols (-OH), amines ($-NH_2$), carboxylic acids (-COOH), aldehydes (-CHO), ketones (-CO) etc.
2. Structure generation and reaction of reactive intermediate including carbenes, nitrenes, arynes and free radicals.

Recommended Texts

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Hendrickson, J. B., Cram, D. J. and Hammond, G. S. (1980). *Organic chemistry*. New York: McGraw-Hill.
3. Pine, S. H. (1980). *Organic chemistry*. New York: McGraw-Hill.

Suggested Readings

1. Streitwieser, A., Heathcock, C. and Kosower, E. M. (2017). *Introduction to organic chemistry*. (4^{th} ed.). New York: Macmillan.
2. Warren, S. (2008). *Organic synthesis*. New York: Wiley.

v) Physical Chemistry

CHEM-6142 Advanced approach of homogeneous and heterogeneous kinetics 4 (3+1)

This course is designed for the students opting Physical Chemistry as Minor Subject along with their field of specialization to provide comprehensive knowledge about the kinetics of homogeneous and heterogeneous reactions. Course include detailed discussion about liquids and gaseous systems of inorganic and organic reactions, single systems, double systems, reactions on solid surfaces, kinetics of single reacting gas, retardation by reaction products, kinetics of two reacting gases, retardation by reactants, reactions in solution, influence of solvents involving ions, primary and secondary salt effect on kinetics of the reactions and comparison between homogeneous and heterogeneous kinetics. Course is designed to make the students capable of understanding the dynamics and phenomena of homogeneous and heterogeneous kinetics. As catalysis is backbone of any synthesis. To control the reaction rate and develop new interfaces suitable for reaction catalysis, students will be trained along with solid foundation of physical chemistry. Kinetics equations dealing different cases of homogeneous and heterogeneous reactions will be guiding torch to make them understand.

Contents

1. Liquids and gaseous systems of inorganic and organic reactions
2. Single systems, double systems
3. Study of reactions on solid surfaces
4. Single reacting gas, retardation by reaction products
5. Two reacting gases, retardation by reactants
6. Adsorb-heterogeneous reaction
7. Reactions in solution
8. Influence of solvents involving ions, primary and secondary salt effect on kinetics of the reactions
9. Comparison between homogeneous and heterogeneous kinetics

Advanced Approach of Homogeneous and Heterogeneous Kinetics Lab

1. Determination of equilibrium constant of reversible reaction $I_2 + I^- \rightleftharpoons I_3^-$ and to evaluate ΔG^o.
2. Determination of molecular mass of polymer by viscosity method.
3. Determination of flocculation value of electrolytes and to verify Hardy-Schultz rule.
4. Determination of activation energy of a chemical reaction.
5. Study of variation of conductance of solution of weak and strong electrolytes with concentration (a) pure solvents (b) binary mixture of solvents
6. Determination of heat of solution of a substance from solubility measurements and to determine thermodynamic quantities like ΔG^o, ΔH^o, ΔS^o of the solution.
7. Potentiometric titration

Recommended Texts

1. Kontogeorgis, G. M. & Kiil, S. (2016). *Introduction to applied colloid and surface chemistry.* John Wiley & Sons Inc.
2. Thomas, J. M. & Thomas, W. J. (2015). *Principles and practice of heterogeneous catalysis.* Germany: Wiley-VCH Verlag GmbH.

Suggested Readings

1. Somorjai, G. A. , Yimin, L. (2010). *Introduction to surface chemistry and catalysis.* John Wiley & Sons Inc.
2. Cosgrove, T. (2010). *Colloid science: principles, methods and application.* John Wiley & Sons Inc.
3. Pashley, R.. & Karaman, M. (2004). *Applied colloid and surface chemistry.* John Wiley & Sons Inc.

CHEM-6143 Polymers and Photochemistry 3 (3+0)

The objective of this course is to make the students enable to understand the process of polymerization and to know the approaches by which polymerization may be achieved. Additionally a deep insight of photochemical reactions and laws of photochemistry is also incorporated in this course. The course includes the kinetics of polymerization occurring through different approaches e.g. condensation, addition and copolymerization along with the knowledge of photochemical reactions. Fluorescence and phosphorescence and relevant information is also a part of this course. A knowledge of polymer chemistry enables the students to know about natural and synthetic polymers. Natural and semi-synthetic polymers find their uses in almost every field of science ranging from drug delivery to common sensors and biosensors. Photochemistry enables students to know how UV/Visible light is absorbed or emitted during a physical or chemical change. The basic knowledge of photochemistry is applied in the field of carbon nanodots because of their unique optical properties which is applied in imaging the biological process.

Contents

1. Classification of polymers
2. Kinetics of condensation polymerization
3. Kinetics of addition polymerization
4. Kinetics of co-polymerization reactions.
5. Molecular mass determination by different methods and laws of photochemistry.
6. Quantum efficiency
7. Methods to determine quantum yield and quantum efficiency
8. Photochemical reactions
9. Photosensitized reactions
10. Phosphorescence
11. Fluorescence
12. Chemiluminescence
13. Lasers.

Recommended Texts

1. Turro, N. J., Ramamurthy, V. & Scaiano, J.C. (2009). *Principles of molecular photochemistry: an introduction.* USA: University Science Books.
2. Rawe, A. (2000). *Principles of polymer chem*istry. (2nd ed.). New York, USA: Plenum publishers.

Suggested Readings

1. Allen, N. S. (2010). *Photochemistry and photophysics of polymeric materials*. John Wiley & Sons Inc.
2. Albini, A. & Protti, S. (2019). *Photochemistry: Volume 47.* Cambridge, UK: Royal Society of Chemistry.
3. Wardle, B. (2010). *Principles and applications of photochemistry.* John Wiley & Sons Inc.
4. Neckers, D. C., Jenks, W. S. & Wolff, T. (2005). *Advances in photochemistry*. John Wiley & Sons Inc.

CHEM-6144 Elementary Group Theory 4 (3+1)

This course is highly advanced for the students having physical chemistry as their field of interest. The course is based on algebraic foundation. Different physical systems including crystals as well as the Hydrogen atom, can be modelled by symmetry groups. So the group theory and representation theory have important applications. Almost all structures in abstract algebra are special cases of groups such as rings can be visualized as abelian groups (corresponding to addition) together with a second operation (corresponding to multiplication). Therefore, group theoretic arguments underlie large parts of the theory of those entities. Course covers concept of symmetry, symmetry elements and operations, point groups, group representation and character table. Moreover, reducible representation, irreducible representation, application of group theory to valence bond theory, application of group theory to molecular orbital theory & crystal field theories and IR spectra are important parts of the course. Group theory and its application in structure finding makes it very vital. This course makes the students able to apply their knowledge at advance applied fields of research and to understand the structure of molecules inside and covers its application on valence bond theory (VBT), molecular orbital theory, (MOT) and crystal field theory (CFT) etc.

Contents

1. Introduction to Elementary Group Theory
2. Symmetry
3. Symmetry elements and operations
4. Point groups
5. Group representation
6. Character table
7. Reducible representation
8. Irreducible representation
9. General applications of group theory
10. Application of group theory to valence bond theory
11. Application of group theory to molecular orbital theory
12. Crystal field theory and IR spectra

Recommended Texts

1. Ramond, P. (2015). *Group theory: a physicist's survey*. UK: Cambridge University Press
2. Carter, N. (2009). *Visual group theory.* USA: Mathematical Association of America

Suggested Readings

1. Joyner, D. (2008). *Adventures in group theory: Rubik's cube, Merlin's machine, and other mathematical toys*. Baltimore, MD, USA: Johns Hopkins University Press.
2. Tinkham, M. (2003). *Group theory and quantum mechanics*. Dover Publications Inc.
3. Vincent, A. (2001). *Molecular symmetry and group theory: a programmed introduction to chemical applications.* John Wiley & Sons Inc.
4. Related Research Papers

REVISED SCHEME OF STUDIES & CURRICULUM
MSc CHEMISTRY
(Semester / Term System)

(2020)

INSTITUTE OF CHEMISTRY
UNIVERSITY OF SARGODHA
SARGODHA

Revised Scheme of Studies and Curriculum for MSc Chemistry with specialization in Analytical, Inorganic Chemistry, Organic Chemistry, Physical Chemistry and Biochemistry

Summary:

M. Sc. Chemistry program comprises of 4 semesters with 66 credit hours.

1st Semester:

No. of Credits = 18 Credits

Course Code	Course Title	Credits
CHEM-6201	Basic Mathematics for Chemists	2(2+0)
CHEM-6202	Biochemistry	4(3+1)
CHEM-6203	Inorganic Chemistry-I	4(3+1)
CHEM-6204	Organic Chemistry-I	4(3+1)
CHEM-6205	Physical Chemistry-I	4(3+1)
Total Credits		**18 (14+4)**

2nd Semester

No. of Credits = 18 Credits

Course Code	Course Title	Credits
CHEM-6206	Computer Applications in Chemistry	2(2+0)
CHEM-6207	Analytical Chemistry	4(3+1)
CHEM-6208	Inorganic Chemistry-II	4(3+1)
CHEM-6209	Organic Chemistry-II	4(3+1)
CHEM-6210	Physical Chemistry-II	4(3+1)
Total Credits		**18 (14+4)**

3rd Semester

Every student will be offered two compulsory theory courses of five credits (3 and 2) in Semester III. Moreover, at the beginning of 3rd Semester every student shall opt one field of specialization (11 credits). Some of the students will be offered research on the basis of merit, while others will be offered a theory course (3 + 1 Credit) from field other than specialization in lieu of research.

List of compulsory courses

Course Code	Title of the Course	Credits
CHEM-6211	Forensic Chemistry	2(2+1)
CHEM-6212	Industrial Chemistry	3(3+0)

Semester with Research

	Credit Th – Pr
Two theory courses (compulsory) of (2+3) credits	5 (5-0)
One theory course of specialization (Major)	3(3+0)
One theory course of specialization (Minor)	4 (3+1)
Research	4 (4+0)
Total	**16 (15+1)**

Fields of Specializations

Every student shall opt any one of the following specializations.

i) Analytical Chemistry
ii) Biochemistry
iii) Inorganic chemistry
iv) Organic chemistry
v) Physical chemistry

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6213	Research	4(4+0)
CHEM-6214	Advanced Spectroscopy – I (Minor)	4(3+1)
CHEM-6215	Advanced Chromatographic Techniques (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6216	Instrumental Methods of Analysis	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6213	Research	4(4+0)
CHEM-6217	Metabolism and Bio-Energetics (Minor)	4(3+1)
CHEM-6218	Microbiology and Industrial fermentation (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6219	Enzymes and Nutrition	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6213	Research	4(4+0)
CHEM-6220	Stereochemistry & Periodicity, Nuclear chemistry (Minor)	4(3+1)
CHEM-6221	Organometallic & Bio-inorganic Chemistry (Major)	3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		

CHEM-6222	Inorganic Polymers & Chemical Forces	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6213	Research	4(4+0)
CHEM-6223	Reaction Mechanism (Major)	3(3+0)
CHEM-6224	Spectroscopic Methods in Organic Chemistry (Minor)	4(3+1)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6225	Organometallics	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6213	Research	4(4+0)
CHEM-6226	Surface Phenomena (Minor)	4(3+1)
CHEM-6227	Molecular Spectroscopy (Major)	3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6228	Statistical and Quantum Mechanics	3(3+0)

Semester without Research

	Credits Th – Pr
Two theory courses (compulsory) of 05 credits	5 (5-0)
One theory course of specialization (Major)	3 (3+0)
One theory course of specialization (Minor)	4(3+1)
One theory course (Minor) from field other than specialization	4(3+1)
Total	**16 (14+2)**

Fields of Specializations

Every student shall opt any one of the following specializations.

i) Analytical chemistry
ii) Biochemistry
iii) Inorganic chemistry
iv) Organic chemistry
v) Physical chemistry

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6214 CHEM-6215	Advanced Spectroscopy – I (Minor) Advanced Chromatographic Techniques (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member.		
CHEM-6216	Instrumental Methods of Analysis	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6217 CHEM-6218	Metabolism and Bio-Energetics (Minor) Microbiology and Industrial fermentation (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member.		
CHEM-6219	Enzymes and Nutrition	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6220 CHEM-6221	Advanced Inorganic Chemistry (Minor) Organometallic & Bio-inorganic Chemistry (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member.		
CHEM-6222	Inorganic Polymers & Chemical Forces	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6223 CHEM-6224	Reaction Mechanism, (Major) Spectroscopic Methods in Organic Chemistry (Minor)	3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member.		
CHEM-6225	Organometallics	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6226	Surface Phenomena (Minor).	4(3+1)
CHEM-6227	Molecular Spectroscopy (Major).	3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member.		
CHEM- 6228	Statistical and Quantum Mechanics	3(3+0)

Semester- IV

Every student will be offered one compulsory theory course of three credits in Semester IV. Moreover, the scheme of studies on behalf of III semester will be carried over to semester IV accordingly.

Compulsory course

Course Code	Title of the Course	Credits
CHEM-6229	Environmental Chemistry	3(3+0)

Semester with Research

		Credits Th – Pr
Research		4(4+0)
One theory course (compulsory)		3(3+0)
One theory course of specialization (Major)		3(3+0)
One theory course of specialization (Minor)		4(3+1)
	Total	**14 (13+1)**

Field of Specialization

Field of specialization will remain same as opted in semester III.

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6213	Research	4(4+0)
CHEM-6230	Advanced Spectroscopy – II (Minor)	4(3+1)
CHEM-6231	FTIR, Raman Spectroscopy, ESR and Surface Analysis (Major)	3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6232	Instrumental Methods of Analysis-II	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6213 CHEM-6233 CHEM-6234	Research Chemotherapy & Immunology (Major) Molecular Biology & Physical Techniques (Minor)	4(4+0) 3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6235	Endocrine System	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6213 CHEM-6236 CHEM-6237	Research Homogeneous Catalysis by Transition Metal Complexes (Minor) Inorganic Reaction Mechanism (Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6238	Physical Methods in Inorganic Chemistry	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6213 CHEM-6239 CHEM-6240	Research Chemistry of Natural Products (Minor) Organic Synthesis (Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member.		
CHEM-6241	Chemistry of Protective Groups & Reactive Intermediates	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6213 CHEM-6242 CHEM-6243	Research Advanced Approaches of Homogeneous and Heterogeneous Kinetics (Minor) Polymers and Photochemistry (Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6244	Elementary Group Theory	3(3+0)

Semester without Research

		Credits Th – Pr
One theory course (compulsory)		3(3+0)
One theory course of specialization (Major)		3(3+0)
One theory course of specialization (Minor)		4(3+1)
One theory course (Minor) from field other than specialization		4(3+1)
	Total	**14 (12+2)**

Field of Specialization

Field of specialization will remain same as opted in semester III.

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6230 CHEM-6231	Advanced Spectroscopy – II (Minor) FTIR, Raman Spectroscopy, ESR and Surface Analysis (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6232	Instrumental Methods of Analysis-II	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6233 CHEM-6234	Chemotherapy & Immunology (Major) Molecular Biology & Physical Techniques (Minor)	3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM- 6235	Endocrine System	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6236 CHEM-6237	Homogeneous Catalysis by Transition Metal Complexes (Minor) Inorganic Reaction Mechanisms (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits course (Major) subject to the interest & availability of the faculty member		
CHEM-6238	Physical Methods in Inorganic Chemistry	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6239 CHEM-6240	Chemistry of Natural Products (Minor) Organic Synthesis (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6241	Chemistry of Protective Groups & Reactive Intermediates	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6242 CHEM-6243	Advanced Approaches of Homogeneous and Heterogeneous Kinetics (Minor) Polymers and Photochemistry (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6244	Elementary Group Theory	3(3+0)

Note: Order of the courses in semesters may be changed depending upon the available resources

SEMESTER-I

CHEM-6201 Basic Mathematics for Chemist 2 (2+0)

This course introduces students with basic mathematics that is used in chemistry. This is the fundamental course of serving as the foundation of mathematics for its use in chemistry and chemical calculation during the lab experiments and research. The course, equally, emphasizes basic concepts and skills needed for mathematical manipulation. It focuses on the study of functions of a logarithmic and exponential functions, single variables, differential equations and their use in chemical problems, and use of Integration, Determinants and Matrices. Applications of differential equations include computations involving velocity and acceleration, the slope of a curve, and optimization. Student are also expected to learn solutions of linear equations (simple, determinant and matrices methods), operator theory, differentiation, integration and matrices. This course will also provide applications of eigen value problem and curve fitting in chemistry. Upon successful completion of course, students will be able to derive basic mathematics equations use in chemistry and apply them to seek solution for related problems in the experiments.

Contents

1. Introduction
2. Review of basic algebra
3. Graphs and their significance in chemistry
4. Trigonometric
5. Logarithmic functions
6. Exponential functions
7. Differentiation
8. Partial differentiation
9. Differential equations and their use in chemical problems
10. Concept of maxima and minima
11. Integration
12. Determinants
13. Matrices
14. Their properties and use in chemical problems.
15. Solutions of linear equations (simple, determinant and matrices methods)
16. Operator theory,
17. The eigen value problem
18. Curve fitting.

Recommended Texts

1. Paul, M. (2006). *Mathematics for chemistry.* (1st ed.). Oxford, United Kingdom: Oxford University Press
2. Ghram, D. (1996). *Mathematics in chemistry*. (1st ed.). New York, USA: Prentice Hall Publishing.

Suggested Readings

1. Tebutt, P. (1998). *Basic mathematics for chemists*. (2nd ed.). New York, USA: John Wiley & Sons.
2. Goldstein, L. J., Lay, D. C., Schneider, D. I., & Asmar, N. H. (2017). *Calculus and Its Applications*. (14th ed.). London: Pearson.

CHEM-6202 Biochemistry 4 (3+1)

This is a basic biochemistry course designed to provide the fundamental concepts about biomolecules, their classifications, functions and significance. This course demonstrates a broad knowledge of the fundamental introductory concepts of biochemistry where students will gain a deep understanding of function of biomolecules with respect to chemical and molecular processes that occur in and between cells. Students will learn about proteins, carbohydrates, lipids and nucleic acids and their types. Lab experiments related to qualitative and quantitative estimation of biomolecules are also part of this course. Upon successful completion of course, students will be able to show a deep understanding of fundamental principles of biochemistry along with scientific reasoning to solve problems. Students will demonstrate a comprehensive understanding of the theory and practice of modern instrumentation and apply it to appropriate chemical problems. Students will also be able to perform basic biochemistry laboratory procedures with good standard lab practices and accurate record keeping. This compulsory course is followed by advance biochemistry courses in next semesters.

Contents

1. History and Scope of Biochemistry. Origin and nature of biomolecules.
2. Proteins: Amino acids, classification and properties of amino acid. Stereochemistry,
3. Primary, Secondary, Tertiary and Quaternary protein structures.
4. Motif and domains in proteins. Biological functions of proteins and peptides,
5. Enzymes: Chemical Nature, Nomenclature and Classification.
6. Enzyme activity. Coenzymes and immobilized enzymes, Specificity of Enzymes,
7. Enzyme Inhibition. Regulation of Enzyme activity.
8. Carbohydrates: Definition and Classification, Monosaccharides:
9. Pyranose and Furanose ring structures. Stereoisomerism and Optical isomerism.
10. Disaccharides; Structures, Polysaccharides; starch, Glycogen and Cellulose.
11. Modified Carbohydrates, Glycoproteins and Glycolipids.
12. Derived sugars, Hemiacetal, Acetal and Glycosidic linkages,
13. Glycosaminoglycans and Glycoconjugates.
14. Lipids: Structures and classification of Fatty Acids, essential and non-essential fatty acids
15. Phospholipids, Fats and oils; Hydrogenation, Oxidation and Rancidity
16. Steroids, Eicosanoids, Fats and oils, Waxes
17. Nucleic Acids: Purines and pyrimidines, nucleosides and nucleotides
18. Structural and functional differences between DNA and RNA.
19. Types of DNA and RNA, their functions in biological systems.
20. Vitamins: Introduction, classification and significance

Biochemistry Lab I

1. Safety Lab Practices – Safety signs and significance
2. Operation and use of micropipettes – types and uses
3. Standard Buffer preparation and use of pH meter
4. Qualitative Tests for carbohydrates
5. Molisch's Test, Fehling's Test, Benedict's Test, Barfoed's Test, Seliwanoff's Test, Bial's Test, Osazone Test
6. Effect of Alkalis on Sugars
7. Quantitative Determination of Reducing Sugars by using Calorimetric Method (Spectrometric)

8. Enzymatic Hydrolysis of Glycogen and Starch
9. Qualitative tests for Amino Acids;
10. Xanthoproteic acid Test, Millon's Test, Hopkins-Cole Test, Sakaguchi Test
11. Estimation of protein by Bradford and Lowery methods
12. Separation of Amino Acids using Paper Chromatography and Thin Layer Chromatography (TLC)
13. Qualitative tests for fats, Sterols and Phospholipids
14. Determination of Ascorbic acid in Lemon Juice.
15. Saponification Tests and Iodine Values of Fat
16. Use of online available Protein Databases to get protein and DNA sequence
17. Use of online software to visualize Secondary structure of Proteins.

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
3. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.

Suggested Readings

1. Murray, R. K., Grammer, D. K., Mayes, P. A., & Rodwell, V.W. (2000). *Harper's biochemistry*. (25th ed.). New York, USA: Appleton & Lange.
2. Stryer, L. (2010). *Biochemistry*. (7th ed.). New York, USA: Freeman & Co.
3. Ausubel, F. M. (2010). *Short protocols in molecular biology.* (5th ed.). New Jersey, USA: John Wiley & Sons.

CHEM-6203 Inorganic Chemistry – I 4 (3+1)

The students will be able to learn the detailed concept of *d*-block elements, inner transition elements, non-aqueous solvents and structural elucidation of compounds. Nature of chemical bonding in coordination compounds is included in the course, which enables the students to understand the color and magnetic properties of compounds. The examples of salts with some properties different from those of double-salts enable us to think about the introduction and nomenclature of coordination compounds. The earlier knowledge of the electronic configuration of elements belonging to d-block elements makes the learning easier about f-block Lanthanides and Actinides. Further, non-aqueous chemistry provides information about reactions which otherwise cannot take place in aqueous polar environment. Moreover, different methods for the analysis of halide ions and transition metals ions will also be studied in lab work. Estimation of different metal ions in the water and biological samples is necessary to explain the properties and nature of such samples.

Contents

1. Survey of Inorganic Structures and Bonding: Structures of molecules having single bonds
2. Resonance and formal charge, Complex structures-a preview of coming attractions
3. Electron-deficient molecules, Structures having unsaturated rings and Bond energies
4. Chemistry of Lanthanides and Actinides: Structure, occurrence and preparation
5. Separation, electronic configuration and oxidation states
6. Spectral and magnetic properties and Complex formation and their applications
7. Chemistry of Coordination Compounds: Introduction of d–block elements
8. Nomenclature, Werner's theory, Valence bond theory, Crystal field and Ligand field theory
9. Molecular orbital theory and John-Teller Theorem
10. The spectrochemical series, color, isomerism and stereochemistry of metal complexes
11. Geometry of complexes having coordination number 2 to 6
12. Applications of coordination compounds in chemistry, life and industry
13. Composition and Stability of Complexes.
14. Non – aqueous Solvents: Introduction and classification of solvents
15. Types of reactions in non-aqueous solvents
16. Effect of physical and chemical properties of solvents
17. Study of reactions in liq. NH_3 and liq. SO_2
18. Reactions in Liq. HF and liq. BrF_3 and in molten salt system

Inorganic Chemistry Lab-I

1. Qualitative Analysis of inorganic mixture (six radicals) by micro and semi-micro techniques.
2. Estimation of Halide ions (Cl^-, Br^-, I^-) by adsorption indicator.
3. Complexometric titrations using EDTA for Ni, Ca (II) and Mg (II) in a mixture.
4. Complexometric titrations using EDTA for Mg (II), Mn (II) and Zn (II) in a mixture.

Recommended Texts

1. Cotton, F.A., & Wilkinson, G. (2015). *Advanced inorganic chemistry*. (7th ed.). New York: John Wiley & Sons.
2. Greenwood, N.N., & Earnshaw, A. (1984). *Chemistry of the elements.* (2nd ed.). U.K.: Elsevier.

Suggested Readings

1. De Lavis, R. (1997). *Principles of quantitative chemical analysis*. (1st ed.). New York, USA: WCB/McGraw Hill.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.). New York: W.H. Freeman and Company

CHEM-6204 Organic Chemistry–I 4 (3+1)

It is a course designed to deliver fundamental concepts in organic chemistry for core understanding of forthcoming courses (CHEM-6209, CHEM-6223 and CHEM-6240) of organic chemistry specialization. The nomenclature of organic molecules (both carbocycles and heterocycles), involvement of electronic (*–I*, *+I*)/resonance (*–R*, *+R*)/steric factors in reactions and stereochemical aspects are major focus of this course. The major part of this course is associated with the study of stereoisomers. Stereochemistry spans the entire spectrum of organic, inorganic, biological, physical and especially supramolecular chemistry. It includes methods for determining and describing these relationships; the effect on the physical or biological properties these relationships impart upon the molecules in question, and the manner in which these relationships influence the reactivity of the molecules in question (dynamic stereochemistry). A basic concept on 3D structures, conformations of molecules, asymmetric synthesis, other stereochemical principles and attributes are essential. The completion of this course shall enable the students to apply fundamental concepts in organic chemistry and stereoisomerism.

Contents

1. IUPAC nomenclature of polyfunctional aliphatic, alicyclic, aromatic, heterocyclic, multicyclic organic compounds, spiro and allenes.
2. Inductive effect, resonance, hyperconjugation, aromaticity & tautomerism. The effect of structure, medium and steric factor on the strength of acids, bases and on acid-base equilibria. Introductory linear free energy relationship.
3. Geometrical Isomerism: *cis/trans, E/Z* &*syn/anti* conventions, optical isomerism
4. Chirality and symmetry, elements of chirality and elements of symmetry.
5. Optical isomerism of compounds up to three asymmetric centers, configuration *vs* conformation.
6. Wedge-head, saw-horse, Newman & Fischer projections. Baeyer's Strain theory.
7. Conformational isomerism in acyclic, alicyclic compounds (cyclobutane, cyclopentane, cyclohexane), mono / di-substituted cyclohexanes and condensed rings, locking groups.
8. Configurational isomerism, relative (*D/L* convention) and absolute configuration (CIP rule &*R/S*, *r/s*, *aR*/*aS* conventions).
9. Configurational isomerism in biphenyls, allenes and spiro compounds.
10. Racemization, resolution of racemic modification and introductory asymmetric synthesis.
11. Stereospecificity *vs* stereoselectivity. Determination of configuration (ORD/CD).

Organic Chemistry Lab. – I
Separation & identification of two and three component mixture of organic compounds by physical and chemical methods.

Recommended Texts

1. Clayden, J., Greeves, N., and Warren, S. (2012). *Organic chemistry*. (2nd ed.). Oxford, London.
2. Solomons, T. W. G. (2016). *Fundamentals of organic chemistry*. (12th ed.). New York: Wiley.
3. Hendrickson, J. B., Cram, D. J., and Hammond, G. S. (1980), *Organic chemistry*. New York: McGraw-Hill Book Co.

Suggested Readings

1. Streitwieser, A., Heathcock, C. and Kosower, E. M. (2017). *Introduction to organic chemistry*. (4th ed.). New York: Macmillan.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (4th ed.). London: Longman Publisher.

CHEM-6205 Physical Chemistry – I 4 (3+1)

This course is designed to have basic concepts and strong foundation of Physical Chemistry. This course will cover laws of thermodynamics, Nernst heat theorem and its applications and knowledge of entropy in detail. Moreover, Maxwell's law and its derivation, Barometric formula, effect of altitude, temperature and molecular mass on vertical distribution of particles and kinetics of third order, opposing reactions, parallel and consecutive reactions is also part of this course. Kinetics of thermally excited chain reactions and theories of reactions will also be focused. As course covers main directions of physical chemistry i.e. kinetics and thermodynamics so it provides a sound foundation to the students in the field of physical chemistry. It makes the students capable of understanding the laws of thermodynamics and their applications. Intensive knowledge of chemical kinetics is very useful for the students to make them understand the dynamics of a chemical reactions and the ways to increase yield at lab and industrial scale.

Contents

1. Review of first law of thermodynamics
2. Second law of thermodynamics and its applications.
3. Clausius inequality. Nernst heat theorem and its applications.
4. Third law of thermodynamics and determination of absolute entropy.
5. Entropy of mixing. Partial molal quantities.
6. Maxwell's law of distribution of velocities and derivation of average velocity, most probable velocity and root mean square velocity from the law.
7. Significance of Maxwell's law.
8. Derivation of Maxwell's distribution for kinetic energy.
9. Barometric formula, effect of altitude, temperature and molecular mass on vertical distribution of particles.
10. Concept of order of reaction.
11. Kinetics of third order reactions with different concentration and molecular identity.
12. Kinetics of opposing, reversible, consecutive and parallel reactions.
13. Kinetics of thermally excited chain reactions.
14. Theories of reactions.

Physical Chemistry Lab – I

1. Determination of specific and molar rotations of optically active substance in solution polarimetrically.
2. Percentage by refractometer.
3. Verification of Beer–Lambert's law, and determination of unknown concentration of $KMnO_4$ and $K_2Cr_2O_7$ solution by colorimeter.
4. Determination of distribution coefficient of I_2 between H_2O and CCl_4.
5. Preparation of buffer solution and measurement of exact pH-value by pH meter.

Recommended Texts

1. Marin, G. B., Yablonsky, G. S. (2011). *Kinetics of chemical reactions: decoding complexity.* New York: Wiley-VCH Verlag GmbH.

2. Koretsky, M. D. (2010). *Engineering and chemical thermodynamics.* New York: John Wiley & Sons Inc.

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd ed.). India: Meerut Krishna Prakashan Media (P) Ltd.
2. Atkins P.W. (2017). *Physical chemistry.* (11th ed.) UK: ELBS Oxford University Press.

SEMESTER-II

CHEM-6206 Computer Applications in Chemistry 2 (2+0)

This course provides a broad and balanced knowledge and understanding of key use of computer in chemistry. This course will introduce the basic use of computer essential for chemistry students. Student will learn the use of basic software including MS Office, ChemDraw/ChemSketch. A knowledge of databases and referencing will be provided. Student will be able to learn a range of practical skills to understand the software required for research in chemistry. Upon successful completion of the course, students will be able to work effectively with a range of current, standard, Office Productivity software applications and Evaluate, select and use office productivity software appropriate to a given situation. This course will enhance student knowledge to solve a range of problems using office productivity applications, and adapt quickly to new software releases. Maintain quality assurance through critically evaluating procedures and results. Students will be able to demonstrate their skills in chemistry related software and will be able to learn more by self-reading and practicing the software learned during the course.

Contents

1. Introduction and history of computers
2. Use of basic internet for chemistry
3. Chemical databases and their applications
4. Data handling for chemistry data
5. Databases for literature survey for chemistry
6. Standard curve fitting and errors calculations
7. Graphical display of data
8. Molecular modeling for small molecules
9. Protein and DNA modelling and applications
10. Introduction to Programming languages i.e., Python
11. Basics concepts in python and its use in chemistry
12. Use of ChemSketch and ChemDraw
13. Use of chemical compound databases on internet i.e PubChem, PDB.
14. Uses of Microsoft Office (MS Word, MS Excel, MS PowerPoint).
15. Basic statistics using MS excel.
16. Use of MS publisher and Poster preparation
17. Basic use of CorelDraw
18. Endnote referencing for Chemistry
19. MD Simulations and animation

Recommended Texts

1. Arora, K. (2004). *Computer applications in chemistry.* Delhi, India: Anmol Publications PVT. LTD.
2. Sherry, W. K,. & Sherry, K. (2007). *Microsoft office 2007 Simplified.* (1st ed.). New York, USA: John Wiley & Sons.
3. *ChemSketch 5.0 User's Guide,* (2001). *Advanced chemistry development*. USA: Chem Sketch Development.

Suggested Readings

1. David, C., & Young, B. (2001). *Computational Chemistry*. New York: John Wiley & Sons
2. Ramesh, K. (2005). *Computers and their applications to chemistry*. Delhi, India: Alpha Science International

CHEM-6207 Analytical Chemistry 4 (3+1)

This course is aimed to build foundation of analytical chemistry among the beginners, introducing them with the basic terminology and phenomenon of Analytical Chemistry, methods and precautions in collection and preservation of different type of samples for chemical analysis. It provides fundamental to deep insight about characterizing a material into its constituents as well as proportion of different ingredients in given sample. All the techniques and precautions for sample collection, and preparation are included in this course. Accuracy of this information is influenced by mode of sampling. This course provides a comprehensive skill development for preparation of solutions for measurements, calibration of volumetric glassware, and measurement of reagents with different types of balances. Skill about data analysis is also included in this course. Besides, basic principle, operational mechanism and applications of three different chromatographic techniques is contained in this course. For advanced information, overview of spectroscopic techniques, with comprehensive focus on UV/Visible spectrophotometry is also included in this course. After studying this course, students will be able to work independently in any quality control laboratory of any industry.

Contents

1. Data Handling: introduction to analytical chemistry
2. Sampling; types of samples, techniques/ steps involved in sample preparation
3. Drying and ignition
4. Weighing, analytical balance, its construction working
5. volumetric glassware; errors in measurements, calibration of glassware
6. Steps involved in chemical analysis, system for units of measurements and their interconversion
7. Chemical concentration and preparation of solutions
8. Calibration and calibration curves (construction and interpretation), Standard addition and internal standard methods
9. Statistical treatment of analytical data; Precision, accuracy and types of errors, sample, population, mean, average, median, range, standard deviation, variance, significant figures
10. Chemical equilibrium ant its types
11. Separation techniques: chromatography (introduction, classification) TLC, column & ion exchange chromatography (with reference to principles & applications), electrophoresis & solvent extraction

Analytical Chemistry Lab – I

1. Calibration of glassware (Pipette, Burette, Flask) used for volumetric Analysis.
2. Use of Analytical balance and calculation of standard deviation.
3. Use of pH meter for plotting acid - base titration curve and assay of commercial caustic soda.
4. Plotting of first differential curve for titration of acetic acid and commercial soda.
5. Measurement of solubility products of sparingly soluble salts.
6. Determination of HCl by titrating with NaOH and plotting of a titration curve.
7. Packing of chromatographic column and separation of mixture of dyes.
8. Separation of various components of plant extract by column chromatography.
9. Separation of mixture of dyes by Radial chromatography.
10. Separation of mixture of Amino acids by paper chromatography.
11. Coating of TLC plates and separation of mixture of dyes.
12. Separation of mixture of Amino acids by TLC.

Recommended Texts

1. Robinson J. W., Frame E. S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.). New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G. D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical chemistry.* (4th ed.). New York, John Wiley & Sons.

CHEM-6208 Inorganic Chemistry – II 4 (3+1)

Basic concept of dipole moments, intermolecular forces and effect of intermolecular forces on properties of solvent and solute will be discussed in detail in this course. The physical properties like dipole moment measure polarity of the molecules. The geometries and shapes of covalent compounds which possess single and double bonds are determined by Valence Shell Electron Repulsion Theory. The Valence Bond Theory in combination with hybridization approach makes it easy to closely know structures of proposed compounds. Further, the pi-acceptor ligands will be discussed in detail emphasizing the nature of bonding in coordination compounds and their chemical applications in industrial processes. Different organic reagents used in inorganic analysis will also be discussed and analysis will be performed in lab to estimate the inorganic species in different types of samples. Some inorganic compounds will also be prepared in the lab work to understand the basic preparation methods of compounds. After the successful completion of this course, students will be able to learn the properties and bonding in metal complexes as well as intermolecular forces.

Contents

1. Dipole Moments and Intermolecular Interactions: Introduction & measurements.
2. Implications of dipole moment in inorganic molecules and dipole-dipole forces.
3. Dipole-induced dipole forces, London (dispersion) forces & other intermolecular forces: hydrogen bonding.
4. VSEPR model followed by VB Theory: for determination of geometries of molecules and ions containing sigma bond as well as pi-bonds.
5. Band theory of metallic bonding Conductors, Insulators and Semiconductors.
6. pi – acceptor Ligands: Transition metal carbonyls (Mononuclear, Binuclear, Polynuclear).
7. The eighteen-electron rule as applied to metal carbonyls.
8. Evaluation of structures based on spectroscopic evidence and Chemistry of metal carbonyls.
9. Applications of metal carbonyls and their derivatives to catalysis and organic synthesis.
10. Organic Reagents used in Inorganic Analysis: Types of reagents, their specific nature and methods of applications with specific examples.
11. Complexometric titrations involving various reagents (EDTA etc).
12. Chelates and chelate effect: Role of organic reagents in different analytical techniques.
13. Gravimetric Estimations (Barium ions and Oxalate ions).
14. Redox titrations (Cu (II) by Potassium iodate, Fe (II) by Ceric sulphate).
15. Preparation of four inorganic compounds in pure state using different techniques of synthesis
    a. *tris* – Etylenediamine Ni(II) chloride dihydrate
    b. Pot. Trioxalatoaluminate (III)
    c. Ammonium Ni(II) sulphate
    d. Hexa aquochromium (III) chloride

Recommended Texts

1. Greenwood, N. N., & Earnshaw, A. (1984). *Chemistry of the elements.* (2nd ed.). U.K.: Elsevier.
2. Sharpe, A. G. (2012). *Inorganic chemistry*. (4th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Kotz, J. C., & Treichel, P. (2018). *Chemistry and chemical reactivity*. (10th ed.). New York: Saunders College Publishing.
2. Cotton, F. A., & Wilkinson, G. (2015). *Advanced inorganic chemistry*. (7th ed.). New York: John Wiley & Sons.

CHEM-6209 Organic Chemistry–II 4 (3+1)

This course (Organic Chemistry-II) focuses on the classification, methods of determination, kinetic and stereochemical aspects of reaction mechanisms of organic reactions. It includes addition (to >C=C<, –C≡C–, >C=O), substitution (nucleophilic & electrophilic) at sp^3&sp^2 hybridized C and elimination reactions. This course is a foundation course for Reaction Mechanism (CHEM-6223, Organic Chemistry major course of semester-VII), Organic Synthesis (CHEM-6240, Organic Chemistry major course of semester-VIII) and Advance Organic Synthesis (CHEM-7146) of MSc and MPhil with organic chemistry specialization. Synthetic organic chemists have the power to replicate some of the most intriguing molecules of living nature in the laboratory and apply their developed synthetic strategies and technologies to construct variations of them. Such molecules facilitate biology and medicine, as they often find uses as biological tools and drug candidates for clinical development. In addition, by employing sophisticated catalytic reactions and appropriately designed synthetic processes, they can synthesize not only the molecules of nature and their analogues, but also myriad other organic molecules for potential applications in many areas of science, technology and everyday life. The practical work involves single step synthesis of small molecules followed by workup, isolation and purification of product.

Contents

1. Introduction and classification of reaction mechanism on different basis. Benefits of thermodynamic and kinetic data towards reaction mechanism.
2. Kinetic *vs* thermodynamic control. Isotopic labeling and trapping of intermediates.
3. Selectivity (Regio-, Chemo- and Stereoselectivity) *vs* Stereospecificity.
4. Addition reactions involving C=C, C≡C and C=O, MOT of C=C and C=O additions.
5. *Syn vs anti* additions, factors affecting addition reactions. Conjugate (1,4-) *vs* direct (1,2-) additions.
6. Electrophilic and nucleophilic substitution reactions at aromatic sytems, Mechanisms involved (Arenium ion, S_E1, simultaneous attack & departure etc.).
7. Nucleophilic substitution reactions (S_N1, S_N2, S_Ni, S_N1', S_N2', S_Ni', S_N1cA, S_N2cA, neighboring group participation / anchimeric assistance etc.) at aliphatic C, Td mechanism.
8. Enol, enolate & enolization, acid/base catalyzed aldol condensations.
9. Alkylation, arylation and acylation of acitve methylene compounds.
10. Conditions, mechanism and synthetic applications of Claisen, Claisen–Schmidt, Knovenagel, Perkin, Reformatsky reactions, Stobbe's condensation, Darzen's glycidic ester synthesis, Mannich and Wittig reactions.
11. Classification of elimination reactions. *Syn* / *anti* and E_1cB eliminations.
12. E_1*vs* E_2, factors affecting eliminations.
13. Free radicals (generation, detection and reactions), application of free radical in industry, role of free radicals in nature and environment.

Organic Chemistry Lab.–I

Estimation of phenol (PhOH) & acetone (Me_2CO), amino (NH_2) groups, synthesis of azodyes, iodobenzene (PhI), iodoform ($CHCl_3$), sulphanilic acid, cinnamic acid, benzil & benzilic acid, ethyl benzene (PhEt).

Recommended Texts

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Pine, S. H. (1987). *Organic chemistry*. New York: McGraw-Hill.
3. Clayden, J., Greeves, N., & Warren, S. (2012). *Organic chemistry*. (2nd ed.). London: Oxford University Press.

Suggested Readings

1. Hendrickson, J. B., Cram, D. J., & Hammond, G. S. (1980). *Organic chemistry.* New York: McGraw-Hill Book Co.
2. Streitwieser, A., Heathcock, C., & Kosower, E. M. (2017). *Introduction to organic chemistry*. (4th ed.). New York: Macmillan.
3. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6210 Physical Chemistry – II 4 (3+1)

Physical chemistry-II is designed to make the students capable of learning in 3 important fields (Quantum Chemistry, Statistical Thermodynamics & Electrochemistry) of Physical Chemistry. The objective includes to make the students understand the foundation of Quantum Chemistry along with derivation of Schrodinger Wave Equation, interpretation of wave function and its mathematical requirements and the application of knowledge to understand the structure of atom & molecules and a glance into sub-atomic phenomenon, properties and occurrences. Classical and quantum treatment of rigid rotor, Stirling approximation. Probability, Statistical treatment of entropy. The Boltzmann distribution law and partition function, partition function and thermodynamics functions like internal energy and entropy and Debye-Huckel Theory are important part of the syllabus to be covered. As course covers three main directions i.e. Quantum Chemistry, Statistical Thermodynamics & Electrochemistry so studying this course will make students capable of applying their knowledge to solve the issue related to the mentioned fields. Students will be able to understand this basic knowledge understand the properties of molecules and their reactions, energetics and probability of an electron to exist. Knowledge will be guiding torch about electrochemical processes and cells too.

Contents

1. Schrodinger's wave equation, postulates of quantum theory.
2. Operators, Eigen value, Eigen function, orthogonality and normalized wave functions.
3. Motion of particle in three-dimensional box and idea of degeneracy.
4. Mathematical treatment of rigid rotator and calculation of bond length of simple molecule
5. Stirling approximation. probability, statistical treatment of entropy. The Boltzman distribution law and partition function.
6. Partition function and thermodynamics functions like internal energy and entropy.
7. Translational, rotational, vibrational and electronic partition function and their comparison).
8. Concept of conductance of electrolytes. Debye–Huckle equation and limiting law.
9. Ionic strength, weak electrolytes and Debye–Huckle theory.
10. Activity and activity coefficients of electrolytic solutions.
11. Determination of activities. Concentration cells. Determination of e.m.f. of concentration cells with and without transference. Fuel cells and hydrocarbon fuel cells.

Physical Chemistry Lab – II

1. Determination of pK_a and K_a value of a weak acid.
2. Molecular mass determination of non-electrolyte solute by cryoscopic method.
3. Determination of number of associated molecule of Benzoic acid in Benzene and to determine the Distribution coefficient of Benzoic acid between H_2O and Benzene.
4. Determination of unknown concentrations of $KMnO_4$ and $K_2Cr_2O_7$ solution spectrophotometrically.
5. Determination of percentage purity of an optically active compound.

Recommended Texts

1. Atkins P.W. (2017). *Physical chemistry.* (11th ed.) UK: ELBS Oxford University Press
2. Lehigh S. M. (2015). *Electrochemistry.* (Vol. 15). UK: Craig Banks Manchester

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd ed.). India: Meerut Krishna Prakashan Media (P) Ltd.
2. Polkinghorne, J. (2002). *Quantum theory: a very short introduction.* UK: Oxford University Press.

SEMESTER-III

a) Compulsory Courses

CHEM-6211 Forensic Chemistry 2 (2+0)

This course provides a comprehensive knowledge about applications of forensic procedures in chemistry. Student will learn about types of evidences and methods to collect them. This course will also provide a detailed knowledge about toxicology and forensic biology. This course explains the principles of operation for common chemistry laboratory instrumentation used in forensic science, using knowledge of chemical structure and properties and instrument design. Furthermore, it will also allow to understand the role of law, ethics, courtroom testimony, quality assurance and professional practice in forensic science. The importance and evidential value of separation and identification techniques, and the scope and limitations of these techniques, is also emphasized in relation to the analysis of forensic samples. Upon successful completion of the course, students will be able to understand the fundamental principles utilized in forensic science and can demonstrate a knowledge of the applications of chemistry and criminal justice in forensic science.

Contents

1. History of Forensic science/forensic chemistry
2. Applications of forensic chemistry in relation to other sciences e.g. Botany, Zoology, Geology, Odontology, Pathology etc
3. Types and classification of evidence, Physical, chemical biological evidence, Classifications of forensic evidences
4. Fingerprint analysis, history, types, latent vs visible fingerprints
5. Chemical tests for latent and visible fingerprints
6. AFIS, fingerprint database.
7. Hair as a forensic physical evidence, composition and structure of hair, differences between human and animal hair and identification.
8. Fiber as a forensic evidence, composition, chemical composition of fiber, microscopic analysis, chemical tests for fiber analysis.
9. Glass as a forensic evidence, Physical and chemical properties of glass, chemical analysis
10. Trace evidences, Physical and chemical properties, qualitative and quantitative
11. Metal analysis
12. Microscopic analysis
13. Trace evidence types, characterization, chemical tests, collection, analysis, exhibiting in court. Analysis of paints, vehicles, fire, bullet and cartridge analysis,
14. Tests for explosive residues, glass comparisons. Anthropometry, body measurement.
15. Toxicology, History, relation with other sciences
16. Introduction to drugs, narcotics, toxins, laws related to poisons
17. Classification of poisons, organic, inorganic and mechanical poisons,
18. Corrosives, irritants, neurotics, and miscellaneous poisons
19. Mechanisms of poisons, methods of administration, routes of excretion. Diagnosis of poisons. Analytical chemistry techniques for drug and poison analysis, narcotics analysis.
20. Serology, forensic analysis of blood patterns, and chemical tests for identifications.
21. Forensic biology and DNA analysis; DNA CODIS databases, PCR, blotting, RE digestion, RFLP, STRs, VNTRs analysis, DNA Fingerprinting, paternity tests.
22. Forensic example cases related to above-said topics

Recommended Texts

1. Bell, S. (2012). *Forensic chemistry.* (2nd ed.). New York, USA: Prentice Hall.
2. Jackson, A. R. W. & Jackson, J. M. (2016). *Forensic science.* (4th ed.). New York, USA: Prentice Hall.

Suggested Readings

1. Khan, J., Kennedy, T. J., & Christian, D. R. (2012). *Basic principles of forensic chemistry*. New Jersey, USA: Humana Press.
2. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.

CHEM-6112 Industrial Chemistry 3 (3+0)

Industry is backbone of the economy of any country and among different industries; chemical industries have versatile novelties in their operation. This course is aimed to provide understanding about upgradation of laboratory processes to commercial scale, installation of industrial units, quality assurance and quality control of a process. Parameters to determine feasibility for installation of an industrial unit, its impact on living organisms and vegetation are also contained in this course. Treatment of industrial effluents, sludge, and smoke are important segments of this course. Significance of research and development in an industry and its need in domestic industries is part of this course. Safety measures including fire extinguishing, saving from toxic chemicals and first-aids in an industry are also part of the course. Chemical reactions, raw materials, process conditions and scope of different industries listed in contents are part of the course. After studying this course, students will have sufficient knowledge about working in any industrial unit as well as one will be able to work at his own.

Contents

1. Chemical processes
2. Unit operations
3. unit process
4. Chemical process control
5. instrumentation
6. Safety
7. Hazards such as fire or toxic materials
8. Research and development
9. Important modern industries, their chemistry and technology
10. Pharmaceutical industry
11. Paper and pulp industries
12. kraft reaction
13. Oil, fats and waxes
14. Soap and detergent industries
15. Water conditioning
16. Flavors
17. food additives
18. Sugar Industry
19. Starch Industry
20. steel Industry
21. Cement Industry

Recommended Texts

1. Shreve, R.N., & Brink, J. A. (1977). *Chemical process industries*. (3rd ed.). New York: McGraw Hill.
2. Witcoff, H.A., & Reuben, B. G. (2012). *Industrial organic chemicals*. (3rd ed.). USA, New York: Wiley.

Suggested Readings

1. Smith, R. (2016). *Chemical process design.* (2nd ed.). New York: McGraw Hill.
2. Relevant Journal Articles

b) Specialization (Total 11 credits)
i) Analytical Chemistry

CHEM-6114 Advanced Spectroscopy – I 4 (3+1)

This course is aimed to provide an advanced knowledge about three spectroscopic techniques, which are widely used in different industries for analytical characterization of samples. Atomic absorption spectrometry is used for elemental analysis of different samples, while atomic emission spectroscopy is used for elemental analysis of hard materials like refractory and ceramics. Among both of these techniques, different atomizers are used to ensure the accurate determination of analyte at low concentrations. Flame emission spectroscopy uses flame as source of excitation and is used for identification of common salts, usually of alkali metals. UV/Visible spectrophotometry is used for analysis of molecular species and is rapid, economical preliminary technique. These techniques are widely used in different industrial units to analyze a wide range of products of daily use, ranging from soil, fertilizer, food, cosmetic and material objects. After learning this course, students will be able to work in any research or industrial laboratory with comprehensive background-knowledge based operational skill.

Contents

1. Atomic Spectrometry: Atomic Absorption and Flame Emission Spectrometry, instrumentation and applications
2. Emission Spectrometry with plasma and electrical discharge sources
3. UV/Visible Spectrophotometry: basic principle, instrumentation and applications.

Analytical Chemistry Lab- III

1. Measurement of λ_{max} and calculation of Molar absorptivity of potassium permanganate.
2. Plotting of calibration graph and measurement of unknown sample concentration.
3. Use of standard addition method in Spectrophotometry.
4. Determination of iron (II) using 1,10-phenanthroline method.
5. Determination of iron (III) using thiocyanate method involving solvent extraction.
6. Determination of phosphate by Spectrophotometry using molybdenum blue method.
7. Determination of Sodium in tap water sample by using Flame photometer.
8. Determination of Potassium in tap water sample by using Flame photometer.
9. Determination of Calcium in chalk sample by using Flame photometer.
10. Determination of Calcium in drinking water by EDTA.
11. Identification of free salicylic acid in aspirin by using TLC.
12. Determination of Methylene blue value of activated charcoal.
13. Determination of iron in tap water by AAS.
14. Determination of copper content in milk samples by AAS.

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.). New York: W.H. Freeman and Company.

Suggested Readings

3. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
4. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2014). *Analytical chemistry.* (7th ed.). New York, USA: Wiley.

CHEM-6115 Advanced Chromatographic Techniques 3 (3+0)

This course is aimed to provide an advanced level information for students opting analytical chemistry as field of specialization. It provides comprehensive overview of two commonly used chromatographic techniques ranging from fundamental principles, instrumentation and applications for analysis of different types of samples. Gas chromatography is used for analysis of gaseous samples like petroleum products, air samples, dust, industrial smoke, and perfumeries. High performance liquid chromatography is used for analysis of liquid samples or solutions like foods, pharmaceuticals. Students will be able to learn optimization of different parameters affecting the quality of separation. Van-Deemter equation gives insight about all the factors contributing towards plate height and decrease efficiency of separation. By learning the course, students would be able to predict the material to be used as stationary phase, mobile phase, length and width of chromatographic column. This will be able to develop cost-effective methods saving time and cost of analysis, which is fundamental target of any industry.

Contents

1. Gas–Liquid chromatography
2. Fundamental principles, instrumentation
3. Types of samples
4. Analysis of gaseous samples
5. Petroleum products Analysis
6. Air samples Analysis
7. Dust Analysis
8. Industrial smoke Analysis
9. Perfumeries
10. HPLC - Analyses
11. Foods Analysis
12. Pharmaceuticals.
13. Concepts of theoretical plates
14. Van–deemter equation
15. High–performance liquid chromatography,
16. Instrumentation
17. Applications of these techniques

Recommended Texts

1. Robinson, J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.). Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2014). *Analytical chemistry.* (7th ed.). New York, USA: Wiley.

CHEM-6216 Instrumental Methods of Analysis 3 (3+0)

This course is aimed to provide a comprehensive overview of different instrumental techniques of industrial significance. For rapid, economical and accurate analysis, electroanalytical techniques are the techniques of choice; amongst which potentiometry is an economical technique with comparable results. Ion-selective electrodes are used for determination of any specific ions in a sample without any interference of matrix. In this course, significance of different electrodes used in potentiometry, methods for development of new electrodes and their representative applications are included. Fluorescence and phosphorescence spectroscopic techniques are electromagnetic techniques used for analysis of atomic and molecular species, on the basis of luminescence characteristics of sample. Efficiency and applications of these luminescence techniques will be compared with UV/Visible spectroscopic techniques. Basic principles, instrumentation, recent advances, limitations, domains and scope of each of these techniques is contained in this course. After studying this course, students will be able to work on these instruments in any of the research or industrial laboratories.

Contents

1. Potentiometry
2. Nernst equation
3. Significance of different electrodes
4. Development of new electrodes
5. Reference electrodes
6. Ion-selective electrodes
7. Glass electrodes
8. pH measurements
9. Potentiometric titrations
10. Fluorescence spectrometry
11. Phosphorescence spectrometry
12. Molecular Fluorescence
13. Atomic Fluorescence
14. Basic principles
15. Applications
16. Structural factors
17. Measurements
18. Comparison of Luminescence
19. UV–Visible absorption methods.

Recommended Texts

1. Robinson J. W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.). Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical chemistry.* (4th ed.). New York: John Wiley & Sons.

ii) Biochemistry

CHEM-6217 Bioenergetics and Metabolism 4 (3+1)

This course aims at providing a better understanding of metabolic pathways, their control mechanisms and disorders. This course includes both theory and practical modules that are offered to the students who have adapted Biochemistry as a major or minor subject. This course focuses on the metabolic pathways in living cells from prokaryotes to Eukaryotes, and how these pathways are regulated and disturbed in disease state, and how metabolic energy is obtained and transduced to meet a cell's requirements. This focus will allow calculations of bioenergy produced and assimilate in the metabolic pathways and will enhance the knowledge of students about how these pathways are integrated. Students will learn about enzymes involved in metabolic reactions and their reaction mechanisms, regulation of metabolic routes for energy production in form of ATP and diseases related to metabolic dysfunctions. Student will also be able to enhance their knowledge about metabolic diseases and their treatments.

Contents

1. Principles of Bioenergetics and Biochemical, Types of reaction involved in metabolism,
2. Carbohydrate Metabolism: Glycolysis; mechanism of reactions of enzymes.
3. Regulation of glycolysis. Reaction energy calculations.
4. Net ATP consumption.
5. Gluconeogenesis; dedicated reaction, regulations and net energy calculations.
6. Fermentation
7. Pentose Phosphate Pathway; relationship to glycolysis, gluconeogenesis
8. Metabolism of carbohydrates other than glucose; fructose, galactose, mannose starch and Glycogen.
9. The Citric Acid Cycle; regulations, reaction mechanism.
10. Fatty Acid Metabolism; Beta oxidation of even and odd chain fatty acids, Lipid Biosynthesis
11. Oxidative Phosphorylation, Electron transport chain and Photophosphorylation.
12. Protein Metabolism; amino Acid Oxidation and production of Urea,
13. Biosynthesis of Amino Acids
14. Nucleotide metabolism, Synthesis and degradation.
15. Integration and Hormonal Regulation of Mammalian Metabolism

Biochemistry Lab-II

1. Isolation of serum and plasma from human blood
2. Estimation of fasting/random glucose levels in human serum by colorimetric methods (DNS method, glucose peroxidase method).
3. Estimation of Hemoglobin in human blood.
4. Estimation of total protein serum/urine proteins by Colorimetric method.
5. Estimation of nitrogen content by microkjeldahl method.
6. Estimation of urea, creatinine triglycerides Glutathione, ammonia and cholesterol in human serum/urine.
7. Liver function tests using human serum/urine and chicken liver sample.
8. Determination of antioxidant and lipid profiles of human serum
9. Determination of vitamin contents i.e. Ascorbic acid in food samples

10. Estimation of Sodium (Na+), Potassium (K+) and Chloride (Cl-) from serum using flame photometer.
11. Estimation of heavy metals in human serum using atomic absorption.
12. Isolation and enzymatic hydrolysis of Glycogen from Liver
13. Sterilization and Preparation of culture media i.e use of autoclave
14. Steak, pour and spread plate methods sing a wire loop and spreader
15. Testing sensitivity to antimicrobial substances, Preparing serial dilutions of cultures
16. Use of microscope and differential staining: Gram's staining method
17. Online resources for metabolic pathways i.e. KEGG, MetaCyc

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
3. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.

Suggested Readings

1. Swaminathan, R. (2011). *Handbook of clinical biochemistry.* (2nd ed.). Singapore: World Scientific Publishing Company.
2. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.

CHEM-6218 Microbiology & Industrial Fermentations 3 (3+0)

This course is offered to the students who have adapted Biochemistry as a major subject and provides a comprehensive understanding of industrial applications of microorganisms in production and fermentation processes. This course also provides technical information on fermenter design, operation and growth kinetics of microbes involved in the fermentation processes. Types of fermentations and the commercial products derived from microbes are also discussed in this course. Students will get hands on experience in the microbial production of biopolymer, enzymes, bioactive compounds and biomass. Based on the skills acquired in this course, graduate students would have a mini project / review writing/ assignment as an additional component. Upon the completion of course, students will be able to have a better understanding of microorganisms, their classification, identification and characterization techniques. Students will also learn about industrial fermentation processes involved in production of Cheese, Alcohol, Citric acid, Acetic acid and Antibiotic synthesis. The students will also be able to discuss the role of microorganisms in industry, as well as to carry out experiments to produce microbial metabolites.

Contents

1. Definitions and Scope of Microbiology and fermentation.
2. Classification, methods of isolation, microscopic examination, general morphology and cytology of microorganisms.
3. General effects of environments on microorganisms.
4. Nutrition of microorganisms.
5. Growth (Normal growth Cycle and Continuous Culture) and Reproduction, Pure culture Study.
6. Introduction to industrial microbiology and chemical biology.
7. Industrial Uses of Bacteria, Molds, Yeast and viruses.
8. Microbial production of Cheese, Alcohol, Citric acid, Acetic acid, Antibiotic, enzyme production, Fermented Foods, Vinegar production, Amino Acid.
9. Petroleum Microbiology and Deterioration of Materials. (Paper, Textile and Cordage, Painted Surface).
10. Microbial assays

Recommended Texts

1. Willey, J., Sherwood, L., & Woolverton, C. J. (2017). *Prescott's microbiology.* (10th ed.). New York, USA: Prescott Publishers.
2. Dawis, B. D., Dulbecco, R., Eisen, H. N., & Ginsbery, H. S. (2002). *Microbiology.* New York, USA: Harper & Row.

Suggested Readings

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

CHEM-6219 Enzymes and Nutrition 3 (3+0)

This course provides insight about the function, classification and characterization of enzymes in terms of kinetics and reaction mechanism. Studying the enzyme kinetics provide a better understanding of enzyme catalytic efficiency and inhibition. This course also provides structural and functional characteristics of macronutrients (carbohydrates, lipids, proteins) and micronutrients (vitamins) in food consumed by humans. Students will learn about the biochemical mechanisms associated with the digestion and assimilation of macronutrients, and are introduced to analytical techniques in food biochemistry. Enzymes involved in food metabolism will also be explained to the students. Upon the completion of this course, students will be able to have a better understanding of classification of food, metabolic rates, micro- and macro- nutrients and their deficiencies. Students will obtain the basic knowledge about the relationship between properties and structure of the enzymes, their mechanism of action and kinetics of enzymatic reactions. Students will obtain basic knowledge about the relationship between properties and structure of the enzymes, their mechanism of action and kinetics of enzymatic reactions.

Contents

1. Enzyme Structure and Functions: Chemical nature, nomenclature and classification of enzymes
2. Cofactors, effect of different factors on enzyme activity
3. Kinetics Studies of substrate reactions. (Michaelis- Menten Equation and Lineweaver-Burke Plot)
4. Quantitative assay of enzyme activity, substrate specificity
5. Enzyme substrate interactions and nature of the active site
6. Models of enzyme substrate complex
7. Mechanism of enzyme action with specific reference to Chymotrypsin and nuclease
8. Inhibition, Competitive, uncompetitive, non-competitive and irreversible inhibition
9. Regulatory enzymes: Allosteric enzymes, Multi-enzyme systems, Zymogens
10. Isoenzymes Non-Protein Bio-catalysis Ribosome's, (RNA as Enzyme)
11. Enzymatic control of metabolic pathways
12. Therapeutic uses of Enzyme and Immobilized enzymes.
13. Nutrition: Classification of Food, Source of Nutrients, Respiration
14. Caloric value of food, Calorimetry, Respiratory Quotient, Basal metabolic rate (BMR)
15. General Factor, chemical composition, functions
16. Deficiency symptoms and requirements of Nutrients and their biological values
17. Balanced diet, Role of nutrition in growth, development and Chronic disease.

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

Suggested Readings

1. Murray, R. K., Grammer, D. K., Mayes, P. A., & Rodwell, V.W. (2000). *Harper's biochemistry*. (25th ed.). New York, USA: Appleton & Lange.
2. Stryer, L. (2010). *Biochemistry*. (7th ed.). New York, USA: Freeman & Co.

iii) Inorganic Chemistry

CHEM-6220 Advanced Inorganic Chemistry 4 (3+1)

In the course, the chemistry of first and second row elements will be discussed along with the anomalies in their general properties. The concept of extended valence among non-metals will be explained by involvement of d-orbital in bonding. The stability and reactivity of certain compounds depends on the pi-bonding whether applying p-orbitals or both p- and d-orbitals. Different factors affecting this stability will be discussed. Moreover, nuclear chemistry will be discussed in detail along with the reactions where nuclear species are emitted or used for bombardment provides the basis for nuclear reactions. Physical methods like TGA, DTA and DSC are very useful in determining texture and inside structures of solid substances. Students will be able to explain the stereochemistry, nuclear chemistry and thermal methods of analysis by learning this course. After the successful completion of this course, students will be able to learn the chemistry of nuclear reactions, nuclear reactors, bonding in compounds and thermal methods of analysis.

Contents

1. Stereochemistry periodicity: concepts of stereochemistry and periodicity
2. Periodic properties, introduction and anomalies of first and second row elements
3. The use of d-orbitals by non-metals, reactivity and d-orbital participation
4. The use of p-orbitals in pi-bonding and periodic anomalies of non-metals
5. Physical methods of analysis in inorganic chemistry
6. Nuclear chemistry: introduction and classification of nuclides
7. Radioactivity, radioactivity series and artificial radioactivity
8. Units of radioactivity and determination of half-life
9. Nuclear fission and fusion reactions, applications of radio isotopes as traces.
10. Structure of inorganic solids: introduction, the close packing of spheres, the structure of ionic solids, ionic radii, crystal's structures and defects
12. Thermal methods of analysis: introduction, instrumentation and applications

Inorganic Chemistry Lab- III:

Use of some organic reagents for the estimation of various elements:

a) 8–Hydroxyquinoline for Al (III) and Fe (III)
b) Salicyladoxine for Ni (II) in presence of Cu (II)
c) Anthranilic Acid for Co (II) and Zn (II) d) Pyrogallol for Bi^{3+}

2. Chromatographic Techniques – Column, Thin layer and Paper chromatographic techniques for the qualitative separation of inorganic compounds
4. Applications of Solvent extraction and ion exchange technique
5. Synthesis of following Inorganic compounds / Complexes in a pure state and determine their state of purity: a. $[Co(NH_3)_5Cl]Cl$ b. $[Co(NH_3)_5NO_2]Cl_2$. c. $[Co(NH_3)_5ONO]Cl$, d. $[Co(en)_3]Cl_3$

Recommended Texts

1. Huheey, J. E., Keiter, E.A., Keiter, R. L. & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.
2. Cotton, F.A., & Wilkinson, G. (2015). *Advanced inorganic chemistry*. (7th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Atkins, P., & Overton, T. (2010). *Shriver and Atkins' inorganic chemistry*. New York: Oxford University Press.
2. Sharpe, A. G. (2012). *Inorganic chemistry*. (4th ed.). New York: John Wiley & Sons.

CHEM-6221 Organometallic & Bio-inorganic Chemistry 3 (3+0)

Bioinorganic chemistry is a field that examines the role of metals in biology. Bioinorganic chemistry includes the study of both natural phenomena such as the behavior of metalloproteins as well as artificially introduced metals, including those that are non-essential, in medicine and toxicology. Interaction of various inorganic compounds with the biological species enables the scientist to design and formulate medicines for different diseases. Preparation of organometallic compounds by using different reaction conditions will also be discussed to lead a new era of research for preparation of stable metal complexes having metal-carbon bonding. Moreover, the role and interaction of different metal ions will also be discussed in living organisms. Further, the metal--carbon bonding unlike carbon-carbon bonding provides basis for catalysis. Starting from polymerization of ethylene by Zeigler and Natta leading to industrial revolution, the recent M-C bond chemistry has been studied in detail to materialize those reactions which otherwise are not possible. The fundamental rules like Eighteen-electron-rule explain the stability of organometallic compounds.

Contents

1. Nature of metal-carbon bonds
2. Compounds with metal-carbon single bonds
3. Compounds with metal-carbon π- bonds
4. Classification of organometallic compounds
5. Compounds of transition metals: single, double and triple bonds to carbon
6. Compound and types of acyls, alkylidene complexes
7. Compound of alkylidyne complexes
8. Delocalized hydrocarbon systems (alkene, olefins, allyl and butadienes)
9. Alkyne complexes and cyclic π complexes (four, five and six member rings)
10. Fundamental processes in reactions of organotransition metal complexes
11. Ligand coordination and dissociation
12. Oxidative addition
13. Reductive eliminations
14. Insertion & extrusion reactions: reaction of coordinated ligands
15. Applications of organometallic compounds in synthetic chemistry
16. Applications of organometallic compounds in industry.
17. Bio-inorganic chemistry: introduction
18. Bio-inorganic chemistry: Environmental intrusion
19. Role of inorganic species in vivo
20. main group ions (Na^{+}, K^{+}, Ca^{++}, Mg^{++})
21. Trace elements: general roles, lanthanides & actinides, Zn, Cu, Cr, Mo, W, Co, Si, Se, Sn, I.
22. Storage and transport of iron
23. Metalloenzymes

Recommended Texts

1. Huheey, J.E., Keiter, E.A., Keiter, R.L., & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.
2. Roat-Malone, R. M. (2007). *Bioinorganic chemistry: a short course*. New York: John Wiley & Sons.

Suggested Readings

1. Hill, A.F., & Hill, A. (2002). *Organotransition metal chemistry*. Cambridge, U.K.: Royal Society of Chemistry.
2. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin, Germany: Springer.

CHEM-6222 Inorganic Polymers & Chemical Forces 3 (3+0)

This course aims to understanding of general concept of polymerization, types of polymerization, inorganic polymers, their properties, stability and applications. Inorganic polymers are polymers with a skeletal structure that does not include carbon atoms in their backbone. Polymers containing inorganic and organic components are sometimes called hybrid polymers, and most so-called inorganic polymers are hybrid polymers. Most of the ceramic material in use in routine life has its origin from inorganic polymers. Blending of metal cluster compounds with carbonates, borates or phosphates gives rise to a wide range of tensile material equally applicable in ceramic appliances and other industrial reaction vessels. The material strength is governed more by a study of the forces responsible within substances for inter- and intra-molecular bonding. After the successful completion of this course, students will be able to synthesize the inorganic polymers of desired properties, elaborate the stability and structure of inorganic polymers and the factors affecting their properties.

Contents

1. Inorganic Polymers: Molecular species
2. Polymeric sulphur and nitrogen compounds
3. Borazines
4. Phosphazines
5. Types and applications of phosphazines
6. Boranes
7. Carboranes
8. Silicones
9. Classification of silicones
10. Polyionic species: Isopropyl ions
11. Heteropoly anions of transition elements
12. Polysilicates
13. Polyphosphates
14. Metal cluster compounds
15. Chemical Forces: Internuclear distances and atomic radii
16. Types of chemical forces
17. Effects of chemical forces on physical properties
18. Hydrogen bond
19. Bonding in Clathrates
20. Urea adducts
21. Effects of Chemical forces

Recommended Texts

1. Miessler, G.L., & Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York: Pearson Education, Inc.
2. Jordan, R.B. (1998). *Reaction mechanisms of inorganic and organometallic systems*. (2nd ed.). U.K.: Oxford University Press.
3. Sharpe, A.G. (2012). *Inorganic chemistry*. (4th ed.). New York: John Wiley & Sons.

Suggested Readings

1. Huheey, J.E., Keiter, E.A., Keiter, R.L., & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.
2. Hill, A.F., & Hill, A. (2002). *Organotransition metal chemistry*. Cambridge, U.K.: Royal Society of Chemistry.
3. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin, Germany: Springer.

iv) Organic Chemistry

CHEM-6223 Reaction Mechanism 3 (3+0)

This course is the continuity of study of organic reaction mechanisms (CHEM-6209) in which rest of the polar mechanism (redox, molecular rearrangements and pericyclic cyclization) are addressed. The chemistry of reactive intermediates (carbenes, nitrenes, arynes) are also focused in this course. This course is a foundation course for Organic Synthesis (CHEM-6240, Organic Chemistry major course of semester-VIII) and Advance Organic Synthesis (CHEM-7146) of MSc and MPhil, respectively, with organic chemistry specialization. The reaction mechanism of a chemical reaction is a step-by-step description of the course on which the starting materials are converted into the products. The course is described on a molecular level and contains information about the position of all atoms and electrons of the reactants (including the solvent, etc.) at each point of the reaction course (called reaction coordinate) and, thus, about all the shiftings and movements of electrons and atoms. At the end of this course the student's shall be able to predict the mechanism of reaction and the synthetic methodologies of small organic molecules.

Contents

1. Oxidation state of organic compounds. Oxidation of C=C. Mild oxidation of 1º-ols → CHO, 2º-ols → ketone.
2. Harsh oxidation of alcohols, amines, nitriles.
3. Reduction involving metal/metal complexes (Wilkinson's *vs* Crabtree catalysts), hydride ($NaBH_4$, $LiAlH_4$, DIBAlH, Red-Al and their derivatives) reductions and reductions involving single electron transfer (SET).
4. Classification of molecular rearrangements.
5. Mechanism of intramolecular 1,2–shifts involving migration of a group from C to C, C to N, N to C, C to O and O to C.
6. Mechanism and examples of Wagner–Meerwein, Pinacol–Pinacolone, Benzidine–Benzillic acid, Favorski, Wolf, Beckmann, Hofmann, Curtius, Lossen, Schmidt, Steven, Baeyer–Villiger, Dakin and Fries rearrangements.
7. Introduction and classification, Hoffman, Fukii, Mobius–Huckle approaches of electrocyclization and cycloadditions involving 4n/4n+2 π electrons
8. Diels-Alder, Alder-ene and 1,3-dipolar additions
9. Sigma tropic reactions, Ireland-Claisen rearrangement.
10. Structure, methods of generation, detection, reactions and synthetic applications of carbenes, nitrenes and arynes.

Recommended Texts

1. Smith M. B., & March, J. (2019). *March's advanced organic chemistry*. (8th ed.). New York: John Wiley.
2. Morrison, R. T., & Boyd, R. N. (1987). *Organic chemistry*. Boston: Allyn & Bacon.
3. Clayden, J., Greeves, N., & Warren, S. (2012). *Organic chemistry*. (2nd ed.). London: Oxford University Press.

Suggested Readings

1. Streitwieser, A., Heathcock, C., & Kosower, E. M. (2017). *Introduction to organic chemistry*. (8th ed.). New York: Macmillan.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.
3. House, H. O. (1972). *Modern synthetic reactions*. California: Benjamin.

CHEM-6224 Spectroscopic Methods in Organic Chemistry 4 (3+1)

This course (Spectroscopic Methods in Organic Chemistry) focuses on the physical methods of characterization of isolated natural products (animal, fungal, marine and terrestrial sources), derivatives of natural products, bio/synthetic polymers and synthetic organic molecules of pharmacological importance. The new molecular entities isolated/synthesized are studied by these methods, which require only 5-10 mg quantity of the analyte as compare to chemical methods of analyses, to elucidate their molecular structure. This course does not cover the medical aspects of spectroscopy (commonly called Radiology) in broader spectrum. In fact, this course is a foundation course for Advance NMR (CHEM-7140) and advance MS (CHEM-7147) courses of MPhil with organic chemistry specialization. The practical work involves the synthesis of a few small molecules in the laboratory by a reported protocol followed by workup, purification (involving crystallization, partitioning, solvent extraction, chromatography etc.) and comparative study of IR, UV, NMR and MS spectra of substrate and product(s).

Contents

1. Basic principle & EMR, spectral regions (bands), allowed and forbidden transitions, spectrum.
2. Application of Schrödinger wave equation to rotational and vibrational transitions.
3. Basic principle, instrumentation and interpretation of IR spectroscopy. Classification of IR band on the basis of functional groups, applications of IR spectroscopy.
4. Mathematical relationship between absorbance (A) and transmittance (T) in UV-Vis spectroscopy. Bathochromic and hypsochromic shifts, factors affecting λ_{max}.
5. Woodward-Fieser rule for calculating λ_{max} of conjugated dienes, carbonyls and acyclic systems. Absorption by aromatic compounds. Applications of UV-Visible spectroscopy
6. Difference between spectroscopy and spectrometry, radical cations, radical anions and cabonium ion.
7. Parts of a mass spectrometer (MS); basic principle, instrumentation, different methods of ionization in MS (EI, APCI, FAB(+), FAB(-), ESI, MALDI).
8. Modes of fragmentation of various functional groups of organic molecules, Low resolution and high-resolution mass spectrometry, radioactive abundance and ratio of isotopes of C, Cl, Br, S & P.
9. Determination of molecular mass, molecular formula and molecular structure, Interpretation of a mass spectrum.
10. NMR active nuclei, basic principle (Spin flipping, Spin relaxation)
11. Chemical shift (δ in ppm), factors affecting it
12. Coupling constant *(J* in Hz), factors affecting it
13. Spin-spin splitting, multiplicity (*s, d, t, q, dd, ddd, dddd*) of ^{1}H signals. Interpretation of ^{1}H-NMR spectra.
14. Structure elucidation of organic compounds by joint applications of IR, UV, ^{1}H-NMR spectroscopy and Mass spectrometry.

Spectroscopic Methods in Organic Chemistry Lab.

1. Experimental techniques e.g. distillation, solvent extraction, chromatography etc.
2. Multi-step synthesis of some organic compounds
3. Estimation of glucose and number of acetyl groups

Recommended Texts

1. Williams, D., & Fleming, I. (1995). *Spectroscopic methods in organic chemistry*. New York: McGraw-Hill.
2. Younas, M. (2005). *Organic spectroscopy*. Lahore: A. H. Publisher.

Suggested Readings

1. Anderson, R. J., Bendell, D., & Groundwater, P. (2004). *Organic spectroscopic analysis – a tutorial chemistry texts (serial-22)*. Cambridge: RSC Publisher.
2. Kemp, W. (1990). *Spectroscopy*. London: Macmillan.
3. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6225 Organometallics 3 (3+0)

The Inorganic Chemistry-I (CHEM-6103/6203) of BS/MSc curricula is the foundation course for having a keen understanding of this course. The organometallic chemistry is the study of organometallic compounds, chemical compounds containing at least one chemical bond between a carbon atom of an organic molecule and a metal, including alkaline / alkaline earth / transition metals and sometimes broadened to include metalloids like boron, silicon and tin as well. Some related compounds such as transition metal hydrides and metal phosphine complexes are often included in discussions of organometallic compounds but they are not necessarily organometallic
This course shall highlight the important transformations of organoboranes, ylides (organophosphorous & organosulphur only) in addition to organotransition-metal (Li^{+}, Mg^{2+}, Cu^{+}, Zn^{0}, Zr^{0}, Sn^{4+}, Pd^{0}, Pd^{2+}, Ru^{3+} etc.) species with an emphasis on their synthesis, basic mechanism of action/catalysis, structure-reactivity relationships and applications in organic synthesis. This course shall serve as foundation course for core understanding of a postgraduate course (Organometallic Chemistry, CHEM-7149).

Contents

1. Historical perspective of organometallics
2. The eighteen-electron rule, classification of organometallics
3. Compounds with M–C & M=C
4. Ligand coordination & dissociation, oxidative addition and reductive elimination
5. Transmetallation, carbonylation, insertion and extrusion reactions
6. Preparation and applications of s-block organometallics; organoLi, organoMg (Grignard's reagent)
7. Preparation and applications of organoCu, orgnaoZn and organoPd in synthetic organic chemistry with special focus on stereochemical outcome.
8. Brief introduction to organoSn, organoB, organoSi, organoS and organoP chemistry.

Recommended Texts

1. Huheey, J. E., Keiter, E. A., & Keiter, R. L. (2016). *Inorganic chemistry: principles of structure and reactivity*. (4th ed.). New York: Harper and Row.
2. Hill, A. F. (2012). *Organotransition metal chemistry*. New York: Wiley-Interscience.
3. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin: Springer-Verlag.

Suggested Readings

1. Spessard, G. O., & Miessler, G. L. (1997). *Organometallic chemistry*. New York: Prentice Hall.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

v) Physical Chemistry

CHEM-6226 Surface Phenomena 4 (3+1)

This course is about the colloids and surfactants. In this course, main focus is on surface tension, adsorption isotherms, Freundlich, Langmuir and BET isotherms, surfactants, micellization, methods of preparation of gels and emulsions, precipitation in gels, Liesegang rings, emulsifiers and breaking of emulsions. Moreover, orientation theory, sols and their preparation, properties of sols, optical properties of sols, determination of particle size, kinetic properties of sols, sedimentations of suspensions, electrical properties of sols electrophoresis and electroosmosis and stability of suspensions, molecular wt. determination of macromolecules are also part of this course. Course is designed in a way that student may be able to prepare colloids (sols, emulsions and gels) by different physical and chemical methods and use them in research and application fields. Knowledge about different adsorption isotherms and the factors affecting adsorption process gives detailed understanding of sorption mechanism which leads their command to prepare efficient sorbents to remove pollutants and contaminations and to purify water etc.

Contents

1. Surface tension, adsorption isotherms, Freundlich, Langmuir and BET isotherms
2. Adsorption at liquid surface
3. Surfactants, micellization
4. Methods of preparation of gels and emulsions, Classification structure of gels, Thixotropy
5. Precipitation in gels. Liesegang rings. Emulsifiers, Breaking of emulsions
6. Orientation theory. Emulsification and wetting, Significance
7. Sols and their preparation, properties of sols, optical properties of sols
8. Determination of particle size.
9. Sedimentations of suspensions,
10. Electrical properties of sols electrophoresis and electro osmosis
11. Stability of suspensions. Precipitation of sols
12. Molecular wt. determination of macromolecules
13. The cause of semi-permeability
14. Mechanism of osmotic pressure.
15. Determination of the molecular weight by osmometry

Surface Phenomena Lab

1. Determination of heat of solution of a substance by solubility method.
2. Determination of empirical formula of Ferric-salicylic acid complex calorimetrically.
3. Determination of order of reaction and the rate constant of a given reaction.
4. Verification of Freundlich isotherm for organic acids.
5. To prepare As_2S_3 sol.
6. Determination of activity coefficients by measuring electromotive force.
7. Determination of Molar extinction coefficient.

Recommended Texts

1. Kontogeorgis, G. M., & Kiil, S. (2016). *Introduction to applied colloid and surface chemistry.* New York: John Wiley & Sons Inc.
2. Thomas, J. M., & Thomas, W. J. (2015). *Principles and practice of heterogeneous catalysis.* Germany: Wiley-VCH Verlag GmbH.

Suggested Readings

1. Somorjai, G. A., & Yimin, L. (2010). *Introduction to surface chemistry and catalysis.* New York: John Wiley & Sons Inc.
2. Cosgrove, T. (2010). *Colloid science: principles, methods and application.* New York: John Wiley & Sons Inc.
3. Pashley, R., Karaman, M. (2004). *Applied colloid and surface chemistry.* New York: John Wiley & Sons Inc.

CHEM-6227 Molecular Spectroscopy 3 (3+0)

The objective of this course is to comprehend the basics of spectroscopic techniques in a precise and compact way and to understand its foundation based on equations of quantum mechanics. Course focuses on classification of spectroscopy, rotational spectra of rigid linear molecules, harmonic and inharmonic oscillator models for the energy of a diatomic molecule, types of vibrational modes, interpretation of IR spectra of simple molecules. Moroever, a comprehensive and detailed knowledge about fermi resonance, applications and sampling techniques, H–atom spectrum, energies of atomic orbital, electronic angular momentum and the fine structure, Raman & Rayleigh scattering and vibrational Raman spectrum and nuclear magnetic resonance spectroscopy will be discussed in detail. The student will learn about updated skills of analysis at laboratory as well as at industry. Analysis by different techniques and the deep insight of interaction of electromagnetic radiation with matter reveals the phenomena occurring and the interpretation of meaningful signals to conclude quantitative and qualitative analyses is a part of this course. After studying this course, students will be able to analyze samples through different spectroscopic techniques and they will be able to understand the way to interpret the meaning of signals for qualitative and quantitative analysis.

Contents

1. Classification of spectroscopy.
2. Rotational spectra of rigid linear molecules
3. Determination of bond lengths
4. The stark-effect
5. Harmonic and inharmonic oscillator models for the energy of a diatomic molecule
6. Types of vibrational modes
7. Interpretation of IR spectra of simple molecules
8. Fermi resonance, applications and sampling techniques
9. Types of electronic transition
10. H–atom spectrum, energies of atomic orbital
11. Electronic angular momentum and the fine structure
12. Idea of Raman scattering
13. Rayleigh scattering and molecular polarizability
14. Rotational Raman spectra of linear molecules
15. Symmetric top molecules and spherical top molecules
16. Vibrational Raman spectra
17. Nuclear magnetic resonance spectroscopy

Recommended Texts

1. Castellan G. W. (2004). *Physical chemistry* (3rd ed.). Delhi, India: Norasa Publishing House.
2. Banwell, C. N., & McCash, E. M. (1994). *Fundamentals of molecular spectroscopy*. (2nd ed.). UK: The Bath Press Avon.

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd ed.). India: Meerut Krishna Prakashan Media (P) Ltd.
2. Related Research Papers

CHEM-6228 Statistical and Quantum Mechanics 3 (3+0)

This course is designed for the students opting Physical Chemistry as a part of their field of specialization to teach the students the detailed objectives, theory, mathematical calculations of Statistical and Quantum mechanics. It enables the students to apply the concepts of Quantum chemistry on very simple and some of the complex molecules. Quantum chemistry is a very powerful tool for studying the properties of molecules and phenomena involved during the reactions taking place between the molecules. The recent years, development in quantum chemistry methods, especially in theoretical methods has made it possible for quantum chemistry calculations to reach accuracies comparable to those obtained in experiments for molecules of moderate sizes. This is further facilitated by the rapid development of computer technologies that has greatly encouraged the chemists to use quantum chemistry to understand, simulate model, and predict molecular properties and their reactions, properties of nanometer materials and processes taking place in biological systems. While doing so the statistical mechanics plays the role of a bridge between the two concepts.

Contents

1. Statistical ensembles
2. Probability
3. Description of various systems
4. Concept of states
5. Accessible states and distribution
6. Maxwell's Boltzmann's statistics (MBS) of the systems of independent particles
7. Applications of partition functions of two chemical equilibrium and chemical kinetics
8. Bose-Einstein statistics (BES)
9. Fermi-Dirac statistics (FDS)
10. Operators and their properties, angular momentum
11. Central field problem, Hydrogen like atoms
12. Approximate methods
13. Perturbation method and variation principle
14. Valence bond theory (VBT)
15. Molecular Orbital theory (MOT)

Recommended Texts

1. Bogolubov, N. N., & Bogolubov, N. N. Jr. (2009). *Introduction to quantum statistical mechanics*. (2nd ed.). Russia: Wiley.
2. Atkins P.W., & Friedman, R. S. (2010). *Molecular quantum mechanics.* UK*:* Oxford University Press.

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd ed.). India. Meerut Krishna Prakashan Media (P) Ltd.
2. Atkins P.W. (2017). *Physical chemistry.* (11th ed.). London: Oxford University Press.
3. William C., & Schieve, W. C. (2009). *Quantum satistical mechanics*. UK: Cambridge University Press.
4. Polkinghorne, J. (2002). *Quantum theory: a very short introduction.* UK: Oxford University Press**.**

SEMESTER-IV

- **Compulsory Courses**

CHEM-6229 Environmental Chemistry 3 (3+0)

This course is aimed to familiarize the students about components of environment, their origin, composition, chemical reactions, fate, and sink. Distribution of water, chemistry of surface, fresh, marine and underground water is part of hydrosphere. Lithosphere deals with the ores, mines, and minerals contained in soil; their determination and extraction are part of this course. Types of soil, chemical composition and reactivity of soil components is also included in this course. Composition of Origin and sources of different pollutants, their reactivity and toxicity in environment, measures to control them are also included in the course. Role of different pollutants in causing acid rain and its impact on quality of life is also part of the course. Source of gases imparting greenhouse effect, its significance, impact on vegetation and environment and artificial greenhouse are part of the course. After studying the course, students will be able to work with any environmental protection organization or sanitation agency. Different techniques for characterization of environmental samples are also included. The acquired knowledge will be helpful for skill development and career building of students, especially in environmental sciences.

Contents

1. The Human Environment
2. The litho, bio and hydrosphere
3. The nature and composition of natural waters
4. Water pollution
5. Chemistry of soil
6. Composition of the atmosphere
7. Oxides of carbon, sulphur and nitrogen in air pollution
8. Atmospheric Monitoring
9. Instrumental methods of environmental chemistry
10. Ozone demolition
11. Acid rain
12. Green House Effect

Recommended Texts

1. Manahan, S.E. (2017). Environmental Chemistry. (7^{th} ed.). New York: CRC press.
2. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7^{th} ed.). New York: Marcel Dekker.
3. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9^{th} ed.) New York: W.H. Freeman and Company.
4. Christian, G. D., Dasgupta, P. K., & Schug, K.A. (2013). *Analytical Chemistry.* (4^{th} ed.). New York, John Wiley & Sons.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9^{th} ed.). Philadelphia: Saunders College Publishing.

b) Specialization

i) Analytical Chemistry

CHEM-6230 Advanced Spectroscopy –II 4 (3+1)

This course gives comprehensive overview about principle, instrumentation and applications of two important spectroscopic techniques. Mass spectrometry is used for determination of elemental composition of samples as well as for molecular analysis, determination of exact molecular mass of a compound using isotopic masses and is ultimate technique for structure elucidation of a compound. Components and operational skills of high-resolution mass spectrometers providing very accurate information are also part of this course. Spectroscopic techniques based on X-rays include X-ray diffraction, X-ray fluorescence, X-ray absorption, X-ray emission and X-ray crystallography; each of these have their typical applications with different detection devices. X-rays find wide application in medical diagnostics, internal structure of large molecules, security check of packed baggage. X-ray crystallography is used for 3-D structure determination of single crystals. X-ray fluorescence spectrometers are used in cement industry. After studying this course, students will be able to work on these instruments in any research or industrial laboratory, independently.

Contents

1. Mass Spectroscopy: Principle of Mass spectroscopy, Instrumentation in details
2. Quantitative and Qualitative application in analytical chemistry
3. X-rays Spectroscopy: Nature and production of X-rays
4. X-rays absorption, X-rays emission, Instrumentation
5. X-rays fluorescence analysis, Diffraction studies single crystal analysis

Analytical Chemistry Lab

1. Verification of deviations from Beer-Lambert's law.
2. Determination of chloride content in drinking water samples by mercury(II) thiocyanate spectrophotometric method.
3. Determination of copper in various food samples by diethyldithiocarbamate spectrophotometric method.
4. Determination of aspirin in pharmaceutical preparation and caffeine in tea and coffee by U.V Visible Spectrophotometry involving extraction.
5. Analysis of analgesic by HPLC.
6. Quantitative and qualitative analysis of different fruit juices for vitamin C by HPLC.
7. Estimation of Sodium and Potassium in biological fluids by flame photometry.
8. Determination of calcium in milk samples by flame photometry.
9. Determination of Magnesium in tap water, food, leaves etc by AAS.
10. Determination of manganese content in tea leaves by AAS.
11. Determination of sulphate and phosphate in commercial samples by complexometric titrations using EDTA.
12. Determination of iron in pharmaceutical samples by redox titration.
13. Determination of Sodium bicarbonate contents in baking Soda powder by conductometric titration with HCl.

Recommended Texts

1. Robinson J. W., Frame E. S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D. A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.). Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical chemistry.* (4th ed.). New York, John Wiley & Sons.

CHEM-6231 FTIR, Raman Spectroscopy, ESR and Surface Analysis 3 (3+1)

This course is aimed to provide a comprehensive overview about four spectroscopic techniques, based on different modes of analysis; mentioned in title. Basic principle, detailed instrumentation, applications, limitations, scope and domain of each of these techniques is part of this course. Infrared spectroscopy gives fast, economical, and reliable information about identification of functional groups of sample components. Raman spectroscopy is based on principle of light scattering and is complement to infrared spectroscopy and can analyze those samples, which could not be analyzed by infrared spectroscopy. Electron spin resonance spectroscopy is based on spinning of nuclei and gives very authentic information about presence of certain compounds in sample. Surface analysis finds wide scope in corrosion resistance, paints, thin films, pharmaceutical coatings and medicines. Auger electron spectroscopy, photoelectron spectroscopy and electron spectroscopy for chemical analysis are the techniques of choice for the characterization of surface of any material. These techniques are widely used in different industries including food, pharmaceutical and fabrics industries. Students after having these instrumental skills will be well versed in handling these machines either in their future research activities or professional career spheres.

Contents

1. Origin of Molecular spectra
2. Origin of infrared and Raman spectra
3. Normal coordinate and normal vibrations
4. Symmetry of normal vibration and selection rules
5. Selection rule for infrared and Raman spectra
6. Metal isotope spectroscopy
7. Vibrational spectra in gaseous phase and inert gas matrices
8. Comparison of Raman with Infrared spectroscopy
9. Quantitative/Qualitative analysis, Instrumental detail and their use as analytical tool
10. Electron spin resonance spectroscopy: Instrumentation, Samples and sample holder
11. ESR spectra and Hyperfine interaction
12. Applications, Spin labels and spin traps
13. Surface Analysis: Introduction, Electron spectroscopy techniques
14. X-Rays photoelectron spectroscopy, Instrumentation for XPS
15. Sample introduction and handling for surface analysis
16. Analytical applications of XPS

Recommended Texts

1. Robinson J. W., Frame E. S., & Frame G. M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D. C. (2016). *Quantitative chemical analysis*. (9th ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D. A., West, D. M., Holler, F. J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.). Philadelphia: Saunders College Publishing.
2. Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2013). *Analytical chemistry.* (4th ed.). New York, John Wiley & Sons.

CHEM-6232 Instrumental Methods of Analysis-II 3 (3+0)

This course is aimed to provide an overview about an important spectroscopic technique, i.e. nuclear magnetic resonance spectroscopy and number of techniques based on thermal methods of anlaysis. Nuclear magnetic resonance spectroscopy is and electromagnetic technique, based on spinning of nuclei and is recognized as an ultimate technique for structure elucidation of compounds with different spatial arrangement of atoms in a molecule. Nuclear reactions linked with radioactive decay gives an important in-depth information about nuclear characteristic of sample; used for identification of sample molecules. Nuclear reactors, accelerators and sources of neutron generation are also contained in this course. Thermogravimetry, differential thermal analysis, differential scanning calorimetry are the techniques based on thermal modes of analysis. These techniques give information about stability of molecules, pyrolysis reactions, kinetics, thermodynamics, and decomposition rates of polymers, medicines and food materials. Energetics of molecule as function of termperature are also included in this course. Students studying this course will be able to work in any hi-tech laboratory at their own with good background troubleshooting skills.

Contents

1. Nuclear Magnetic Resonance
2. Nuclear emission Alpha particles, Beta particles, Gamma – rays
3. Neutron activation analysis
4. Nuclear reactors; materials and working
5. Nuclear reactions
6. Radiochemical decay and activity
7. Necessary instrumentation including sources, accelerators and detectors
8. Thermal method of Analysis
9. Thermogravimetric analysis (TGA), Differential thermal analysis (DTA) and differential scanning Calorimetry (DSC)
10. Thermogravimetric curves and interpretation of thermograms
11. Pyrolysis and thermometric titration, type of measurements and applications of these techniques

Recommended Texts

1. Robinson J. W., Frame E. S., & Frame G. M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York: Marcel Dekker.
2. Harris, D. C. (2016). *Quantitative chemical analysis*. (9th ed.). New York: W. H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.). Philadelphia: Saunders College Publishing.
2. Christian, G. D., Dasgupta, P. K., & Schug, K. A. (2013). *Analytical chemistry.* (4th ed.). New York, John Wiley & Sons.

ii) Biochemistry

CHEM-6233 Chemotherapy and Immunology 3 (3+0)

This course provides insights about classification, characterization and diagnosis of various types of cancers and its therapies in respect to theoretical knowledge of the disease process. It will examine the concepts of epidemiology, aetiology and pathology of cancer along with contemporary and emerging treatment modalities and their effects. The course serves as an ideal primer for students who seek an entry point to the domain of cellular transformation, carcinogenesis and immune surveillance. This course will also examine cancer vaccine development (dendritic, genetic, anti-idiotypic, use of adjuvants) as well as the use of vaccination to counter microbial causes of cancer. Students will learn about chemical structures, mechanism of action and mechanism of drug resistance of various classes of antibacterial, antifungal, antiviral, antipyretic, analgesic and antimalarial drugs. The course will also provide basic concepts about immune system, its functioning, disorders of immune system, principles of Innate, adaptive, cell-mediated, local/remote, and humoral immunity.

Contents

1. Cancer: Reasons, Types and definition of various terms
2. Metastasis, Benign and malignant tumors, Oncogenes, Proto-oncogenes, hyperplasia
3. Chemotherapy: Definition, different treatment strategies
4. Problems associated with chemotherapy, mechanism of drug resistance
5. Chemotherapeutic Agents: Chemical structure
6. Mechanism of action and mechanism of drug resistance of various classes
7. Antitumor-antibiotics, Antimetabolites, Alkylating agents, Microtubule Inhibitors
8. Steroids and their Antagonists, Aromatase inhibitors
9. Monoclonal antibodies, Platinum based drugs, Irinotecan and topotecan
10. Etoposide, L-Asparaginase, Interferons and Imatinib.
11. Chemical structures, mechanism of action and mechanism of drug resistance of various classes of antibacterial, antifungal, antiviral, antipyretic, analgesic and antimalarial drugs.
12. Immunology: Fluid systems of the body, Blood groups (A, B, O and Rh system)
13. Components of Immune system, Definitions and Principles of Innate, adaptive, cell-mediated and humoral immunity, and the complement system.
14. Antibodies: Classes, biochemical structures, characteristics and functions.
15. Mechanism of allergy, hypersensitivity, acquired immunity, Immunodeficiencies and antigen-antibody reaction.

Recommended Texts

1. Sharma, A. K. (2019). *Immunology: an introductory textbook*. Singapore: Jenny Stanford Publishing.
2. Gadebusch, H. (2019). *Chemotherapy of infectious Disease.* (1st ed.). Florida, USA: CRC Press.

Suggested Readings

1. Kuby, (2002). *Immunology.* (5th ed.). New York, USA: Macmillan Publishing Co.
2. Dawis, B. D., Dulbecco, R., Eisen, H. N., & Ginsbery, H. S. (2002). *Microbiology.* New York, USA: Harper & Row.

CHEM-6234 Molecular Biology & Physical Techniques 4 (3+1)

This course provides a deep understanding of molecular biology central phenomenon including DNA replication, transcription and translation with respect to their functionality at the molecular leve and including the flow of information from genes to proteins, and regulation of cellular processes, signaling and proliferation in eukaryotic cells. This course is designed as a theory and practical course and introduces some of the major ideas and experimental approaches in molecular biology using biophysical methods and techniques. Student will learn basic concepts about physical techniques that are involved in characterization of biomolecules in the theory portion, while same techniques will also be performed in the lab. Students will also learn to understand and apply general concepts of cell and molecular biology to relevant, specific problems and will be able to describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function.

Contents

1. Molecular dogma; DNA as a genetic material
2. DNA replication in prokaryotes and Eukaryotes
3. Type of DNA polymerases and functions
4. DNA damage; types of mutations. DNA repair; NER, MMR, homologous DNA repair.
5. Virus DNA/RNA replication and its protein regulation
6. Transcription in prokaryotes and Eukaryotes
7. Differences and types of DNA polymerases, operons
8. Splicing; introns, exons and ribozymes. Gene regulation
9. Translation; protein synthesis, regulation
10. Metabolism of RNA and DNA nucleosides
11. Structure of Chromatin and its functions.
12. Protein expression, purification and characterization using different biophysical methods
13. UV/Vis Spectrophotometry, FT-IR, Circular Dichroism (CD)
14. Surface Plasmon Resonance (SPR)
15. Gel electrophoresis (SDS-PAGE, agarose gel electrophoresis and capillary electrophoresis)
16. Ultra-, analytical and gradient centrifugation
17. Cryo-electron microscopy, protein NMR, X-ray crystallography/Diffraction.
18. DNA amplification by PCR and real time PCR.
19. Applications of DNA sequencing
20. Mass spectrometry and isotopes in molecular biology.

Biochemistry Lab-III

1. Methods for the isolation of proteins from plant and animal samples i.e. liver/plasma protein, Salivary and Barley amylase using various cell disruption methods.
2. Protein precipitation by NH_4SO_4 method, using acid and organic solvent methods.
3. Protein dialysis and ultrafiltration methods.
4. Estimation of proteins using UV, Braford and Lowry's methods.
5. Characterization of proteins i.e. Amylase activity by enzyme assays, plasma proteins by characterization by SDS PAGE and Western blotting, analysis of a Protein from Egg White
6. Chromatographic separation/purification of proteins
7. Characterization of protein secondary structure using UV, FT-IR and circular dichroism spectroscopy.

8. Estimation and Isolation of total DNA/RNA from plant/animal tissues/cells
9. Preparation of genomic/plasmid DNA from bacteria.
10. Phenol/chloroform extraction of DNA. Mini- and Maxi- preparation of DNA
11. Isolation of RNA from mammalian cells
12. Characterization of DNA by Agarose Gel Electrophoresis and Southern blotting
13. Primer design and amplification of target DNA by PCR
14. Restriction enzyme digestion
15. Preparation of competent cells and gene cloning
16. Preparation of sequencing gels and DNA sequencing
17. PCR primer designing by online resources
18. Characterization of proteins using online tools.

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
3. Boyer, R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.

Suggested Readings

1. Swaminathan, R. (2011). *Handbook of clinical biochemistry.* (2nd ed.). Singapore: World Scientific Publishing Company.
2. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.
3. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Martin A. A. (2016). *Molecular cell biology*. (8th ed.). New York USA: W. H. Freeman.

CHEM-6235 Endocrine System 3 (3+0)

This course provides details for functions and control of signaling pathway using the hormone that are chemical substance secreted by a ductless gland into blood that is transported to a distant target organ. This course also covers the endocrine system from the standpoints of anatomic and histologic structure, hormones including their structures, functions, mechanisms of action receptors, and their metabolism in addition to the endocrinologic disorders including hyperactivity or hypoactivity, immune-mediated diseases, benign and malignant tumours and pharmacological properties of hormones and drugs used in the treatment of endocrine diseases. Hormones specifically control the certain pathways in the cell by binding to their specific receptors. This course also overview various diseases related to endocrine dysfunctions. Upon the successful completion of course, students will be able to identify the location, blood supply, innervation and anatomical relations of the endocrine glands and will have better understanding of the development and histological features of the endocrine glands.

Contents

1. Introduction, Chemical nature of Hormones
2. Common characteristics of hormones
3. Mode of action of Hormones, Chemistry and mechanism
4. Hormonal receptors
5. Metabolism and biological functions of Pituitary, Adrenal, Thyroid, Parathyroid, Pancreatic and gonadal hormones.
6. Biochemistry and body fluids
7. Composition and function of Blood, blood plasma
8. Blood proteins, Red blood cells, Hemoglobin
9. White blood cells, Platelets
10. Blood coagulation, Blood pressure
11. Antibodies, Antigens and blood groups
12. Composition of Urine
13. Extra- cellular fluid like cerebrospinal fluid, Lymph sweats tears
14. Synovial fluid and interstitial fluid.

Recommended Texts

1. Guyton, A. C., & Hall, J. E. (2010). *Text book of medical physiology.* (12th ed.). Philadelphia, Pennsylvania, USA: W. B. Saunders Company.
2. Bolander, F. F. (2012). *Molecular endocrinology.* (5th ed.). Cambridge, USA: Academic Press.

Suggested Readings

1. Jameson, J. L., Kasper, D. L., Fauci, A. S., Braunwald, E., Longo, D. L., & Hauser, S. L. (2006). *Harrison's endocrinology.* New York, USA: McGraw Hill.
2. Gardner, D., & Shoback, D. (2007). *Greenspan's basic & clinical endocrinology.* (8th ed.). New York, USA: McGraw Hill Medical.

iii) Inorganic Chemistry

CHEM-6236 Homogeneous catalysis by transition metal complexes 4(3+1)

This course aims to the understanding of homogeneous catalysis by transition metal complexes of different ligands to synthesize different compounds having useful applications. Catalysis is responsible to economize processes and revolutionize the industrial era. Beginning with the polymerization of ethylene to produce polythene, an important commercial product of daily use in life at room temperature and normal atmospheric pressure, to the state-of-the art production of silicon from sand for solar technology, all are the fruitful outcomes of catalysis. Transition metals play a pivotal role in bringing about all the dreams to come true. Different analytical techniques such as conductometry, spectrophotometry and potentiometry will be studied for the estimation and identification of chemical species in lab work. Accurate and precise determination of different hazardous species in biological and lab samples is very important for the health of workers and consumers. After the successful completion of course, students will be able to explain the concept of catalysis carried out by the metal complexes formed by inorganic ligands or hybrid lgands.

Contents

1. Reaction of CO and Hydrogen: Hydroformylation and Reductive Carbonylation,
2. Reduction of CO by hydrogen,
3. Synthesis of water gas and the water gas shift reactions
4. Carbonylation reactions: Synthesis of methanol and methyl acetate
5. Adipic ester, Carbonylation reactions and Decarbonylation reactions
6. Catalytic addition of molecules to C – C multiple bonds
7. Homogeneous hydrogenation
8. Hydroxylation and Hydrocynation

Inorganic Chemistry Lab-IV

a. Conductometry
   1. Titration of Strong acid and Weak acid with a Strong base
   2. Precipitation Titration involving $AgNO_3$ and KCl
   3. Determination of Dissociation Constant (K_a) for Acetic Acid

b. Spectrophotometry (Colorimetry)
   1. Microdetermination of Cr (III) by diphenylecarbazide
   2. Determination of Fe (II) by I:10 - Phenanthroline
   3. Determination of Nitrites
   4. Determination of Fe (III) by 8 – hydroxyquinoline

c. Potentiometry
   1. Determination of K_1, K_2, and K_3 for H_3PO_4
   2. Determination of Chloride in the presence of Iodide and evaluation of K_{sp} of AgI and AgCl
   3. Determination of Co (II) and Fe (II)

Recommended Texts

1. Kotz, J.C., Treichel, P.M., & Townsend, J. (2012). *Chemistry and chemical reactivity*. Boston, USA: Cengage Learning.
2. Angelici, R.J. (1986). *Synthesis and technique in inorganic chemistry*. (1st ed.). California, USA: University Science Books.

Suggested Readings

1. Miessler, G.L., & Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York, USA: Pearson Education, Inc.

CHEM- 6237 Inorganic Reactions Mechanism 3 (3+0)

This course aims to the understanding of kinetics and mechanism of different inorganic reactions. The mechanism of a chemical reaction is the most important part which is normally not visible to the chemist. However, the pace of a chemical reaction is controlled by the kinetic parameters that govern these changes. Geometry of the transition state of metal catalyst is always important because it guides the reaction pathway in the forward or backward direction. The two most significant steps in a typical catalysis are the oxidative addition and the reductive elimination. Moreover, different types of effects such as cis-effect, trans-effect, steric effects of inert ligand etc. also govern the synthesis of different types of products. After the successful completion of this course, students will be able to learn the factors affecting the kinetics and stability of inorganic products. Moreover, they will also be able to carry out different oxidative and reductive reactions.

Contents

1. Kinetics and mechanisms of inorganic reactions: rate law
2. Stationary state approximation,
3. Inert and labile complexes
4. Substitution reaction
5. Octahedral complexes
6. Acid hydrolysis and acid catalyzed equation
7. Anation reactions
8. Base hydrolysis
9. Attack on ligands
10. Steric effects of inert ligand
11. Square planar complexes
12. Nucleophilic reactivity
13. Trans effect
14. Cis effect
15. Effect of leaving group
16. Electron transfer processes: outer and inner sphere reactions
17. Complimentary and non - complimentary reactions
18. Mechanism of oxidative
19. Addition and reductive eliminations
20. Oxidative addition, one electron oxidative addition
21. Addition of oxygen
22. Addition of bimetallic species
23. Hydrogen addition and hx addition
24. Organic halides
25. Reductive elimination

Recommended Texts

1. Jordan, R. B. (1998). *Reaction mechanisms of inorganic and organometallic systems*. (2nd ed.). U.K.: Oxford University Press.
2. Kotz, J. C., Treichel, P. M. & Townsend, J. (2012). *Chemistry and chemical reactivity*. Boston, USA: Cengage Learning.

Suggested Readings

1. Miessler, G. L., & Tarr, D. A. (2004). *Inorganic chemistry.* (3rd ed.). New York: Pearson Education, Inc.
2. Purcell, K.F., & Kotz, J. C. (1980). *An introduction to inorganic chemistry.* (1st ed.). Philadelphia, USA: Saunders College Press.

CHEM-6238 Physical Methods in Inorganic Chemistry 3 (3+0)

This course aims to the understanding of different physical methods used for the analysis of inorganic products such as thermogravimetric analysis. Analysis of the product formed in a chemical reaction is an important step in chemical laboratory preparations. Different analytical techniques are used for this purpose ranging sensitivity from mg level to as low as Nano gram level. Isolation and purification of a product from the reaction mixture is accomplished by techniques like solvent extraction, thin layer chromatography, column chromatography etc. After the successful synthesis of a new compound the most important is now to find out its applications. Certain physical techniques are meant for the purpose of analysis of product like TGA, DTA, DSC, chromatography, conductometry and potentiometry etc. After the successful completion of this course, students will be able to understand the different techniques used for the purification, isolation and determination of inorganic specie from the reaction mixture as well as the importance of physical methods of analysis.

Contents

1. Thermogravimetric Analysis
2. Applications in lab and industry
3. Thermogravimetry (TG)
4. Differential Thermal Analysis (DTA)
5. Instrumentation of DTA
6. Differential Scanning Calorimetry (DSC)
7. Separation Methods
8. Solvent Extraction
9. Solid phase micro extraction
10. Applications of SPME
11. Column chromatography
12. TLC
13. Analytical applications and instrumentation of TLC
14. Ion Exchange Chromatography
15. Types of ICE
16. Industrial applications of IEC
17. Potentiometry
18. Applications of potentiometry
19. Conductometry
20. Applications of conductometry

Recommended Texts

1. Jordan, R. B. (1998). *Reaction mechanisms of inorganic and organometallic systems*. (2nd ed.). U.K.: Oxford University Press.
2. Kotz, J.C., Treichel, P.M., & Townsend, J. (2012). *Chemistry and chemical reactivity*. Boston, USA: Cengage Learning.
3. Skoog, D.A., West, D.M., & Holler, F.J. (1994). *Analytical chemistry*. (6th ed.). Philadelphia, USA: Saunders College Publications.

Suggested Readings

1. Miessler, G. L., & Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York: Pearson Education, Inc.
2. Purcell, K. F., & Kotz, J. C. (1980). *An introduction to inorganic chemistry.* (1st ed.). Philadelphia, USA: Saunders College Press.
3. Harris, D.C. (2006). *Quantitative chemical analysis.* (ed.). New York: Freeman.

iv) Organic Chemistry

CHEM-6239 Chemistry of Natural Products 4 (3+1)

This course is a foundation course for Natural Product Chemistry (CHEM-7148) and Steroids (CHEM-8108) courses of MPhil and PhD classes, respectively, with Organic Chemistry specialization. Natural products have high structural diversity and unique pharmacological or biological activities due to the natural selection and evolutionary processes that have shaped their utility over hundreds of thousands of years. In fact, the structural diversity of natural products far exceeds the capabilities of synthetic organic chemists within the laboratory. Thus, natural products have been utilized in both traditional and modern medicine for treating diseases.
This course focuses on the biosynthesis, isolation of new natural products, rational structural modifications of known natural products scaffolds for new lead discovery, total synthesis of complex natural products and green chemistry. Special emphasis is given to the development of synthetic methodologies to facilitate generation of diversity around the scaffolds, which can be utilized as key intermediates for total synthesis. The new molecular entities generated are screened for pharmacological activities with focus on cancer and anti-bacterial properties. The practical work involves the purification of selected natural products and the synthesis of a few small sized natural products.

Contents

1. Primary and secondary metabolites, introduction to natural products and classification on different basis;
2. Hormones (endocrines, exocrines, paracrines), pheromones (chemical communication) and allomones (chemical defense)
3. Isolation, biosynthesis, laboratory synthesis and structure elucidation of alkaloids (ephedrine, atropine, indole, quinine, morphine etc.) by chemical, spectroscopic and spectrometric methods of analyses
4. Isolation, biosynthesis, laboratory synthesis and structure elucidation of terpenoids (lemonenes, carvones, pinenes, menthol, camphor, tritepenoids) by chemical, spectroscopic and spectrometric methods of analyses
5. Isolation, biosynthesis, laboratory synthesis and structure elucidation of steroids (ecdysteroids, corticocoids, gonadal & neuro steroids, phytosteroids, brassinoloids, withanolides etc.) by chemical, spectroscopic and spectrometric methods of analyses
6. Isolation, classification, biosynthesis, laboratory synthesis and structure elucidation of vitamins (A, B, C, D, E and K) by chemical, spectroscopic and spectrometric methods of analyses
7. Isolation, classification, biosynthesis, laboratory synthesis and structure elucidation of flavonoids by chemical, spectroscopic and spectrometric methods of analyses.

Chemistry of Natural Products Lab.

1. Multistep synthesis of different types of organic compounds. Purification of the products by chromatographic and other techniques.
2. Isolation and purification of some natural products.
3. Conformation of natural products by different techniques e.g., elemental analysis, spectroscopy

Recommended Texts

1. Finar, I. L. (2001). *Natural product chemistry*. Vol-I, London: Longman.
2. Clayden, J., Greeves, N., Warren, S. & Wothers, P. (2012). *Organic chemistry*. (2nd ed.). Oxford University Press.

3. Dewick, P. M. (2008). *Medicinal natural products - A biosynthetic approach*. (3rd ed.). England: Wiley.

Suggested Readings

1. Bhat, S. V. (2005). *Chemistry of natural products*. (1st ed.). Berlin: Springer.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6240 Organic Synthesis 3 (3+0)

This course is a foundation course for Advance Organic Synthesis (CHEM-7146) of MPhil class, with Organic Chemistry specialization. This course focuses on general methods and strategies for the synthesis of complex organic molecules. Emphasis is on strategies for stereoselective synthesis, including stereocontrolled synthesis of complex acyclic compounds. The transformation of functional groups by substitution reactions, protecting groups, dummy groups, electrophilic addition to C-C double and triple bonds, hydroboration, reactions with organoboranes, reduction of carbonyl, C-C double and triple bonds, hydrogenation, hydride reductions are included in this course. The stereocontrol in pericyclic reactions (cycloadditions, sigmaotroptic rearrangements, electrocyclic reactions), group transfer reactions are also part of this course including introduction to retro synthesis.
After the end of course the students are supposed to be able to:plan syntheses of organic molecules by proper choice of starting materials, reagents and reaction conditions and shall be able to predict competing reactions and plan simple synthetic routes based on retrosynthetic synthesis strategy.

Contents

1. Introduction to reterosynthesis, retrosynthetic analysis
2. Protective groups (protection of alcohols, amines, carboxylic acids, aldehydes and ketones)
3. Dummy groups and umpulong
4. Functional group inter-conversion (FGI)
5. Methods for C–C, C–N and C–O bond formation
6. Applications to the synthesis of a variety of target molecules.
7. Difunctionalized compounds
8. Role of crown others and quaternary ammonium salts in organic synthesis
9. Recent trends in organic synthesis.

Recommended Texts

1. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). *Organic chemistry*. (2nd ed.). London: Oxford University Press.
2. Smith, M.B., & March, J. (2019). *March's advanced organic chemistry*. (8th ed.). New York: John Wiley.
3. Warren, S. (2008). *Organic synthesis*. New York: Wiley.

Suggested Readings

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.

CHEM-6241 Chemistry of Protective Groups and Reactive Intermediates 3 (3+0)

Protecting groups are used in synthesis to temporarily mask the characteristic chemistry of a functional group because it interferes with another reaction. A good protecting group should be easy to put on, easy to remove and in high yielding reactions and inert to the conditions of the reaction required. In many preparations of delicate organic compounds, some specific parts of their molecules cannot survive the required reagents or chemical environments. Then, these parts, or groups, must be protected. For example, $LiAlH_4$ is a highly reactive but useful reagent capable of reducing esters to alcohols. It will always react with carbonyl groups, and this cannot be discouraged by any means. Neutral reactive intermediates (radicals, carbenes, nitrenes, and aryenes) occupy a fascinating place in the history of organic chemistry. First regarded as mere curiosities, neutral reactive intermediates ultimately came under the intense scrutiny of physical organic chemists from a mechanistic point-of-view. This concise text concentrates on how these electron-deficient species now play a key role in synthetic chemistry research. Important reactions are clearly and simply laid out with carefully chosen examples that illustrate their use in organic synthesis.

Contents

1. Important protective groups of different organic functional groups involved in organic synthesis including alcohols/phenols (-OH), amines ($-NH_2$), carboxylic acids (-COOH), aldehydes (-CHO), ketones (-CO) etc.
2. Structure generation and reaction of reactive intermediate including carbenes, nitrenes, arynes and free radicals.

Recommended Texts

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Hendrickson, J. B., Cram, D. J. and Hammond, G. S. (1980). *Organic chemistry*. New York: McGraw-Hill.
3. Pine, S. H. (1980). *Organic chemistry*. New York: McGraw-Hill.

Suggested Readings

1. Streitwieser, A., Heathcock, C. and Kosower, E. M. (2017). *Introduction to organic chemistry*. (4^{th} ed.). New York: Macmillan.
2. Warren, S. (2008). *Organic synthesis*. New York: Wiley.

v) Physical Chemistry

CHEM-6242 Advanced Approach of Homogeneous and Heterogeneous Kinetics 4 (3+1)

This course is designed for the students opting Physical Chemistry as Minor Subject along with their field of specialization to provide comprehensive knowledge about the kinetics of homogeneous and heterogeneous reactions. Course include detailed discussion about liquids and gaseous systems of inorganic and organic reactions, single systems, double systems, reactions on solid surfaces, kinetics of single reacting gas, retardation by reaction products, kinetics of two reacting gases, retardation by reactants, reactions in solution, influence of solvents involving ions, primary and secondary salt effect on kinetics of the reactions and comparison between homogeneous and heterogeneous kinetics. Course is designed to make the students capable of understanding the dynamics and phenomena of homogeneous and heterogeneous kinetics. As catalysis is backbone of any synthesis. To control the reaction rate and develop new interfaces suitable for reaction catalysis, students will be trained along with solid foundation of physical chemistry. Kinetics equations dealing different cases of homogeneous and heterogeneous reactions will be guiding torch to make them understand.

Contents

1. Liquids and gaseous systems of inorganic and organic reactions
2. Single systems, double systems
3. Study of reactions on solid surfaces
4. Single reacting gas, retardation by reaction products
5. Two reacting gases, retardation by reactants
6. Adsorb-heterogeneous reaction
7. Reactions in solution
8. Influence of solvents involving ions, primary and secondary salt effect on kinetics of the reactions
9. Comparison between homogeneous and heterogeneous kinetics

Advanced Approach of Homogeneous and Heterogeneous Kinetics Lab

1. Determination of equilibrium constant of reversible reaction $I_2 + I^- \rightleftharpoons I_3^-$ and to evaluate ΔG^o.
2. Determination of molecular mass of polymer by viscosity method.
3. Determination of flocculation value of electrolytes and to verify Hardy-Schultz rule.
4. Determination of activation energy of a chemical reaction.
5. Study of variation of conductance of solution of weak and strong electrolytes with concentration (a) pure solvents (b) binary mixture of solvents
6. Determination of heat of solution of a substance from solubility measurements and to determine thermodynamic quantities like ΔG^o, ΔH^o, ΔS^o of the solution.
7. Potentiometric titration

Recommended Texts

1. Kontogeorgis, G. M., & Kiil, S. (2016). *Introduction to applied colloid and surface chemistry.* New York: John Wiley & Sons Inc.
2. Thomas, J.M., & Thomas, W.J. (2015). *Principles and practice of heterogeneous catalysis.* Germany: Wiley-VCH Verlag GmbH.

Suggested Readings

1. Somorjai, G. A., & Yimin, L. (2010). *Introduction to surface chemistry and catalysis.* New York: John Wiley & Sons Inc.

2. Cosgrove, T. (2010). *Colloid science: principles, methods and application.* New York: John Wiley & Sons Inc.
3. Pashley, R.. & Karaman, M. (2004). *Applied colloid and surface chemistry.* New York: John Wiley & Sons Inc.

CHEM-6243 Polymers and Photochemistry 3 (3+0)

The objective of this course is to make the students enable to understand the process of polymerization and to know the approaches by which polymerization may be achieved. Additionally a deep insight of photochemical reactions and laws of photochemistry is also incorporated in this course. The course includes the kinetics of polymerization occurring through different approaches e.g. condensation, addition and copolymerization along with the knowledge of photochemical reactions. Fluorescence and phosphorescence and relevant information is also a part of this course. A knowledge of polymer chemistry enables the students to know about natural and synthetic polymers. Natural and semi-synthetic polymers find their uses in almost every field of science ranging from drug delivery to common sensors and biosensors. Photochemistry enables students to know how UV/Visible light is absorbed or emitted during a physical or chemical change. The basic knowledge of photochemistry is applied in the field of carbon nanodots because of their unique optical properties which is applied in imaging the biological process.

Contents

1. Classification of polymers
2. Kinetics of condensation polymerization
3. Kinetics of addition polymerization
4. Kinetics of co-polymerization reactions.
5. Molecular mass determination by different methods and laws of photochemistry.
6. Quantum efficiency
7. Methods to determine quantum yield and quantum efficiency
8. Photochemical reactions
9. Photosensitized reactions
10. Phosphorescence
11. Fluorescence
12. Chemiluminescence
13. Lasers.

Recommended Texts

1. Turro, N. J., Ramamurthy, V., & Scaiano, J.C. (2009). *Principles of molecular photochemistry: an introduction.* USA: University Science Books.
2. Rawe, A. (2000). *Principles of polymer chem*istry. (2nd ed.). New York, USA: Plenum publishers.

Suggested Readings

1. Allen, N. S. (2010). *Photochemistry and photophysics of polymeric materials*. New York: John Wiley & Sons Inc.
2. Albini, A., & Protti, S. (2019). *Photochemistry.* (Vol. 47). Cambridge, UK: Royal Society of Chemistry.
3. Wardle, B. (2010). *Principles and applications of photochemistry.* New York: John Wiley & Sons Inc.
4. Neckers, D. C., Jenks, W. S. & Wolff, T. (2005). *Advances in photochemistry*. New York: John Wiley & Sons Inc.

CHEM-6244 Elementary Group Theory 3 (3+0)

This course is highly advanced for the students having physical chemistry as their field of interest. The course is based on algebraic foundation. Different physical systems including crystals as well as the Hydrogen atom, can be modelled by symmetry groups. So the group theory and representation theory have important applications. Almost all structures in abstract algebra are special cases of groups such as rings can be visualized as abelian groups (corresponding to addition) together with a second operation (corresponding to multiplication). Therefore, group theoretic arguments underlie large parts of the theory of those entities. Course covers concept of symmetry, symmetry elements and operations, point groups, group representation and character table. Moreover, reducible representation, irreducible representation, application of group theory to valence bond theory, application of group theory to molecular orbital theory & crystal field theories and IR spectra are important parts of the course. Group theory and its application in structure finding makes it very vital. This course makes the students able to apply their knowledge at advance applied fields of research and to understand the structure of molecules inside and covers its application on valence bond theory (VBT), molecular orbital theory, (MOT) and crystal field theory (CFT) etc.

Contents

1. Introduction to Elementary Group Theory
2. Symmetry
3. Symmetry elements and operations
4. Point groups
5. Group representation
6. Character table
7. Reducible representation
8. Irreducible representation
9. General applications of group theory
10. Application of group theory to valence bond theory
11. Application of group theory to molecular orbital theory
12. Crystal field theory and IR spectra

Recommended Texts

1. Ramond, P. (2015). *Group theory: a physicist's survey*. UK: Cambridge University Press.
2. Carter, N. (2009). *Visual group theory.* USA: Mathematical Association of America.

Suggested Readings

1. Joyner, D. (2008). *Adventures in group theory: Rubik's cube, Merlin's machine, and other mathematical toys*. Baltimore, MD, USA: Johns Hopkins University Press.
2. Tinkham, M. (2003). *Group theory and quantum mechanics*. New York: Dover Publications Inc.
3. Vincent, A. (2001). *Molecular symmetry and group theory: a programmed introduction to chemical applications.* New York: John Wiley & Sons Inc.
4. Related Research Papers

REVISED SCHEME OF STUDIES & CURRICULUM
MPhil CHEMISTRY
(Semester System)

(2020)



INSTITUTE OF CHEMISTRY
UNIVERSITY OF SARGODHA
SARGODHA

Revised Scheme of Studies and Curriculum for MPhil Chemistry with specialization in Analytical, Inorganic Chemistry, Organic Chemistry, Physical Chemistry and Biochemistry

Summary

Areas of Specializations

1. Analytical & Inorganic Chemistry
2. Physical Chemistry.
3. Organic Chemistry
4. Biochemistry

Course Work: 24 Credit Hours

Semester	Courses/Credits	Total
First	4 courses, 3 credits each	12
Second	4 courses, 3 credits each	12
Third and Fourth	Research/Thesis	06
Total Credits		30

- In addition to the course work and thesis, each student will have to give two seminars in fourth semester.
- Each student will present a literature survey report in the beginning of third semester related to his/her area of research.

  The course work will be completed in first and second semesters where as research/ thesis will be completed in third and fourth semesters.

Course Description of Analytical & Inorganic Chemistry

Semester I: Total credit: 12

Course Code	Course Title	Credits
CHEM-7101	Environmental Analysis	3 (3+0)
CHEM-7102	Electro-analytical Techniques	3 (3+0)
CHEM-7103	Chromatographic Techniques-I	3 (3+0)
CHEM-7104	Spectroscopic Techniques-I	3 (3+0)
CHEM-7105	Chemistry of Main Group Elements	3 (3+0)
CHEM-7106	Organo-transition Metal Chemistry	3 (3+0)
CHEM-7107	Medicinal Uses of Transition Metals/Inorganic Compounds	3 (3+0)
CHEM-7108	Modern Inorganic Chemistry	3 (3+0)
Total Credits		12*

*A student may opt four courses of 12 credit hours offered from the list depending upon the availability of the teacher. Each course will be of 3 credit hours

CHEM-7101 Environmental Analysis 3 (3+0)

This course is designed to provide fundamental overview of the phenomenon and terminology associated with environment, composition of different environmental segments, characterization of environmental entities and methodologies/ techniques for analysis of environmental samples. The course gives comprehensive description about principles of techniques, instrumentation and interpretation of data about the environmental samples. Sources and origin of different pollutants affecting the quality of environment as well as reactions of these pollutants, fate, sinks are contained in this course. Learning about chemical nature of pollutants, ranging from particulate to aggregates, sludge, dust and sediments is also depicted in this course. Quality of life of all living organisms is strongly influenced with their environment and all the environmental components. This course will provide a deep insight for skill development towards analysis of environmental samples in addition to awareness about hazardous impacts of different industrial pollutants. This will provide a good readership for technical professionals of different environmental protection agencies.

Contents

1. Introduction, General principles and Techniques for Soil, sludge, sediment and dust analysis
2. Analysis of plant Material
3. Analysis of Atmospheric Samples
4. Analysis of Water determination of toxic organic Chemistry
5. Analysis of toxic heavy metals
6. Biological indicators
7. Echo toxicology

Recommended Texts

1. Manahan, S.E. (2017). Environmental Chemistry. (7th Ed.). New York: CRC press.
2. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th Ed.). New York: Marcel Dekker.
3. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th Ed.) New York: W.H. Freeman and Company.
4. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th Ed.). New York, John Wiley & Sons.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th Ed.) Philadelphia: Saunders College Publishing.

CHEM-7102 Electroanalytical Techniques 3 (3+0)

This course is aimed to provide a comprehensive overview about set of electroanalytical techniques to M.Phil. students. A comprehensive information, ranging from basic operational principles to instrumentation and applications of different electroanalytical techniques including polarography, voltammetry and amperometry. This course is aimed to provide learning about development of electrodes for specific purposes and biosensors. Development of electrical sensors for obtaining qualitative and quantitative information about different samples are also included. After learning this course, students will be able to apply fundamental principles, mechanistic details, instrumental developments, limitations and challenges for each of these techniques on their samples during research. Characterization of different materials including food, environment, and other industrial samples at low concentrations is a challenging task, for which electroanalytical techniques are recognized superior over others. Being economical, rapid in action, sensitive, selective and specific, electroanalytical devices are preferred machines in different industrial segments for analysis of various type of samples.

Contents

1. Polarography and Amperometric Techniques: Basic principle, Instrumentation including various electrodes
2. Modes of operation uses in polarography
3. Applications of polarography in Analytical Chemistry
4. Basic principle of Amperometric techniques and Instrumentation
5. Voltammetric techniques: Instrumentation, Linear Potential Sweet (DC) Voltammeter, Potential Methods
6. Phase-Sensitive Alternating Current Voltammeter, Stripping Voltammeter
7. Qualitative and Quantitative aspects of Voltammeter.

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th Ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th Ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th Ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th Ed.). New York, John Wiley & Sons.

CHEM-7103 Chromatographic Techniques-I 3 (3+0)

This course is aimed to provide a comprehensive information about basic principles, applications and instrumentation of advanced chromatographic techniques, for M.Phil. students. In this course, theoretical principles, recent advancements and data acquisition modes of the most commonly used chromatographic technique in industries, i.e. high-performance liquid chromatography are focused. Besides, GC-MS, which is a hi-tech technique used for ultrasensitive analysis of different materials is also contained in the course. For the targeted separation of any specific components from the sample-matrix or preparation of bioactive-enriched fractions is carried out by supercritical fluid extraction chromatography, which has got recognition as a green, eco-friendly technique with zero hazardous effects. By learning the course, students would be able to predict the material to be used as stationary phase, mobile phase, length and width of chromatographic column as well as other set of optimized parameters for achieving maximum recovery of targeted compounds from complex matrix. In addition, comparative scope and domains of these techniques will be helpful for students to make right selection of the chromatographic technique in their research.

Contents

1. Introduction, theory, instrumentation and Applications of High-Performance Liquid Chromatography
2. Gas Chromatography-Mass spectrometry
3. Supercritical Fluid Chromatography

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th Ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th Ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th Ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th Ed.). New York, John Wiley & Sons.

CHEM-7104 Spectroscopic Techniques-I 3 (3+0)

This course is aimed to provide first-hand, preliminary knowledge to M.Phil. students about identification, structure elucidation and skeletal information about the chemical compounds present in various industries. Infrared spectroscopy is a non-destructive, fast, sensitive and economical technique, which gives reliable information about identification of functional groups of compounds. While, Raman spectroscopy has superiority to analyze those samples, which could not be analyzed by infrared spectroscopy. NMR and mass spectrometry are the ultimate and sole techniques for final structure elucidation of any compound with exact spatial arrangement of atoms in a molecule as well as proportion of any isotope in a molecule. Mass spectrometry can be used to analyze the atomic, molecular and ionic samples, while rest of three techniques can be used for analysis of molecular species. As all of these four spectroscopic techniques are based on different mechanistic principles and have different domains; so comparative studies of different techniques will give a broader view about domains of each technique for analysis of different types of samples.

Contents

1. NMR spectroscopy
2. Raman spectroscopy
3. Mass spectrometry
4. IR spectroscopy

Recommended Texts

3. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th Ed.). New York: Marcel Dekker.
4. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th Ed.) New York: W.H. Freeman and Company.

Suggested Readings

3. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th Ed.) Philadelphia: Saunders College Publishing.
4. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th Ed.). New York, John Wiley & Sons.

CHEM-7105 Chemistry of Main Group Elements 3 (3+0)

This course aims to the understanding of chemistry of main group elements, general properties, chemical reactions, synthesis, stability and applications of important compounds of these elements. One of the important properties of main group elements is the catalytic ability of their compounds. Besides transition metals, the metals of main group of periodic table do play role in catalysis. The reactions of the type like enolization, nucleophilic substitution, addition, elimination etc. are specifically channelized by the application of trace amounts of metals. Moreover, reaction conditions supporting the organometallic reactions will also be discussed. The stereo-specificity for creation of chiral centers at particular chain lengths in a molecule produces certain important properties in resulting molecules enabling them to be applied for a peculiar role. After the successful completion of this course, students will be able to understand the general concepts about the properties of main group elements, their reactivity, chemical reactions, factors affecting the synthesis of the different derivatives of organometallic compounds and their important applications.

Contents

1. Introduction to main group elements
2. Importance and uses of main group elements
3. Preparation of organometallic reagents
4. Organometallic reactions
5. Classes of nucleophilic organometallic reactions
6. Synthesis and reactions of organo-Li compounds
7. Synthesis of organo-Se, Si, Sn, Sb compounds
8. Reactivity of organo-Se, Si, Sn, Sb compounds
9. Synthesis of organo-zinc compounds
10. Applications of organometallic compounds
11. Control side reactions
12. Chemistry of enolization
13. Nucleophilic addition reactions
14. Importance of Nucleophilic addition reactions
15. Substitution vs. Elimination
16. Selectivity among functional groups via organometallic reagents

Recommended Texts

1. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin, Germany: Springer.
2. Alexander, D.G., & Boris I.K. (2003). *Synthetic, coordination and organometallic chemistry*. (1st ed.). New York: Marcel Dekker, Inc.
3. Jordan, R.B. (1998). *Reaction mechanisms of inorganic and organometallic systems*. (2nd ed.). U.K.: Oxford University Press.

Suggested Readings

1. Miessler, G.L., & Tarr, D.A. (2004). *Inorganic chemistry.* (3rd ed.). New York: Pearson Education, Inc.
2. Mingos, D.M.P., & Parkin, G. (2006). *Comprehensive organometallic chemistry-III: From fundamentals to applications.* (1st ed.). U.K.: Elsevier.
3. Huheey, J.E., Keiter, E.A., Keiter, R.L., & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.

CHEM-7106 Organo-transition Metal Chemistry 3 (3+0)

The organic ligand molecules bind with metals in two ways; one through carbon and other through hetero-atoms like oxygen, nitrogen, sulfur etc. This bonding style differentiates between organometallic and coordination chemistry. Both of this type of compounds is useful in medicinal industry. Preparation of organometallic compounds by using different reaction conditions leads to a new era of research for preparation of stable metal complexes having metal-carbon bonding. Introduction and history of organometallic compounds will be discussed in this course. Moreover, the role and interaction of different metal ions will also be discussed in living organisms. Further, the metal--carbon bonding unlike carbon-carbon bonding provides basis for catalysis. Starting from polymerization of ethylene by Zeigler and Natta leading to industrial revolution, the recent M-C bond chemistry has been studied in detail to materialize those reactions which otherwise are not possible. The fundamental rules like Eighteen-electron-rule explain the stability of organometallic compounds. After the completion of this course, students will be able to explain the chemistry of metal-carbon bond, reactivity and fundamental applications of organometallic compounds in different fields of life.

Contents

1. Introduction and history of organometallic compounds
2. Nomenclature of organometallic compounds
3. Classification of organometallic compounds,
4. Transition metal to carbon sigma bonded compounds
5. Compounds with metal-carbon pi-bonds such as η^2 to η^7 systems
6. Synthesis compounds with metal-carbon pi-bonds
7. Properties of metal-carbon bond containing compounds
8. Nature of bonding in pi complexes
9. Experimental techniques used in synthesis
10. Separation of organometallic compounds
11. Characterization of organometallic compounds
12. Fundamental process in organometallics synthesis
13. Applications of organometallics in medicines
14. Applications of organometallics in industry

Recommended Texts

1. Callister, W.D. (2003). *Material science and engineering; an introduction*. New York, USA: John Wiley & Sons.
2. Weight, J.D., & Nico A.J.M. (2001). *Sol-gel Material Chemistry and Application.* London, U.K.: Taylor and Francis Books Ltd.
3. Rosette, M., & Malone, R. (2016). *Bioinorganic chemistry: a short course*. New York: John Wiley & Sons.

Suggested Readings

1. Rao C. N.R. (1993). *Chemistry of advanced materials*. Oxford, U.K.: Oxford Blackwell Scientific Publications.
2. Atkins, P., & Overton, T. (2010). *Shriver and Atkins' inorganic chemistry*. Boston, USA: Oxford University Press.
3. Huheey, J.E., Keiter, E.A., Keiter, R.L., & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.

CHEM-7107 Medicinal Uses of Transition Metals/Inorganic Compounds 3 (3+0)

Bioinorganic chemistry is a field that examines the role of metals in biology. Bioinorganic chemistry includes the study of both natural phenomena such as the behaviour of metalloproteins as well as artificially introduced metals, including those that are non-essential, in medicine and toxicology. Interaction of various inorganic compounds with the biological species enables the scientist to design and formulate medicines for different diseases. The role of metals in life is evident from medicinal applications of metal-based drugs in chemotherapy for the treatment of various types of cancers in humans and animals. Many essential and non-essential metals play part in various metabolic activities within living organisms. From here their importance is stemmed in life. Micronutrients are one of the major groups of nutrients your body needs. They play an important role in growth, bone health, fluid balance and several other processes. This course aims to the study of role of different elements in human body and use of different transition metals for the treatment of various diseases. After the successful completion of this course, students will be able to understand the interaction of various metals with the naturally occurring compounds in human body as well as their uses as medicines.

Contents

1. Introduction of micro-nutrient
2. Elements in human body
3. Role of micronutrients in human body
4. Metal bearing enzymes
5. Functions of metal bearing enzymes
6. Working of metal bearing enzymes
7. Adverse effects of excess of micro-nutrients
8. Deficiency of micro-nutrients
9. Use of transition elements
10. Preparation of organo-transition compounds
11. Use of transition metal compounds in diagnosis
12. Treatment of various diseases
13. Metal based drugs
14. Importance of metals and non-metals in biological systems
15. Metal ions and their importance in living organisms
16. Chelating agents for medicinal purposes

Recommended Texts

1. Dabrowiak, J.C. (2009). *Metals in medicine*. New York, USA: John Wiley & Sons Ltd.
2. Farrell, N. (2002). *Coordination chemistry reviews*. Oxford, U.K.: Elsevier Publishing Company.
3. Schwietert, C.W., & Mc Cue, J.P. (1999). *Coordination chemistry reviews.* Oxford, U.K.: Elsevier Publishing Company.

Suggested Readings

1. Atkins, P., & Overton, T. (2010). *Shriver and Atkins' inorganic chemistry*. Boston, USA: Oxford University Press.
2. Huheey, J. E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.

CHEM-7108 Modern Inorganic Chemistry 3 (3+0)

The arrangement of elements in periodic table provides the basis for fundamental knowledge about each element. This is the simple beginning of modern inorganic chemistry. The chemists have always been after the extraction of metals from their natural resources. The interest in the art of extraction has prompted from synthesis of new rings, cages and clusters. Moreover, the applications of elements for the preparation of fuel cells which acts as an important source of electricity in spacecraft can also be understood by learning the electrode potentials of elements. This course aims to the understanding of periodic table, general trends of properties, important compounds and their applications. Many phenomenon such as corrosion, purification and extraction of metals etc. will also be discussed. After the successful completion of this course, students will be able to explain the general concepts of inorganic chemistry and the applications of its compounds in various fields of life.

Contents

1. Periodic Table
2. Periodic Trends of properties of elements
3. Anomalies of periodic trends
4. Application
5. Nomenclature of compounds
6. Extraction of Cu
7. Extraction of Ag
8. Extraction of Au
9. Extraction of U
10. Extraction of Lanthanides
11. Purification of metals
12. Corrosion phenomenon
13. Classification and Theories of corrosion
14. Corrosion Prevention techniques
15. Inorganic rings
16. Cages
17. Clusters
18. Structure and preparation of fuel cells
19. Types of fuel cells
20. Applications of Fuel cells

Recommended Texts

1. Choy, K.L. (2003). *Chemical vapour deposition of coatings.* Oxford, U.K.: Elsevier publications.
2. Lee, J. D. (2008). *Concise inorganic chemistry*. (1st ed.). New York: John Wiley & Sons.
3. Huheey, J. E., Keiter, E. A., Keiter, R. L., & Medhi, O. K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Mumbai, India: Pearson Education.

Suggested Readings

1. Atkins P.W., Langford, C.H. & Shriver, D.F. (1994). *Inorganic chemistry.* (2nd ed.). Oxford, U.K.: Oxford University Press.
2. Shriver, D.F., Kaesz, H.D., & Adams, R.D. (1990). *The chemistry of metal cluster complexes*. (1st ed.). California, USA: VCH publishers.

Semester II

Total credit: 12

Course Code	Course Title	Credits
CHEM-7109	Chromatographic Techniques-II	3 (3+0)
CHEM-7110	Spectroscopic Techniques-II	3 (3+0)
CHEM-7111	Thermal Methods of Analysis	3 (3+0)
CHEM-7112	Inorganic and Organometallic Polymers	3 (3+0)
CHEM-7113	Applied Transition Metal Chemistry	3 (3+0)
CHEM-7114	Inorganic Material Chemistry (II)	3 (3+0)
CHEM-7115	Advanced Practicals in analytical & inorganic Chemistry	3 (3+0)
CHEM-7116	Solid State Chemistry	3 (3+0)
CHEM-7117	Recent Advances in Metal Based Drugs	3 (3+0)
CHEM-7118	Experimental Techniques in Coordination & Organometallic Chemistry	3 (3+0)
Total Credits		12*

*A student can opt four courses of 12 credit hours offered from the list depending upon the availability of the teacher. Each course will be of 3 credit hours

CHEM-7109 Chromatographic Techniques-II 3 (3+0)

This course is aimed to provide an overview about basic principles, instrumentation, applications and domains of different non-conventional separation techniques, for M.Phil. students. Ion chromatography and Ion-Exchange chromatography are the techniques used for the separation or exchange of different ionic species from food, pharmaceutical or environmental samples, having applications for synthesis of newer compounds or water purification. Molecular exclusion chromatography is used to separation the components of sample on the basis of their sizes, it is typically used for separation of components having resembling structures or enantiomers and finds versatile applications in amino acids and proteins analysis. Affinity chromatography is used for preparative separation of one targeted compound from a complex matrix, while electrophoresis is a non-chromatographic separation technique, in which sample components are separated under the influence of electric fields. HPTLC is a preparative, economical technique used for the analysis of compounds of varying structures. Fundamental introduction, understanding of basic principles, instrumentation and application of all these techniques are encompassed in this course.

Contents

1. Introduction, theory, instrumentation and applications of Ion & Ion-Exchange Chromatography
2. Molecular Exclusion Chromatography
3. Affinity Chromatography
4. Electrophoresis
5. HPTLC

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th Ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th Ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th ed.). New York, John Wiley & Sons.

CHEM-7110 Spectroscopic Techniques-II 3 (3+0)

This course is designed for advanced classes and is aimed to provide a comprehensive information about principles, instrumentation, advancements, applications and scope of these spectroscopic techniques. Atomic absorption and atomic emission spectroscopy are used for analysis of elemental species in food, environmental and pharmaceutical samples. Advancements in accessories of these techniques have led to determination upto ppt levels. X-ray spectroscopy also finds versatile applications in medical diagnostics, bone scanning and other industries. It encompasses number of techniques including X-ray absorption, X-ray diffraction, X-ray fluorescence and X-ray crystallography; each of these having different domains of analysis. Laser spectroscopy uses lasers as radiation sources and is more sensitive than other techniques. Luminescence spectroscopy is used to determine defect structure and impurity in biological matrices and thin films. Nephelometry is widely used in immunological studies to determine the level of plasma in blood proteins. Comparison of different techniques, based on different mechanistic principles, will provide an authenticated version about characterization of materials.

Contents

1. Atomic absorption spectroscopy
2. Atomic emission Spectroscopy
3. X-ray spectroscopy
4. Inductive coupled plasma Spectroscopy
5. Nephelometry
6. Laser spectroscopy
7. Luminescence spectroscopy

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th Ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th Ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th ed.). New York, John Wiley & Sons.

CHEM-7111 Thermal Methods of Analysis 3 (3+0)

This course is aimed to provide a detailed learning about fundamental principles, instrumentation, applications and domains of different techniques based on thermal methods of analysis. Thermogravimetry gives information about thermal stability of different components of a sample and its fragmentations. Differential thermal analysis gives measurement of energy released or absorbed by the sample subject to thermal measurements, in comparison to certain reference. Differential scanning calorimetry also gives same information but operational mechanism and principle is different. All these three techniques give a comprehensive overview about structure, thermal stability and energetics of samples typically refractory materials and polymers. Comparative overview of thermal curves obtained by these different techniques gives deep insight and more elucidative version of analytical information. Different types of thermal balances to give changes in mass measurement as function of thermal degradation are also included in this course. This will give knowledge about thermal stability of materials, kinetics and thermodynamics of pyrolysis reactions.

Contents

1. Introduction to Thermogravimetry
2. Types of thermobalances
3. Factors affecting TG curves, sources of error,
4. Applications of TGA, DTA and DSC; theory, instrumentation
5. Factors affecting DTA curves, Quantitative analysis, applications.

Recommended Texts

1. Robinson J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate Instrumental Analysis.* (7th Ed.). New York: Marcel Dekker.
2. Harris, D.C. (2016). *Quantitative Chemical Analysis*. (9th Ed.) New York: W.H. Freeman and Company.

Suggested Readings

1. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of Analytical Chemistry*. (9th ed.) Philadelphia: Saunders College Publishing.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2013). *Analytical Chemistry.* (4th ed.). New York, John Wiley & Sons.

CHEM-7112 Inorganic and Organometallic Polymers 3 (3+0)

Organic polymers in general and inorganic polymers in particular are important for their application in the field of medicinal chemistry. Most of the diagnostic instruments and their accessories are made up of these types of polymers. The elements like silicon have given rise long lives to these items along with inert nature. This course aims to understanding of general concept of polymerization, types of polymerization, inorganic polymers, their properties, stability and applications. Polymers containing inorganic and organic components are sometimes called hybrid polymers, and most so-called inorganic polymers are hybrid polymers. Most of the ceramic material in use in routine life has its origin from inorganic polymers. Blending of metal cluster compounds with carbonates, borates or phosphates gives rise to a wide range of tensile material equally applicable in ceramic appliances and other industrial reaction vessels. The material strength is governed more by a study of the forces responsible within substances for inter- and intra-molecular bonding. After the successful completion of this course, students will be able to synthesize the inorganic polymers of desired properties, elaborate the stability and structure of inorganic polymers and the factors affecting their properties.

Contents

1. Introduction to inorganic polymers
2. Organometallic polymers
3. General properties of polymers
4. Synthetic strategies of polymers
5. Cyclo and polyphosphazines
6. Cyclo polyphosphazines containing polymers
7. Synthesis of phosphazines
8. Applications of phosphazines
9. Phosphorous, sulphur and boran containing polymers
10. Introduction and historical preview of sulphur and boran containing polymers
11. Synthesis, applications and latest developments of sulphur containing polymers
12. Synthesis, applications and latest developments of boran containing polymers
13. Polysiloxanes
14. Synthesis of polysiloxanes
15. Industrial applications of polysiloxanes
16. Other silicon containing polymers
17. Introduction, history, synthesis, applications and latest developments of polymers

Recommended Texts

1. Alexander, D.G., & Boris I.K. (2003). *Synthetic, coordination and organometallic chemistry.* (1st ed.). New York: Marcel Dekker, Inc.
2. Dabrowiak, J.C. (2009). *Metals in medicine*. New York: John Wiley & Sons Ltd.
3. Angelici, R.J. (1986). *Synthesis and technique in inorganic chemistry.* (1st ed.). California: University Science Books.

Suggested Readings

1. Farrell, N. (2002). *Coordination chemistry reviews*. U.K.: Elsevier Publishing Company.
2. Atkins P.W., Langford, C.H., & Shriver, D.F. (1994). *Inorganic chemistry.* (2nd ed.). U.K.: Oxford University Press.

CHEM-7113 Applied Transition Metal Chemistry 3 (3+0)

The idiom "Necessity is the mother of invention" was exactly followed in its true spirit by the chemists of Germany after the World War I. By this time the scientists developed C_1-Chemistry by re-utilizing the effluent gases like syngas from industrial plants, crude oil well or from combustion of natural gas in limited supply of oxygen. Synthetic gasoline took its origin from coal through catalytic reactions.This course aims to the understanding of the preparation of different types of polymers by using different catalysts. Catalysis is responsible to economize processes and revolutionize the industrial era. Beginning with the polymerization of ethylene to produce polythene, an important commercial product of daily use in life at room temperature and normal atmospheric pressure, to the state-of-the art production of silicon from sand for solar technology, all are the fruitful outcomes of catalysis. Transition metals play a pivotal role in bringing about all the dreams to come true... After the successful completion of course, students will be able to explain the concept of catalysis, types of polymers, synthesis strategies of polymers stability and applications of polymers.

Contents

1. Ziegler-Natta catalysis
2. Wacker catalyst
3. Polymerization reactions
4. Oligomerization
5. Polymerization of Ethylene
6. Polymerization of Propylene
7. Polymerization of Olefins
8. Polymerization of Cyclic Olefins
9. Polymerization of Alkynes
10. Fischer-Tropsch Process
11. Oxidation Reaction
12. Synthesis of acrylates
13. Properties of acrylates
14. Applications of acrylate
15. Related Derivatives
16. General properties of polymers

Recommended Texts

1. Cotton, F. A., Wilkinson, G., Murillo, C. A. & Bochmann, M. (1999). *Advanced inorganic chemistry*. (6th ed.). Oxford, U.K.: Wiley International Inc.
2. Alexander, D. G. & Boris I. K. (2003). *Synthetic, coordination and organometallic chemistry.* (1st ed.). New York, USA: Marcel Dekker, Inc.

Suggested Readings

1. Atkins P.W., Langford, C.H., & Shriver, D.F. (1994). *Inorganic chemistry.* (2nd ed.). Oxford, UK.: Oxford University Press.
2. Angelici, R.J. (1986). *Synthesis and technique in inorganic chemistry.* (1st ed.). California, USA: University Science Books, Mill Valley.

CHEM-7114 Inorganic Material Chemistry (II) 3 (3+0)

The chemistry of semi-solids and those of ceramic materials has stemmed forward towards polymer-ceramic combinations. Because of their wide-spread applications and with added advantages these inorganic-organic hybrids are now-a-days the most "wanted" species in everyday life. This course aims to study the different types of materials, their chemistry, properties, methods of synthesis and daily life applications. Many materials such as zeolites, ceramics, glass, alloys etc. are commonly used in our daily life. Polymers containing inorganic and organic components are sometimes called hybrid polymer have important applications in daily life such as zeolites used for the purification of water. Most of the ceramic material in use in routine life has its origin from inorganic polymers. These materials can be prepared by different methods with varying properties. Moreover, their properties can be improved by addition of different reagents during synthesis. After the successful completion of this course, students will be able to understand the general properties, preparation and their applications in various fields of life.

Contents

1. Introduction to material sciences
2. Synthesis and design of inorganic materials
3. Characterization techniques
4. Inorganic-organic hybrid materials
5. Zeolites
6. Applications of zeolites
7. Intercalation in layer materials
8. Some recent development in inorganic material chemistry
9. Ordered solids including interstitial compounds
10. Alloys
11. Uses of alloys
12. Amorphous solids
13. Types of amorphous solids
14. Glass
15. Polymers
16. Applications of polymers

Recommended Texts

1. Alexander, D.G., & Boris I.K. (2003). *Synthetic, coordination and organometallic chemistry.* (1st ed.). New York: Marcel Dekker, Inc.
2. Farrell, N. (2002). *Coordination chemistry reviews*. U.K.: Elsevier Publishing Company.
3. Atkins P.W., Langford, C. H., & Shriver, D.F. (1994). *Inorganic chemistry.* (2nd ed.). UK.: Oxford University Press.

Suggested Readings

1. Huheey, J.E., Keiter, E.A., Keiter, R.L., & Medhi, O.K. (2006). *Inorganic chemistry: principles of structure and reactivity*. (1st ed.). Mumbai, India: Pearson Education.
2. Angelici, R.J. (1986). *Synthesis and techniques in inorganic chemistry.* (1st ed.). California, USA: University Science Books.

CHEM-7115 Advanced Practicals in Analytical & Inorganic Chemistry 3 (3+0)

Besides conventional titration methodology which still in typical cases has its own significance, mostly the instrumental methods of analyses have been introduced and taken the advantage of more precision and accuracy. This course is aimed to impart practical training to the students on specialized spectroscopic and chromatographic techniques with special reference to analytical and inorganic chemistry. Mainly the applications of UV-visible, FTIR, AAS, HPLC, CHN analyzer and GC-MS techniques towards analysis and characterization of analytical and inorganic materials are covered. Different sample models are given for analysis using these techniques. It involves determination of trace, heavy and essential minerals/metals, functional group studies, thermal stability profiles, separation of chemical mixtures, determination of CHN profiles as well as separation and authentic identification of constituents involving various techniques. The package of broad spectrum spectroscopic and chromatographic analyses provides reliable data for qualitative and quantitative measurements and structural elucidation of targeted compounds in various samples such as soil and water samples, pesticide residues, foods, inorganic salts and metal complexes etc. The practical knowledge gained through this course will be helpful towards skill developments of students and imparting them technical training to be useful in their research and professional career activities.

Contents

1. Practicals related to inorganic chemistry enabling the students to use the:
    a. UV-Visible spectroscopy,
    b. FTR,
    c. TGA,
    d. Atomic absorption spectroscopy,
    e. HPLC,
    f. CHN analyzer,
    g. GC-MS etc

Recommended Texts

1. Robinson, J.W., Frame E.S., & Frame G.M. (2014). *Undergraduate instrumental analysis.* (7th ed.). New York, USA: Marcel Dekker.
2. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2014). *Analytical chemistry.* (7th ed.). New York, USA: Wiley.

Suggested Readings

1. Fifield, F.W., & Kealey, D.(2000). *Principles and Practice of Analytical Chemistry*. 5th Edition, Wiley-Blackwell.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York, USA: W.H. Freeman and Company.
3. Skoog, D.A., West, D.M., Holler, F.J., & Crouch S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.) Philadelphia, Pennsylvania: Saunders College Publishing.
4. Related Journal Articles

CHEM-7116 Solid State Chemistry 3 (3+0)

Arrangement of atoms in a solid determines the nature, texture, physical properties and hence the consequent applications in life, industry and diagnostic laboratories. The amorphous solids like powdery materials, glass and suitably oriented crystalline compounds possess all these possible patterns of atoms. This course aims to the understanding of nature of bonds in solid materials, their strength, properties and applications. Composition of solid materials such as alloys, glass and polymers can be greatly varied by the change of reaction conditions and additive chemicals. Therefore, studies will also be carried out on the changes of physical and chemical parameters of polymers by changing the reaction conditions. Alloys play important role in daily life because of corrosion resistant nature and durability in different environmental conditions. Moreover, after the completion of this course, students will be able to learn the general properties, preparations and applications of several solid materials either they are crystalline or amorphous in nature in daily life.

Contents

1. Classification of Bonds
2. Crystals
3. The Effect of Radius Ratio
4. Charge on Crystals
5. Types of crystals
6. Application of Isoelectronic principle
7. Ordered solids
8. Industrial Compounds
9. Alloys
10. Applications of Alloys
11. Superclusters
12. Storage Batteries
13. Charging and discharging of batteries
14. Amorphous Solids
15. Glass
16. Types and properties of glasses
17. Polymers
18. Types of polymers
19. Applications of polymers

Recommended Texts

1. Callister, W.D. (2003). *Material science and engineering: an introduction*. New York: John Wiley & Sons.
2. Weight, J.D., & Nico A.J.M. (2001). *Sol-gel material chemistry and application.* Oxford, U.K.: Sommerdijk, Taylor and Francis Books Ltd.
3. Crabtree, R. H. (2005). *The organometallic chemistry of transition metals*. New York: John Wiley & Sons.

Suggested Readings

1. Rao C.N.R. (1993). *Chemistry of advanced materials.* Oxford, U.K.: Oxford Blackwell Scientific Publications.
2. Christian, G.D. (2010). *Analytical chemistry.* (6th ed.). Singapore: John Wiley & Sons, Inc.

CHEM-7117 Recent Advances in Metal Based Drugs 3 (3+0)

Since the advent of *cis*-platin, an anti-cancer drug, the importance of metals for curing various diseases has been highlighted. Since these are life-saving drugs and are associated with adverse effects on human organs, an alternate or a better substitute is always a requirement. The course is mainly designed with the objective impart knowledge to students about the chemistry, synthesis and biological applications of selected metal complexes. The course focuses on recent developments and future prospects of metal based complexes as chemotherapeutic agents to treat different disorders especially cancers. Infact with advancement in coordination chemistry, ligand substitution and alteration of chemical structures led to the synthesis of a wide array of metal-based compounds, some of which have promising cytotoxic and pharmacokinetic properties. With the new developments in chemotherapy, metal based drugs are gaining recognition of researchers as effective anticancer agents. Anticancer activities and drug designing involving different metals is also covered in this course. The students will acquire knowledge about metal based drug developments. This will help students to start their experimental research and professional career in this emerging area of coordination chemistry. Moreover, they will have opportunity for professional engagements in pharmaceutical industrial sector

Contents

1. Introduction to metal based pharmaceuticals,
2. Historical perspective.
3. Metal-based drugs as general therapeutics,
4. Metal based anticancer drugs; Platinum, Ruthenium, Gallium, Osmium,
5. Copper, Tin, Titanium and gold based chemotherapeutics.
6. Mode of action of metal based Drugs.
7. Latest developments and strategies in chemotherapy,
8. Structure activity relationships,
9. Non-classical metal based drugs,
10. Metal based drugs in diabetics and malaria,
11. Antiviral and Anti-fungal agents,
12. Metals based drugs as diagnostic tool (Ga, Cu, Mn, Tc, Re),
13. Medicinal applications of ionic liquids.

Recommended Texts

1. Farrell, N. (2002). *Coordination chemistry reviews.* UK: Elsevier Publishing Company.
2. Casini, A., Vessières, A., & Meier-Menches, S. M. (2019). *Metal-based anticancer agents.* London, UK: Royal Society of Chemistry.
3. Dabrowiak, J. C. (2009). *Metals in medicines.* NY, USA: Wiley Interscienc
4. Winterton, N., & Leigh, J. (2007). *Modern coordination chemistry: the legacy of Joseph Chatt.* London, UK: Royal Society of Chemistry.

Suggested Readings

1. Avendano, C., & Menendez, J. C. (2015). *Medicinal chemistry of anticancer drugs.* (2nd ed.). London, UK: Elsevier.
2. Meegan, M. J., & O'Boyle, N. M. (2019). *Anticancer drugs.* Basel, Switzerland: Multidisciplinary Digital Publishing Institute (MPDI).
3. Gielen, M., and Edward, R. T. (2005). *Metallotherapeutic drugs and metal-based diagnostic agents.* CA, USA: John Wiley & Sons.
4. Dabrowiak, J.C.(2009). *Metals in Medicine.* UK: John Wiley & Sons.

CHEM-7118 Experimental Techniques in Coordination & Organometallic Chemistry 3 (3+0)

The sophistication required for identification, characterization, extraction and isolation for organometallic compounds has been a question unanswered for a long. However, now it has been understood and techniques and methods developed to address the issue of air- and moisture-sensitive organometallics. This course is aimed to impart knowledge about selected experimental techniques applicable for characterization and studying the structural features and composition of various organometallic & coordination compounds. Especially spectroscopic techniques such as IR, FTIR, and Raman spectroscopy is included for the chemical analyses whereas X-ray diffraction and Neutron analyses are used for the study of molecular weight of the compounds. Mass spectroscopy is covered to deal with the mass to charge/ molecular mass determination and authentic characterization of compounds. NMR spectroscopy as a tool for determination of spatial arrangement of compounds is also covered. It is expected that students after acquiring this course technical knowledge will be able to apply these modern techniques in their research activates and professional careers in experimental research labs and industrial sector.

Contents

1. Manipulation of air sensitive compounds
2. Characterization of organometallic & coordination compounds
3. Chemical analysis, IR & Raman spectroscopy
4. Molecular weight, X-ray diffraction & Neutron diffraction analysis
5. Mass spectrometry
6. Visible and UV- spectroscopy
7. Mössbauer spectroscopy
8. Magnetic susceptibility and ESR spectroscopy
9. NMR spectroscopy

Recommended Books

1. Hil, A.F. (2002). *Organotransition metal chemistry*.UK: Royal Society of Chemistry.
2. Alexander, D.G., & Boris, I.K. (2003). *Synthetic, coordination and organometallic chemistry.* New York: Marcel Dekker Inc.
3. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York, USA: W.H. Freeman and Company.

Suggested Books

1. Winterton, N., & Leigh, J. (2007). *Modern coordination chemistry: the legacy of Joseph Chatt.* London, UK: Royal Society of Chemistry
2. Yamamoto, A. (1986). *Organotransition Metal Chemistry. Fundamental concepts and applications*. New York: John Wiley & Sons.
3. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2014). *Analytical chemistry.* (7th ed.). New York, USA: Wiley.
4. Related Journal Articles

Semester-III & IV

Total Credit hour: 6 (Research/Thesis)

The research scholars are supposed to carry out research on any specialized topic as assigned by the research supervisor throughout semester-III and IV. The comprehensive examination will be held before the viva voce examination. It is essential to pass the comprehensive examination before appearing for the viva voce examination.

Course Description of Physical Chemistry

Semester-I

Course Code	Course Title	Credit
CHEM-7119	Polymer and Advanced Composite Materials	3 (3+0)
CHEM-7120	Advanced Quantum Chemistry	3 (3+0)
CHEM-7121	Advanced Electrochemistry	3 (3+0)
CHEM-7122	Advanced Reactions Dynamics	3 (3+0)
CHEM-7123	Advanced Photochemistry	3 (3+0)
CHEM-7124	Surface Chemistry	3 (3+0)
CHEM-7125	Solution Chemistry	3 (3+0)
CHEM-7126	Advanced Techniques in Physical Chemistry	3 (3+0)
CHEM-7127	Nanomaterials	3 (3+0)
CHEM-7128	Physical Aspects of Environment	3 (3+0)
Total Credits		12

*A student may opt four courses of 12 credit hours offered from the list depending upon the availability of the teacher. Each course will be of 3 credit hours

CHEM-7119 Polymers and Advanced Composite Materials 3 (3+0)

This is an advanced course about knowledge of polymers of natural and synthetic nature and their use in different fields. Natural and semi-synthetic polymers find their used in almost every field of science ranging from drug delivery to sensor and biosensor. This course is designed with the target to make the students capable of preparing polymers used in research field. Main focus of this course is on the topics such as high polymers, their classification, molecular forces and chemical bonding involved in polymerization, configuration & conformation of polymer chains, theories of polymer solutions, phase separation and fractionation and plasticization. Moreover, the topics such as molecular size measurement, spectroscopic analysis, thermal analysis, morphology and order in crystalline polymers, polymer rheology, electrical and magnetic properties of polymers will be discussed in detail. After studying this course, students will be able to use their knowledge in academic research and later on in industrial sector for synthesis of polymers and composite materials. Polymers and advanced composite material are widely applicable in the field of synthesis of biosensors etc.

Contents

1. High polymers
2. Classification
3. Molecular forces and chemical bonding in polymers
4. Configuration of polymer chains
5. Conformation of polymer chains
6. Theories of polymer solutions
7. Phase separation and fractionation
8. Plasticization
9. Molecular size measurement
10. Spectroscopic analysis
11. Thermal analysis
12. Morphology and order in crystalline polymers
13. Polymer rheology
14. Electrical properties of polymers
15. Magnetic properties of polymers

Recommended Texts

1. Tiwari, A., Alenezi, M. R. & Chan, S. (2016). *Advanced composite materials.* John Wiley & Sons Inc.
2. Wang, D. Y. (2016). *Novel fire-retardant polymers and composite materials.* Elsevier Science & Technology.

Suggested Readings

1. Bruce, T. (2020). *Advanced composite materials.* Independently Published
3. Rawe, A. (2000). *Principles of polymer chemistry*. (2nd Edition). New York, USA: Plenum Publishers.
2. Related Research Papers

CHEM-7120 Advanced Quantum Chemistry 3 (3+0)

Advanced Quantum Chemistry is very vital field for physical and computational chemists due to its application in advanced type of research. This course is specifically designed with the objective of covering comprehensive knowledge about crystal field, single and many electron systems and density functional method (DFT). Course is very useful and finds its application to understand the structure of atom& molecules and a glance into sub-atomic phenomenon, properties and occurrences. This basic knowledge leads further to understand the properties of molecules and their reactions. Which enables students in finding the possible outcomes of a reaction by using computational approach. Course focuses on topics such as angular momentum central field problem, variation method, perturbation methods, many electron atoms, molecules (system), self-consistent field method, approximate methods in molecular quantum chemistry, applications to quantum mechanical systems, theoretical and computational approach, basis sets and functional, density functional methods, optimization and molecular modelling. After learning this course, students will be capable of visualizing the molecules on computational grounds and utilizing their knowledge they may interpret the structure of molecules on basis of DFT. Studying this course will provide a strong foundation to physical chemists to apply knowledge in computational chemistry and simulation

Contents

1. Angular momentum
2. Central field problem
3. Variation Method
4. Perturbation methods
5. Many electron atoms, molecules (system).
6. Self-consistent field method
7. Approximate methods in molecular quantum chemistry
8. Applications to quantum mechanical systems
9. Theoretical and computational approach
10. Basis sets and functional
11. Density functional methods
12. Optimization and molecular modelling.
13. Introduction with software used in computational chemistry

Recommended Texts

1. Al-Khalili, J. (2017). *Quantum mechanics (a ladybird expert book).* Penguin Books Ltd
2. Atkins P.W. & Friedman, R. S. (2010). *Molecular quantum mechanics.* UK*:* Oxford University Press.

Suggested Readings

1. Richard, G. (2000). *Computer simulations with mathematics.* Germany: Springer Verlag.
2. Grant, G. H and Richard, W.G. (1995). *Computational chemistry*. UK: Oxford Science Publications.
3. Polkinghorne, J. (2002). *Quantum theory: a very short introduction.* UK: Oxford University Press.
4. Related Research Papers

CHEM-7121 Advanced Electrochemistry 3 (3+0)

This course reveals the all-pervasive and interdisciplinary nature of electrochemistry, especially reactions involving electrodes using concepts of modern electrochemistry. Also, it guides the students as well as experts to understand the nascent developments that this subject has undergone in terms of concepts and applications. Course includes the knowledge of electrical conductivity and interionic interactions and focuses on topics such as the electrical double layer and its structure, electrical potentials and electric current, thermodynamics of electrochemical reactions, kinetics of electrochemical reactions, electrode and electrolytes: Working electrodes, Reference electrodes, electrolytes, electrochemical methods for the study of the electrode/electrolyte interface, electroanalytical techniques: cyclic voltammetry, pulse voltammetry, square wave voltammetry, chronocoulometry, electrochemical impedance spectroscopy
UV/Vis/NIR spectroelectrochemistry, stripping voltammetry, electrochemical studies of solid compounds and materials, potentiometry, applications: Potentiometric sensors, amperometric and voltammetric sensors, electrochemistry in industry and corrosion. Students will be able to use knowledge of electrochemistry studied in this course in different research fields to establish the method based on electrochemistry for the purification of water, preparation of voltic and galvanic cells with better storage capacity and so on.

Contents

1. Overview of electrochemistry
2. Concepts: electrical conductivity and interionic interactions
3. The electrical double layer and its structure
4. Electrical potentials and electric current
5. Thermodynamics of electrochemical reactions
6. Kinetics of electrochemical reactions
7. Electrode and electrolytes: Working electrodes, Reference electrodes, electrolytes
8. Electrochemical methods for the study of the electrode/electrolyte interface
9. Electroanalytical techniques: Cyclic voltammetry, pulse voltammetry, square wave voltammetry
10. Chronocoulometry, electrochemical impedance spectroscopy
11. UV/Vis/NIR spectroelectrochemistry, stripping voltammetry
12. Electrochemical studies of solid compounds and materials,
13. Potentiometry
14. Applications: Potentiometric sensors, amperometric and voltammetric sensors
15. Electrochemistry in industry, corrosion.

Recommended Texts

1. Lefrou, C., Fabry, P. & Poignet, J. C. (2012)., E*lectrochemistry : the basics, with examples.* Germany: Springer-Verlag Berlin and Heidelberg GmbH & Co. KG.
2. Compton, R. G., Banks, C. E. (2011). *Understanding voltammetry.* (2nd Edition). UK: Imperial College Press

Suggested Readings

1. Hamann, C. H., Hamnett, A. & Vielstich, W. (2007). *Electrochemistry*. Germany: Wiley-VCH Verlag GmbH.
2. Steven, M. *Electrochemistry.* Volume 15 UK: Craig Banks Manchester Metropolitan University
3. Related Research Papers

CHEM-7122 Advanced Reactions Dynamics 3 (3+0)

The field of chemical reaction dynamics has made tremendous progress during the last decade. This is due largely to the development of many new, state-of-the-art experimental and theoretical techniques during that period. The primary purpose of this course is to provide the students in the field with a rather detailed picture of the current status of advanced experimental and theoretical research in chemical reaction dynamics. This course covers the topics such as potential energy surfaces, statistical and quantum mechanical approaches for the study of unimolecular decomposition rate, collision & transition state theory, microscopic reversibility, theories of molecular reactions, kinetics in liquid solutions, fast reactions, molecular beam method, linear free energy relationships, temperature effect, heat capacity of activation, pressure effects and the volume of activation, applications of transition state theory, solvent effects, salt effects, kinetic isotope effects, composite rate constants, isokinetic relationship and extra-kinetic probes of mechanism etc. After studying this course students will be capable of understanding and imparting knowledge about reaction rate at lab and industrial level to get the better yield in any environment.

Contents

1. General overview of advanced reactions dynamics
2. Potential energy surfaces
3. Statistical and quantum mechanical approaches for the study of unimolecular decomposition rate
4. Collision theory
5. Transition state theory
6. Microscopic reversibility
7. Theories of molecular reactions
8. Kinetics in liquid solutions
9. Kinetics of fast reactions
10. Molecular reaction dynamics
11. Molecular beam method
12. Linear free energy relationships, temperature effect
13. Heat capacity of activation.
14. Pressure effects and the volume of activation
15. Applications of transition state theory
16. Solvent effects, salt effects, kinetic isotope effects
17. Composite rate constants, isokinetic relationship
18. Extra-kinetic probes of mechanism

Recommended Texts

1. Marin, G. B. & Yablonsky, G. S. (2011). *Kinetics of chemical reactions: decoding complexity.* Germany: Wiley-VCH Verlag GmbH.
2. Gerhard E., Knozinger, H., Schüth, F. & Weitkamp, J. (2008). *Handbook of heterogeneous catalysis: 8 Volume Set.* Germany: Wiley-VCH Verlag GmbH.

Suggested Readings

1. Murzin, D. Y., Salmi, T. & Murzin, D. (2005). *Catalytic kinetics.* Elsevier Science & Technology
2. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.). Meerut Krishna Prakashan Media (P). Ltd.
3. Related Research Papers

CHEM-7123 Advanced Photochemistry 3 (3+0)

Knowledge of Photochemistry enables the students to know how UV/Visible light is absorbed or emitted during a physical or chemical change. The basic knowledge of photochemistry is applied in the field of carbon nanodots because of their unique optical properties which is applied in imaging biological process. Course focuses on important topics such as sources of radiation, actinometry (both physical and chemical), primary & secondary photochemical processes, quantum yields, quantum efficiency, experimental techniques, photolytic studies of aqueous systems, photolytic studies of non-aqueous systems, effects of photo radiation on solids, kinetics of photochemical reactions, mechanism of photochemical reactions, energetics of photochemical reactions etc. After studying this course students will be capable to deal with different kinds of issues in photochemical reactions and to produce new energy sources to proceed photochemical processes. Course is of applied nature and really very vital. Knowledge of kinetics in the course will be helpful to increase yield and to propagate photochemical reactions rapidly or as desired. After studying this course the students will be able to impart their knowledge for determination of kinetics and mechanism of a photochemical reaction at lab or industrial scale.

Contents

1. Principle of photochemistry.
2. Sources of radiation
3. Actinometry (both physical and chemical).
4. Primary photochemical processes
5. Secondary photochemical processes
6. Quantum yields
7. Quantum efficiency
8. Experimental techniques
9. Photolytic studies of aqueous systems
10. Photolytic studies of non-aqueous systems
11. Effects of photo radiation on solids
12. Kinetics of photochemical reactions
13. Mechanism of photochemical reactions
14. Energetics of photochemical reactions

Recommended Texts

1. Allen, N. S. (2010). *Photochemistry and photophysics of polymeric materials*. John Wiley & Sons Inc.
2. Albini, A. & Protti, S. (2019). *Photochemistry: Volume 47.* Cambridge, UK: Royal Society of Chemistry.

Suggested Readings

1. Wardle, B. (2010). *Principles and applications of photochemistry.* John Wiley & Sons Inc.
2. Turro, N. J., Ramamurthy V. & Scaiano, J.C. (2009). *Principles of molecular photochemistry: an introduction.* USA: University Science Books.
3. Neckers, D. C., Jenks, W. S., Wolff, T. (2005). *Advances in photochemistry*. John Wiley & Sons Inc.
4. Related Research Papers

CHEM-7124 **Surface Chemistry** **3 (3+0)**

This course is about the colloids & surfactants, which additionally focuses on different isotherms e.g. Langmuir, Freundlich, Henry, Temkin, Slygin-Frumkin and BET adsorption isotherms, chemisorption and surface heterogeneity. Moreover the important topics to be covered in this course include adsorption at liquid/gas interface, surface tension of solutions and surface excess amount, Gibbs adsorption isotherm, potential theory of adsorption, comparison of gas and vapor adsorption theories, Nature of surface bond, conductivity measurements. Surface techniques, field emission microscopy (FEM), field ion microscopy (FIM), low energy election diffraction studies (LEED), Measurement of gas and vapor adsorption, gas chromatography coupled with mass spectrometry in the study of heterogeneous catalysis. As having comprehensive knowledge of reactions occurring on surface of adsorbent and dynamics is part of this course. After studying this course students will be able to apply the knowledge of adsorption isotherms and sorption process to understand and interpret the mechanism of a reaction and to calculate Gibbs free energy. By applying this knowledge physical chemists are able to apply isothermal and kinetic models on sorption and interpret the mechanism of reaction involved.

Contents

1. Adsorption systems.
2. Comparison of various adsorption isotherms (Langmuir & Freundlich adsorption isotherm)
3. Henry adsorption isotherm
4. Temkin adsorption isotherm
5. Slygin-Frumkin isothermal model
6. BET adsorption isotherm
7. Chemisorption and surface heterogeneity
8. Adsorption at liquid/gas interface
9. Surface tension of solutions and surface excess amount.
10. Gibbs adsorption isotherm
11. Potential theory of adsorption
12. Comparison of gas and vapor adsorption theories, Nature of surface bond.
13. Conductivity measurements. Surface techniques, Field Emission Microscopy (FEM)
14. Field Ion Microscopy (FIM)
15. Low Energy Election Diffraction studies (LEED)
16. Measurement of gas and vapor adsorption
17. Gas Chromatography coupled with Mass Spectrometry in the study of heterogeneous catalysis
18. Applications of radiotracers in catalysis

Recommended Texts

1. Kontogeorgis, G. M. & Kiil, S. (2016). *Introduction to applied colloid and surface chemistry.* John Wiley & Sons Inc.
2. Thomas, J. M. & Thomas, W. J. (2015). *Principles and practice of heterogeneous catalysis.* Germany: Wiley-VCH Verlag GmbH.

Suggested Readings

1. Somorjai, G. A., Yimin, L. (2010). *Introduction to surface chemistry and catalysis.* John Wiley & Sons Inc.
2. Cosgrove, T. (2010). *Colloid science: principles, methods and application.* John Wiley & Sons Inc.
3. Pashley, R., Karaman, M. (2004). *Applied colloid and surface chemistry.* John Wiley & Sons Inc.
4. Related Research Papers

CHEM-7125 Solution Chemistry 3 (3+0)

This course is designed with the objective of giving the students a comprehensive knowledge related to the solutions. As solutions are used in all fields such as physical chemistry, chemical physics, molecular biology, statistical mechanics, biochemistry, and biophysics etc. So the knowledge of this course has a broader spectrum of application in almost every scientific field. The course focuses on preparation, dynamics, energetics and properties of solutions. A detailed discussion about the phenomena of solvation, ineteraction involved and the thermodynamic changes during solvation process gives clear picture of solvation or solute-solvent interactions at molecular level. This course gives comprehensive insight such as physicochemical characteristics of solvents, solvation of ions, preferential solvation, and thermodynamic properties of solute in bare solvents, thermodynamic properties of solute in mixed solvents, transport properties of solutions and study of solute-solvent-solute interactions by spectroscopic techniques. After covering this course students will be able to apply the knowledge in preparation of all kind of solution along with the solid command of knowledge about thermodynamic properties and interactions involved and to determine the interaction by applying spectroscopic techniques. Knowledge will be helpful for the students for academic research and later on to apply in industrial sector too.

Contents

1. Introduction of solutions
2. Physicochemical characteristics of solvent
3. Solubility and polarity
4. Solubility and temperature
5. Lyophilic and lyophobic phenomena
6. Solute-solvent interaction
7. Solvation of ion
8. Preferential solvation
9. Thermodynamic properties of solute in bare solvents
10. Thermodynamic properties of solute in mixed solvents
11. Transport properties of solutions
12. Concept of association constant of ions in solution
13. Study of solute-solvent-solute interactions by spectroscopic techniques

Recommended Texts

1. Somasundaran, P. & Wang, D. (2019). *Solution chemistry: Volume 17: Minerals and Reagents.* Arcler Education Inc.
2. Xiong, Y. (2018). *Solution chemistry: advances in research and applications.* Nova Science Publishers Inc.

Suggested Readings

1. Bostrelli, D. V. (2008). *Solution chemistry research progress.* Nova Science Publishers Inc.
2. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.). Meerut Krishna Prakashan Media (P). Ltd.
3. Bertini , A. D. & Lunazzi, L. (2011). *Advances in solution chemistry.* Springer-Verlag New York Inc.
4. Related Research Papers

CHEM-7126 Advanced Techniques in Physical Chemistry 3 (3+0)

The objective of this course is to comprehend the basics of analytical and spectroscopic techniques in a precise and compact way. The student will learn about updated skills of analysis at laboratory as well as at industry. Analysis of different types of samples by Fourier-transform infrared spectroscopy (FTIR). Spectroscopy and Raman spectroscopy would be taught to students. Merits & limitations of each technique would be communicated. Instrumentation and operational principles will be shared. Additionally, Thermal gravimetric analysis (TGA). High-performance liquid chromatography (HPLC) and atomic absorption spectroscopy (AAS), gas chromatography–mass spectrometry (GC-MS) & CHN analyzer etc. will be discussed in detail to have a command on instrument. Course is highly useful for analysis of functional group by FTIR, determination of electronic transition with the help of UV/Vis spectroscopy. Trace elements/pollutants/contaminants can be determined with the help of Atomic absorption spectroscopy (AAS). Moreover, the practical related to physical chemistry enabling the students to use the UV-Visible spectroscopy will also be discussed in detail. After studying this course students will be able to use advanced techniques for research and later in professional life knowing each and every aspect and interferences and the methods to deal with issues in measurements.

Contents

1. Practical related to Physical chemistry enabling the students to use the UV-Visible spectroscopy
2. Fourier-transform infrared spectroscopy (FTIR).
3. Thermal gravimetric analysis (TGA).
4. Atomic absorption spectroscopy (AAS).
5. High-performance liquid chromatography (HPLC).
6. CHN analyzer
7. Gas chromatography–mass spectrometry (GC-MS). etc.

Recommended Texts

1. Skoog, D. A. Holler, F. J. & Stanley, R. (2012). *Principles of instrumental analysis*. (6th Edition).
2. Nanjwade B. & Patel M. K. (2012). *Analytical techniques.* LAP Lambert Academic Publishing

Suggested Readings

1. Haghi, A. K., Thomas, S., Palit, S. (2018). *Methodologies and applications for analytical and physical chemistry.* Apple Academic Press Inc.
2. National Aeronaut Administration (Nasa). (2018). *Isothermal thermogravimetric data acquisition analysis system.* Createspace Independent Publishing Platform.
3. Ewing, G.W. (1985). *Instrumental methods of chemical analysis*. (5th Edition). New York, USA: McGraw Hill.
4. Related Research Papers

CHEM-7127 Nanomaterials 3 (3+0)

Nano science, is the study of phenomena and manipulation of materials at nano scale. Nanotechnology deals with design, production, characterization and application of materials at at nano scale and exploitation of useful noval properties obtained at nanoscale into future nanodevices. Course focuses on nanomaterials, classification of nanomaterials: manufacturing/synthesis process and growth mechanism, properties of nanomaterials, theory Lorentz oscillator model, Mie theory readings, flow behavior of nanoparticles, a brief intro to suspension rheology, fullerenes, graphenes, carbon nanotubes, quantum dots, quantization of resistance, single electron transistors, Esaki and resonant tunneling diodes, magnetoresistance, spintronics, semiconductor quantum dots, photonic crystal and metamaterials. Studying this course will make the students enable to prepare nanomaterial and will enhance the skill and capability of students in the nanotechnology field. Students will be able to apply their knowledge for preparation of nanomaterial to be used in medicinal chemistry and other fileds relying on nanotechnology such as production of energy storage devices etc.

Contents

1. Nanomaterials
2. Classification of nanomaterials: Manufacturing/synthesis process and Growth Mechanism
3. Properties of nanomaterials
4. Theory lorentz oscillator model
5. Mie theory readings
6. Flow behavior of nanoparticles
7. A brief intro to suspension rheology, Fullerenes
8. Graphenes
9. Carbon nanotubes
10. Quantum dots
11. Quantization of resistance
12. Single electron transistors
13. Esaki and resonant tunneling diodes
14. Magnetoresistance,
15. Spintronics,
16. Semiconductor quantum dots
17. Photonic crystal
18. Metamaterials

Recommended Texts

1. Cao, G. & Wang, Y. (2011). *Nanostructures and nanomaterials: synthesis, properties and applications.* London, UK: World scientific publishing Co.
2. Schodek, D. Ashby, M. F. & Ferreira, P. J. (2009). *Nanomaterials, nanotechnologies and design.* (1st Edition). Elsevier Publishers.

Suggested Readings

1. Singh, A.A. (2008). *Nanofabrication, fundamentals and applications*. (1st Edition). USA: World Scientific Publishers.
2. Wang, Z. L. (2000). *Characterization of nanophase materials*. (1st Edition). Germany: Willy-VCH.
3. Bandyopadhyay, A. k. (2009). *Nano materials*. New Academic Science Ltd.
4. Related Research Papers

CHEM-7128 Physical Aspects of Environment 3 (3+0)

This is comprehensive course in which environment is discussed in detail. Course includes the knowledge of Human Environment, the litho, bio and hydrosphere, the nature and composition of natural waters, water pollution, and chemistry of soil and composition of the atmosphere. Course focuses on topics such as the nature and composition of human environment, the aquatic environment, compellation in natural waters, the catalysis of aquatic reactions, liquid-solid gas interactions in aquatic chemistry, water pollution and trace-level substances in water, water treatment. environmental chemical and soil analysis.
the nature and composition of the atmosphere, the oxides of carbon, sulphur and nitrogen in the atmosphere and others. Moreover the oxides of carbon, sulphur and nitrogen in air pollution, atmospheric monitoring, instrumental methods of environmental chemistry, ozone demolition, acid rain, green-house effect are also part of this course. As environmental pollution is of global concern and Pakistan is one of the most affected countries, so this course will show the picture of environment to the students very clearly and they might be able to find the ways to control environmental pollution by adopting different removal techniques or remediation processes.

Contents

1. The nature and composition of human environment.
2. The aquatic environment.
3. Compellation in natural waters.
4. The catalysis of aquatic reactions
5. Liquid-solid gas interactions in aquatic chemistry
6. Water pollution and trace-level substances in water.
7. Water treatment. Environmental chemical and soil analysis.
8. The nature and composition of the atmosphere.
9. The oxides of carbon, sulphur and nitrogen in the atmosphere.
10. Particulate matter and minor inorganic pollutants in the atmosphere,
11. Atmospheric monitoring and chemical toxicology.
12. Human environment and its resources; resource depletion and environmental pollution.
13. Interaction of pollutants with materials; noxious emissions from industrial processes, aerosol production.
14. Chemistry of pollutants. Nuclear waste and its management.
15. Kinetic and thermodynamic aspects of atmospheric phenomena.
16. Clean energy for future experimental techniques for environmental monitoring.

Recommended Texts

1. VanLoon, G. W. & Duffy, S. J. (2018). *Environmental chemistry: a global perspective.* UK: Oxford University Press.
2. Wesly, W.E. Jr. (2000). *Industrial water pollution control*. New York, USA: McGraw Hill.

Suggested Readings

1. Baird, C. & Cann, M. (2012). *Environmental chemistry*. W. H. Freeman & Co Ltd.
2. Vesilind, P. A., Peirce, J. J. & Weiner, R. F. (1998). *Environmental pollution and control.* Oxford, UK: Elsevier Science & Technology.
3. Related Research Papers

Semester-II

Course Code	Course Title	Credit
CHEM-7129	Magnetic Spin Dynamics	3 (3+0)
CHEM-7130	Advanced Molecular Spectroscopy	3 (3+0)
CHEM-7131	Biophysical Chemistry	3 (3+0)
CHEM-7132	Advanced Statistical Thermodynamics	3 (3+0)
CHEM-7133	Chemistry of Polyoxometalates (POM).	3 (3+0)
CHEM-7134	Colloids and Surfactants	3 (3+0)
CHEM-7135	Nuclear Chemistry and Radiation Chemistry	3 (3+0)
CHEM-7136	Advanced Solid State Chemistry and Characterization Techniques	3 (3+0)
CHEM-7137	Heterogeneous Catalysis	3 (3+0)
CHEM-7138	Ion Exchange Chemistry	3 (3+0)

A student can opt four courses of 12 credit hours offered from the list depending upon the availability of the teacher. Each course will be of 3 credit hours.

CHEM-7129 Magnetic Spin Dynamics 3 (3+0)

Magnetic Dynamic Spin is a comprehensive course with increasing concerns over the effects of electromagnetic radiation on the human body, it has become essential to understand how chemical and biological reactions are affected by magnetic fields. Comprehensive knowledge about magnetic spin resonance will be delivered by focusing topics such as spin and applied field, magnetic field, Larmor precession, relaxation mechanism, dynamic nuclear magnetic resonance, chemical shift, chemical analysis by NMR, HNMR and CNMR. Moreover, detailed knowledge related quadrupole effects, technique and instrumentation, electron spin resonance spectroscopy, double resonance in ESR, electron-electron coupling and ESR instrumentation will also be provided to the students. Dynamic Spin Chemistry focuses on theoretical and experimental research showing the great influence on the dynamic behavior of molecules due to external magnetic fields, such as magnetic quenching of gaseous fluorescence, effects on chemical reaction rates and chemically induced dynamic nuclear and electron polarization. This course discusses both the theoretical and experimental foundations of dynamic spin chemistry, as well as its future trends. Students after studying this course will be able to work on NMR and analyze sample by HNMR & CNMR and ESR.

Contents

1. Spin and applied field
2. Spin and magnetic field
3. Larmor Precession
4. Relaxation mechanism
5. Dynamic Nuclear Magnetic Resonance
6. Application in structure elucidation
7. Chemical shift
8. Coupling constant
9. Coupling among several nuclei
10. Chemical analysis by NMR
11. Chemical analysis by HNMR
12. Chemical analysis by CNMR
13. Quadrupole Effects
14. Technique and Instrumentation
15. Electron spin resonance spectroscopy
16. Double resonance in ESR
17. Electron-Electron Coupling
18. ESR instrumentation

Recommended Texts

1. Levitt, M. H. (2008). *Spin dynamics: basics of nuclear magnetic resonance.* John Wiley & Sons Inc.
2. Keeler, J. (2003). *Understanding NMR spectroscopy*. (2nd Edition). John Wiley & Sons.

Suggested Readings

1. Haghi, A. K., Thomas, S. & Palit, S. (2018). *Methodologies and applications for analytical and physical chemistry.* Apple Academic Press Inc.
2. Levitt, M. H. (2000). *Spin dynamics: basics of nuclear magnetic resonance*. John Wiley & Sons Inc.
3. Related Research Papers

CHEM-7130 Advanced Molecular Spectroscopy 3 (3+0)

The objective of this course is to comprehend the basics of spectroscopic techniques in a precise and compact way and to understand its foundation based on equations of quantum mechanics. The student will learn about updated skills of analysis at laboratory as well as at industry. Analysis by different techniques and the deep insight of interaction of electromagnetic radiation with matter reveals the phenomena occurring and the interpretation of meaningful signals to conclude quantitative and qualitative analyses is a part of this course. Course emphasis on on topics such as classification of spectroscopy
rotational spectra of polyatomic molecules, vibrations of polyatomic molecules (linear and symmetric top), types of vibrational modes, fermi resonance, the influence of nuclear spin, symmetry, symmetry elements and operations, point groups, fourier-transform infrared spectroscopy (FTIR), theory and applications including differences of FTIR and dispersive IR instruments, applications of IR spectroscopy in structural chemistry and electronic spectra of many electron atoms. After studying this course students will be able to analyze samples through different spectroscopic techniques and they will be able to understand the way to interpret the meaning of signal.

Contents

1. Introduction of molecular spectroscopy
2. Classification of spectroscopy
3. Rotational spectra of polyatomic molecules
4. Vibrations of polyatomic molecules (linear and symmetric top).
5. Types of vibrational modes
6. Fermi resonance
7. The influence of Nuclear spin
8. Symmetry, Symmetry elements and operations, Point groups
9. Fourier-transform infrared spectroscopy (FTIR).
10. Theory and applications including differences of FTIR and dispersive IR instruments
11. Applications of IR spectroscopy in structural chemistry
12. Electronic spectra of many electron atoms

Recommended Texts

1. Castellan G. W. (2004). *Physical chemistry* (3rd Ed.). Dehli, India: Norasa Publishing House.
2. Banwell, C. N. & McCash, E. M. (1994). *Fundamentals of molecular spectroscopy*. (2nd Edition). UK: The Bath Press Avon.

Suggested Readings

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.). Meerut Krishna Prakashan Media (P) Ltd.
2. Croasmun, W.R. & Carlson, R.M.K. (1994). *2D NMR spectroscopy: applications for chemists and biochemists* (2nd Edition). Canada: John Wiley & Sons.
3. Simpson, J.H. (2012). *Organic structure determination using 2d nmr spectroscopy-a problem based approach*. Oxford, UK: Academic Press.
4. Related Research Papers

CHEM-7131 Biophysical Chemistry 3 (3+0)

This course introduces the students with advanced biophysical phenomenon and techniques. Course is especially designed to address biological issues on the basis of physical chemistry. Course includes the detailed knowledge about the topics such as macromolecules, biopharmaceutics, enzymology and kinetics, metal based-enzymes, thermodynamics and interactions between the biomolecules, oxidation/reduction reactions and bioenergetics, biophysical basis of separation, ultafilteration, dialysis, centrifugation, electrophoresis, and sedimentation. Moreover the comprehensive discussion about the biological system using physical chemistry (biochemical pathway for visual response, membrane potential, transporters and channels, photosynthesis), biophysical chemistry of interface and radioactivity and its effect on human body is also part of this course. Students will learn about enzymology, macromolecules and bioenergetics with respect to physical chemistry. As recently researchers have been trying to solve the issues with the help of interdisciplinary research, so, this kind of interdisciplinary course is highly applicable in research about medicines. Students after studying this course will be able to utilize their knowledge in research related biomedical and interdisciplinary areas.

Contents

1. Introduction to biophysical chemistry
2. Macromolecules
3. Biopharmaceutics
4. Enzymology and kinetics
5. Metal based-enzymes
6. Thermodynamics and interactions between the biomolecules
7. Oxidation/Reduction reactions and bioenergetics
8. Biophysical basis of separation
9. Ultafilteration
10. Dialysis
11. Centrifugation
12. Electrophoresis
13. Sedimentation
14. Understanding biological system using physical chemistry (biochemical pathway for visual response, membrane potential , transporters and channels, photosynthesis).
15. Biophysical chemistry of interface
16. Radioactivity and its effect on human body

Recommended Texts

1. Coope, A. (2011). *Biophysical chemistry.* (2nd Edition). RSC Publisher
2. Ohshima, H. (2011). *Biophysical chemistry of biointerfaces*. (2nd Edition). Wiley

Suggested Readings

1. Allen, J. P. (2009). *Biophysical chemistry.* (2nd Edition). Blackwell Publisher.
2. Das, D. (2007). *Biophysics & biophysical chemistry.* (5th Edition). Academic Publisher
3. Related Research Papers

CHEM-7132 Advanced Statistical Thermodynamics 3 (3+0)

The wide-ranging course titled as Advanced Statistical Thermodynamics provides extensive coverage of topics of current interest in equilibrium statistical mechanics. Indeed, certain traditional topics are given somewhat condensed treatment to allow room for a survey of more recent advances. Statistical thermodynamics gives a concise and accessible account of this fundamental topic by emphasizing the underlying physical chemistry, and using this to introduce the mathematics in an approachable way. Course has generally focus on very important topics such as ensembles, microcanonical, canonical and grand canonical, average values, fluctuations, partition functions of diatomic gases, partition functions of polyatomic gases, statistical mechanical treatment of chemical processes and equilibria, imperfect gases, liquid state, dilute solutions and perfect crystals, Fermi-Dirac statistics, Bose-Einstein statistics and applications of Fermi-Dirac statistics (FDS) & Bose-Einstein statistics (BES). Students after studying this course will be able to apply their knowledge to solve the complicated chemistry issues with approach of statistical thermodynamics.

Contents

1. Ensembles, microcanonical, canonical and grand canonical.
2. Average values
3. Fluctuations.
4. Partition functions of diatomic gases
5. Partition functions of polyatomic gases
6. Statistical mechanical treatment of chemical processes and equilibria
7. Imperfect gases
8. Liquid state
9. Dilute solutions and perfect crystals.
10. Fermi-Dirac statistics
11. Bose-Einstein statistics.
12. Applications of Fermi-Dirac statistics & Bose-Einstein statistics

Recommended Texts

1. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.). Meerut Krishna Prakashan Media (P) Ltd.
2. Maczek, A. & Meijer, J. H. M. A. (2017). *Statistical thermodynamics.* Oxford, UK: University Press.

Suggested Readings

1. Roy, B. N. (2002). F*undamentals of classical and statistical thermodynamics.* John Wiley.
2. Ebeling, W., Sokolov, I. M. & Geier, S. L. (2005). *Statistical thermodynamics and stochastic theory of nonequilibrium systems.* Singapore: World Scientific Publishing Co Pte Ltd.
3. Sears, F.W & Salingers, G.L. (1975). *Thermodynamics, kinetic theory and statistical thermodynamics.* (3rd Edition). John Wiley
4. Related Research Papers

CHEM-7133 Chemistry of Polyoxometalate (POM). 3 (3+0)

The present course is intended to provide an important overview of various processes and procedures devoted to the eco-sustainable synthesis of fine chemicals. In recent decade, using an applicable industrial catalyst that is eco-friendly, green and simply recycled in the reaction mixtures has been under attention. POM are vital and have wide range of application. Course includes detailed informations about Polyoxometalate (POM), their history, their structure, topology, framework and organic-inorganic hybrid composites of POM origin. Moreover, the emphasis of the course on very important topics such as functionalization of Hexamolybdates (POM), stability of POM in general context, concept of second-order non-linear optics (NLO), quantum chemical approach, NLO properties of POM-based hybrid materials, polyxometalate-protected nanoparticles: synthesis, structure and catalysis and applications of POM. Studying this course will enable the students to apply their knowledge for production of eco-friendly, green industrial catalysts.

Contents

1. Polyoxometalate (POM).
2. History of POM
3. Structure of POM
4. Topology and framework of POM
5. POM-based organic−inorganic hybrid composites
6. Functionalization of Hexamolybdates (POM).
7. Stability of POM in General Context
8. Concept of second-order non-linear optics (NLO).
9. Quantum Chemical Approach
10. NLO Properties of POM-based hybrid materials
11. Polyxometalate-Protected Nanoparticles: Synthesis, Structure and Catalysis.
12. Applications of POM.

Recommended Texts

1. Janjua, M.R.S.A. (2013). *Quantum mechanical study of NLO properties in hybrid composites.* Saarbrcken, Germany: Scholars' Press, Heinrich-Bcking-Str. 6-8, 66121.
2. Janjua, M.R.S.A. Mahmood, A & Ahmad, T. (2013). *Quantum chemical perspective of NLO properties of ruthenium complexes*. Saarbrcken, Germany: LAMBERT Academic Publishers, Heinrich-Bcking-Str. 6-8, 66121.

Suggested Readings

1. Pope , M.T & Müller, A. (2013). *Polyoxometalate chemistry from topology via self-assembly to applications.* ISBN: 978-0-7923-7011-6 (Print).
2. Gharib, A. (2012). *Applications of polyoxometalates (Poms) in chemistry and medicine*. Saarbrcken, Germany: LAP Lambert Academic Publishing.
3. Sécheresse, F. (2013). *Polyoxometalate chemistry: some recent trends.* New Jersey, USA: World Scientific.
4. Related Research Papers

CHEM-7134 Colloids and Surfactants 3 (3+0)

This course is designed for the students of Physical Chemistry at MPhil (2nd Semester) level which has the objective to provide complete and comprehensive knowledge related with colloids, suspensions, surfactants and detergency. Course covers the comprehensive and detailed knowledge on topics such as classification of colloids, preparation of colloids, properties of colloids, micro and macro emulsions, colloidal dispersions, coagulation and flocculation, Hardy Schulz Rule. Moreover, optical properties of colloids, electrical properties of colloids, liquid interfaces, surface tension and adsorption from solution, insoluble surface monolayer (Langmuir-Blodgett Films) will be discussed in detail. Surfactants, detergency, organized molecular assemblies (micelles, vesicles and membranes) is also part of this course. As colloids provide greater surface area so they are extensively used in research related to sorption. The course is advanced and makes the students capable of preparing colloids, emulsion and surfactants at lab scale which may be extensively used in research.

Contents

1. Introduction of colloids & surfactants
2. Classification of colloids
3. Preparation of colloids
4. Properties of colloids
5. Micro and macro emulsions
6. Colloidal dispersions
7. Coagulation and flocculation
8. Hardy Schulz rule
9. Optical properties of colloids
10. Electrical properties of colloids
11. Liquid interfaces
12. Surface tension and adsorption from solution
13. Insoluble surface monolayer (Langmuir-Blodgett films).
14. Surfactants
15. Detergency
16. Organized molecular assemblies (micelles, vesicles and membranes).

Recommended Texts

1. Cosgrove, T. (2010). *Colloid science: principles, methods and application.* John Wiley & Sons Inc.
2. Pashley, R. & Karaman, M. (2004). *Applied colloid and surface chemistry,* John Wiley & Sons Inc.

Suggested Readings

1. Somorjai, G. A., Yimin, L. (2010). *Introduction to surface chemistry and catalysis.* John Wiley & Sons Inc.
2. Raj, G. (2010). *Advanced physical chemistry.* (3rd Ed.). Meerut Krishna Prakashan Media (P) Ltd.
3. Castellan G. W. (2004). *Physical chemistry* (3rd Ed.). Dehli, India: Norasa Publishing House.
4. Related Research Papers

CHEM-7135 Nuclear Chemistry and Radiation Chemistry 3 (3+0)

This course is designed to have a comprehensive knowledge about energy related to nuclear reaction. Course includes principles, kinetics and mechanism of nuclear reactions and intensive knowledge about tracers. This course will enable the students to know about changes taking place in the nucleus of an atom. How an unstable nucleus decays and what type of radiations are coming out of this nucleus as a result of decay is also scope of this course. Course focuses on very important topics such as nuclear chemistry principles, sources of nuclear radiation, nuclear track detectors, kinetics and mechanism of track etching, nuclear materials, nuclear techniques, tracers, radiation chemistry, theoretical aspects, various models, kinetic studies of radiolytic processes, dosimetry (physical and chemical), radiation chemical yields, dose and dose rate effects on primary and secondary products, steady state and pulse radiolysis techniques. Moreover the comprehensive knowledge related to the topics such as radiolytic studies of gaseous, water, aqueous and organic systems and radiology is also part of this course. Students are made capable to know the medical uses of these radiations. A knowledge of radiation chemistry enables students to know how radiations interact with living organism bodies and with different materials.
Students may apply their knowledge in the field of research for isotope production as cancer treatment.

Contents

1. Overview of Nuclear Chemistry
2. Nuclear Chemistry Principles
3. Sources of nuclear radiation
4. Nuclear track detectors
5. Kinetics and mechanism of track etching
6. Nuclear materials
7. Nuclear techniques
8. Tracers
9. Radiation Chemistry, theoretical aspects
10. Various models. Kinetic studies of radiolytic processes
11. Dosimetry (physical and chemical).
12. Radiation chemical yields
13. Dose and dose rate effects on primary and secondary products
14. Steady state and pulse radiolysis techniques
15. Radiolytic studies of gaseous, water, aqueous and organic systems
16. Radiology

Recommended Texts

1. Choppin, G. R., Liljenzin, J. O., Jan Rydberg, J. & Ekberg, C. (2013). *Radiochemistry and nuclear chemistry*. Elsevier Science Publishing Co. Inc.
2. Walter D. Loveland, W. D. Morrissey, D. J. & Seaborg, G. T. (2017). *Modern Nuclear Chemistry.* John Wiley & Sons Inc.

Suggested Readings

1. Koskinen, A. N. (2009). *Nuclear chemistry: new research*, Nova Science Publishers Inc.
2. Related Research Papers

CHEM-7136 Advanced Solid State Chemistry and Characterization Techniques 3 (3+0)

Advanced Solid State Chemistry and Characterization Techniques is designed for the students to have comprehensive knowledge about the modern materials which are used in modern technology. Solid state Chemistry can be defined as the study of the materials that are important for modern technology. The study of the microscopic chemistry of semiconductor materials is an important branch of the broader discipline of solid-state science. Solid state chemistry deals with the microscopic properties of large colliding particles in contrast to the particle Chemistry that focuses on the properties of individual particles. Particle physicists tend to break composite objects up into their constituent building blocks, while Solid State Physicists (& Semiconductor Physicists). are interested in New Properties that emerge when these building blocks are grouped together in various ways. The study of Semiconductor Chemistry is the fact that the microscopic properties to which it deals with, are responsible for the majority of modern technology. Studying this course will enable students to excel in research about conductors and their application in different instruments.

Contents

1. Introduction: Solid state Chemistry & Characterization techniques
2. Metal conductors
3. Band theory
4. Semiconductors
5. Insulators
6. Work function
7. Electrochemical potential
8. Fermi levels
9. Super conductivity
10. Recent theories about super conductivity
11. Preparation and characterization of super conducting ceramics
12. Electrical and magnetic properties of super conducting ceramics

Recommended Texts

1. Anthony, R.W. (2004). *Solid state chemistry and its application.* Wiley Student Edition. John Wiley & Sons.
2. Philippe, K., Vona, D. & Luisa, M. (2012). *Solid state proton conductors*. John Wiley & Sons.

Suggested Readings

1. Smart, L. E. & Moore, E. A. (2012). *Solid state chemistry: an introduction*. (4th Edition). CRC Press.
2. Callister, W.D. (2003). *Material science and engineering; an introduction*. New York, USA: John Wiley.
3. Lefrou, C., Fabry, P. & Poignet, J. C. (2012). *Electrochemistry: the basics, with examples,* Germany: Springer-Verlag Berlin & Heidelberg GmbH & Co. KG.
4. Compton, R. G. & Banks, C. E. (2011). *Understanding voltammetry* (2nd Edition). UK: Imperial College Press.

CHEM-7137 Heterogeneous Catalysis 3 (3+0)

This course is designed for the students opting Physical Chemistry as their field of specialization and having interest in catalysis. Course is designed to make the students capable of understanding the dynamics and phenomena of homogeneous and heterogeneous kinetics. As catalysis is backbone of any synthesis. To control the reaction rate and develop new interfaces suitable for reaction catalysis students will be trained along with solid foundation of physical chemistry. Kinetics equations will be guiding torch to make them understand. Course includes important topics such as rates of surface reaction, rate expressions for unimolecular reactions, bimolecular reactions, the Langmuir-Hinshelwood mechanism, specific rate of catalytic reactions with typical examples, Rideal-Eley mechanism, comparison between catalytic reactions with homogeneous reaction, the exchange of saturated hydrocarbons, the stereochemistry of exchange reactions, exchange reactions involving bonded intermediates, metal catalyzed hydrogenation of unsaturated and unsaturated hydrocarbons, the mechanism of alkyne hydrogenation, surface reactions on oxides and hydrodesulphurization reactions. Students will be able to apply the knowledge in catalysis based synthesis and to achieve the maximum yield with less input at lab and industrial scale.

Contents

1. Overview of heterogeneous catalysis
2. Rates of surface reaction
3. Discussion on rate expressions for unimolecular reactions
4. Rate expression of bimolecular reactions
5. The Langmuir-Hinshelwood Mechanism
6. Rideal-Eley Mechanism
7. Specific rate of catalytic reactions with typical examples
8. Comparison between catalytic reactions with homogeneous reaction
9. The exchange of saturated hydrocarbons
10. The stereochemistry of exchange reactions
11. Exchange reactions involving bonded intermediates
12. Metal catalyzed hydrogenation of unsaturated and unsaturated hydrocarbons
13. The mechanism of alkyne hydrogenation
14. Surface reactions on oxides
15. Hydrodesuphurisation reactions

Recommended Texts

1. Thomas, J. M. & Thomas, W. J. (2015). *Principles and practice of heterogeneous catalysis.* Germany: Wiley-VCH Verlag GmbH.
2. Somorjai, G. A., Yimin, L. (2010). *Introduction to surface chemistry and catalysis.* John Wiley & Sons Inc.

Suggested Readings

1. Murzin, D. Y., Salmi, T. & Murzin, D. (2005). Catalytic kinetics. Elsevier Science & Technology
2. Raj, G. (2010). Advanced physical chemistry. (3rd Ed.). Meerut Krishna Prakashan Media (P). Ltd.
3. Gerhard E., Knozinger, H., Schüth, F. & Weitkamp, J. (2008). Handbook of heterogeneous catalysis: 8 Volume Set. Germany: Wiley-VCH Verlag GmbH.
4. Related Research Papers

CHEM-7138 Ion Exchange Chemistry 3 (3+0)

This course is really important due to its wide application of ion exchangers. Course includes important topics such as matrix & functional groups, capacity, physical structure, properties of ion exchange resins, swelling, isotherms, mechanism, Donnan potential, kinetics, processes, rate law, diffusion in porous media, breakthrough curves, sorption fronts, hydrodynamic effects, purification of gases, separation of metal ions, medical applications and catalysis by ion exchangers. Ion exchange materials are extremely effective absorbents generally containing some functional groups with insoluble structures, which have high affinity capacities towards the targets among a series of structurally similar ions or ion groups. Recently, the various methods used to prepare the absorbents for contaminant removal and resource recycle from environment have been extensively studied under the backgrounds of environment pollution. Currently researchers have focus on molecular imprinting technology (MIT) to prepare ion exchange materials with shape memory effects. In consideration of the advantages of molecular imprinted polymers (MIPs) including high adsorption capacities, high selectivity, easy recycle etc., their applications in the separation and concentration of target molecules or ions will be widely explored. Course will make the students capable of preparing efficient ion exchangers which has wide applications for removal of unwanted ions.

Contents

1. Introduction: Ion exchange reactions
2. Matrix and functional groups, capacity, physical structure
3. Properties of ion exchange resins
4. Ion exchange Equilibra: Swelling of ion exchange resins
5. Ion exchange isotherms
6. Ion exchange mechanism
7. Donnan potential
8. Ion Exchange kinetics
9. Ion exchange processes
10. Ion exchange rate law, diffusion in porous media
11. Column Processes: breakthrough curves, sorption fronts, hydrodynamic effects.
12. Applications of ion exchange: purification of gases
13. Separation of metal ions
14. Medical applications
15. Catalysis by ion exchangers

Recommended Texts

1. Spencer, N. & Thornton, J. (2017). *Ion exchange : theory & applications* Nova Science Publishers Inc.
2. Naushad, M., Al-othman, Z. A. (2013). *Book on ion exchange, adsorption & solvent extraction,* Nova Science Publishers Inc.

Suggested Readings

1. Harland, C. E., (1994). *Ion exchange : theory and practice*, Royal Society of Chemistry Paperbacks
2. Related Research Papers

Semester-III & IV

Total Credit hour: 6 (Research/Thesis).

The research scholars are supposed to carry out research on any specialized topic as assigned by the research supervisor throughout semester-III and IV. The comprehensive examination will held before the viva voce examination. It is essential to pass the comprehensive examination before appearing for the viva voce examination.

Course Description of Organic Chemistry

Semester-I

Total credit: 12

Course Code	Course Title	Credits
CHEM-7139	Advanced Stereochemistry	3 (3+0)
CHEM-7140	Advance NMR Spectroscopy	3 (3+0)
CHEM-7141	Physical-Organic Chemistry	3 (3+0)
CHEM-7142	Medicinal Chemistry	3 (3+0)
CHEM-7143	Pericyclic Reactions	3 (3+0)
CHEM-7144	Advance By-Name Reactions	3 (3+0)
CHEM-7145	Advanced Practicals in Organic Chemistry	3 (3+0)
Total Credits		12

A student may opt four courses of 12 credit hours offered from the list depending upon the availability of the teacher. Each course will be of 3 credit hours

CHEM-7139 Advance Stereochemistry 3 (3+0)

Stereochemistry is the study of the relative arrangement of atoms or groups in a molecule in 3D space. Stereochemistry of molecules dictates isomerism, chemical and biochemical reactivity. These days chiral drugs have become an integral part of pharmaceutical industry and replacing racemic (enantio impure) drugs. A basic concept on 3D structures, conformations of molecules, asymmetric synthesis, other stereochemical principles and attributes are essential. Stereochemistry spans the entire spectrum of organic, inorganic, biological, physical and especially supramolecular chemistry. It includes methods for determining and describing these relationships; the effect on the physical or biological properties these relationships impart upon the molecules in question, and the manner in which these relationships influence the reactivity of the molecules in question (dynamic stereochemistry). This course shall lay foundation for asymmetric transformations with an emphasis on mechanisms, structure-reactivity relationships and applications in organic synthesis. After acquiring the given advanced stereochemistry knowledge, students will be able to apply these principles and reactions in organic synthesis research activities with productive outcomes and gain in their professional career.

Contents

1. Chirality and symmetry, elements of chirality and symmetry, polarimeter
2. Wedge-head, saw-horse, Newman & Fischer projections of a 3D molecule to 2D
3. Stereochemical notations (*cis/trans, E/Z* & *syn/anti, +/-, d/l, D/L, R/S*, *r/s*, *aR*/*aS, pR*/*pS* etc.)
4. Conformational isomerism in substituted cyclohexanes and condensed rings (decalene, steroids, terpenoids etc.), locking groups
5. Configurational isomerism in acyclic/cyclic (enantiomers, diastereomers, epimers, stereomers), biphenyls, terphenyls, allenes and spiro compounds
6. Stereochemical outcomes of addition, substitution, elimination, pericyclic reactions and molecular rearrangements, Felkin-Anh's model; *ee* and *de*
7. *S*tereoselectivity *vs* stereospecificity
8. Chiron (chiral Pool) approach
9. Asymmetric syntheses involving chiral substrates, chiral reagents and chiral catalysts
10. Racemization, methods of resolution of racemic modification
11. Determination of configuration by ORD/CD.

Recommended Texts

1. Eliel, E. L. Wilen S. H., & Mander, L. N. (1994). *Stereochemistry of organic compounds*. New York: John Wiley & Sons.
2. Morris, D. G. (2001). *Stereochemistry*. Cambridge), UK: RSC.
3. North, M. (1998). *Principles and applications of stereochemistry*. Cheltenham, UK: Stanley Thornes Publishers Ltd.

Suggested Readings

1. Nasipuri, D. (2012). *Stereochemistry of organic compounds: principles and applications.* New Delhi: New Age International Ltd.
2. Gal, J. (2011). *Stereochemical vocabulary for structure; Chirality*. 23, 647-659 (A review article).

CHEM-7140 Advance NMR Spectroscopy 3 (3+0)

The objective of the course is to teach the advance aspects of nuclear magnetic resonance (NMR) spectroscopy, which is an important analytical tool in chemical and pharmaceutical industry for structural characterization of molecules. The topics to be covered will include one-dimensional NMR, Chemical shifts, *J*-coupling, interpretation of 1D NMR spectrum, basics of 2D NMR, different heteronuclear and homonuclear 2D NMR experiments and their application/interpretation, application of 2D NMR for assignment of molecules and peptides. After the completion of this course the student shall be able to analyze and interpret complex 1D and multidimensional NMR spectra and use them to resolve molecular structures. The student shall be able to explain how these techniques can be used to resolve the structure of biomacromolecules. A student would be able to interpret simple pulse diagrams and to explain the effect of the pulses on the magnetization using the vector model and/or the product operator formalism. Finally, a student shall be able to understand a scientific paper related to NMR and explain the concepts used in own words and apply this important technique for structural elucidations of compounds in research activities.

Contents

1. A short review of 1D NMR including chemical shift (δ), coupling constant (*J*), spin-spin splitting (*s*, *d*, *t*, *q*, *p*, *dd*, *ddd*, *dddd*) etc.
2. ^{13}C-NMR, broad band (bb), dept-45°, 90° and 135°; applications of nÖe
3. 2D NMR; merits and demerits of each 2D NMR technique
4. Homonuclear (COSY, NOESY, inadequate) 2D NMR
5. Heteronuclear (HMQC, HMBC, HOHAHA, TOCSY, SECSY etc.) 2D NMR
6. Joint applications of 1D and 2D NMR with LRMS, HRMS techniques, IR and UV for structure elucidation of small, medium sized compounds / natural products
7. Stereochemistry and dynamic studies of intermediate sized molecules.

Recommended Texts

1. Croasmun, W. R., & Carlson, R. M. K. (1994). *2D NMR spectroscopy: applications for chemists and biochemists*. (2nd ed.). Canada: John Wiley & Sons.
2. Simpson, J. H. (2012). *Organic structure determination using 2D NMR spectroscopy-a problem based approach*. UK (Oxford): Academic Press.
3. Lambert, J. B., & Rittner, R. (1987). *Recent advances in organic NMR spectroscopy*. USA: Norell Press.

Suggested Readings

1. Williams, D., & Fleming, I. (1995). *Spectroscopic methods in organic chemistry*. New York: McGraw-Hill.
2. Silverstein, R. M., Bassler, G. C., & Morrill, T. C. (1991). *Spectrometric identification of organic compounds*. New York, USA: Wiley.
3. Related Journal Articles

CHEM-7141 Physical-Organic Chemistry 3 (3+0)

Structure and bonding in organic molecules, including MO calculations, perturbation methods, and aromaticity; stereochemistry and conformational analysis; pericyclic reactions; thermochemistry and kinetics; transition state theory and activation parameters; acids and bases; and methods for the determination of mechanisms. After the completion of this course the students shall be able to demonstrate fundamental understanding in order to describe molecular structure by the use of the VBT and MOT, use kinetics as a tool for understanding reaction mechanisms and calculate a reaction's activation energy, enthalpy of activation and entropy of activation by help of Arrhenius and Eyrings equations. They can also feel comfortable in making estimates on reaction mechanisms by use of the Hammett equation as a tool in studies of organic reactions; interpret data for the inclusion of isotops and how this can be used in mechanistically studies of organic reactions and explaining steric and electronic effects in several important reactions. After acquiring these knowledge students will be able to start innovative research projects in this emerging area.

Contents

1. Chemical reactions and energy changes
2. Qualitative aspects of collision; transition state theories, reaction rates and equilibria
3. Tracer techniques, trapping of intermediates
4. Interpretation of kinetic data
5. Correlation of structure with reactivity
6. Linear free energy relationship
7. Stereochemical and stereoscopic evidences
8. Study of reaction mechanism of some recent reactions.

Recommended Texts

1. Grossman, R. B. (2003). *The art of writing reasonable organic reaction mechanisms*. (2nd ed.). Berlin, Germany:Springer.
2. Isaacs, N. S. (1995). *Physical organic chemistry*. Longmans.
3. Carpenter, B. K. (1994). *Determination of organic reaction mechanisms*. New York, USA: Wiley.

Suggested Readings

1. Smith, M. B., & March, J. (2000). *March's advanced organic chemistry: reactions, mechanisms, and structure*. (5th ed.). New Jersey, United States; Wiley.
2. Lowry, T. H., & Richardson, K. S. (1987). *Mechanism and theory in organic chemistry*. (3rd ed.). New York, USA: Harper and Row.
3. Related Journal Articles

CHEM-7142 Medicinal Chemistry 3 (3+0)

This course explores how to bring a drug from concept to market, and how a drug's chemical structure relates to its biological function. The course opens with an introduction to the drug approval process. This introduction combines the social, economic, and ethical aspects of drug discovery. Topics include how diseases are selected for treatment, the role of animal testing, and the costs of various discovery phases. The course then focuses on the scientific side of drug discovery. Topics include how drugs interact with biological molecules, drug absorption and elimination, and the discovery of weakly active molecules and their optimization into viable drugs. After the completion of this course the students shall be able to demonstrate knowledge of the connection between the structural features of the drugs and their physico-chemical characteristics, mechanism of action and use. They shall also feel comfortable in counselling and giving information about the drug action. The acquired knowledge of medicinal chemistry will facilitate students to start research activities in nutra-pharmaceutical and phytochemistry areas. Moreover, students will be able to compete for job opportunities in the pharmaceutical market as medicinal chemists.

Contents

1. Introduction to medicinal chemistry
2. Structure activity relationship (SAR)
3. Classification of synthetic drugs
4. General properties, chemistry, biological action, SAR and therapeutic applications of alkaloids (atropine, morphine, ephedrine etc.)
5. General properties, chemistry, biological action, SAR and therapeutic applications of anti-neoplastics (tamoxifen, mercaptopurine, vincristine etc)
6. General properties, chemistry, biological action, SAR and therapeutic applications of antibiotics (penicillins, cephalosporins, streptomycin, tetracyclins, chloramphenicol, erythromycin' etc.)
7. General properties, chemistry, biological action, SAR and therapeutic applications of non-steroidal anti-inflammatorial drugs (NSAIDs).

Recommended Texts

1. Graham, L.,& Patrick, R. (1995). *An introduction to medicinal chemistry*. UK: Oxford University Press.
2. Richard, B. S., & Holladay, M. W. (2015). *The organic chemistry of drug design and drug action*. (3rd ed.). Amsterdam, Netherlands: Elsevier.

Suggested Readings

1. Thomas, G. (2003). *Fundamentals of medicinal chemistry*. New York, USA: Wiley.
2. Wermuth, C. G. (1996). *The practice of medicinal chemistry*. (2nd ed.). Amsterdam, Netherlands: Elsevier.
3. Related Journal Articles

CHEM-7143 Pericyclic Reactions 3 (3+0)

The aim of the course is to make students familiar with the concepts and applications in two important topics in advanced organic chemistry, namely concerted organic reactions and organic photochemistry. The pericyclic reactions occurs stereo-specifically because the symmetry of the molecular orbitals must be conserved for the reaction to occur. We can analyze these reactions using a frontier orbital method that considers the symmetry of only the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO). Pericyclic reactions are concerted organic reactions and are governed by Woodward-Hoffmann rules. After the completion of this course the students shall be able to predict and rationalise the outcomes of other cycloaddition reactions. Understand, recall and apply the Woodward-Hoffmann Rules to cycloaddition reactions in thermal or photochemical conditions. They shall feel comfortable in predicting the electrocyclic reactions in terms of orbital interactions.

Contents

1. Introduction: Shape of bonding and anti-bonding σand πorbitals; extended πsystems; energy levels; orbital interactions.
2. Diels-Alder Cycloaddition: The basic reaction and its disconnection; Orbitals involved and their implications for transition state geometry; Stereospecificity with respect to diene and dienophile. Substituted dienes and dienophiles and their orbitals; Orbital energy and its effect on reaction rate; Regioselectivity; Stereoselectivity (*exo*/*endo*) governed by secondary orbital interactions. Intramolecular reactions. Chiral starting materials.
3. Other Cycloadditions: 1,3-Dipolar cycloadditions; [2+2] cycloadditions; Woodward-Hoffmann Rules as applied to cycloadditions; synthetic applications; Alder'sene reaction; cheletropic reactions; comparison with cycloadditions.
4. Electrocyclic Reactions: Occurrence with 2, 3, 4, etc. electron pairs; direction of equilibrium; *con*-and *dis*-rotatory reaction; Woodward-Hoffmann Rules as applied to electrocyclic reactions.
5. Pericyclic Rearrangements: Prototropic and sigmatropic rearrangements, including Claisen and related rearrangements, and rearrangements involving sulfur or selenium;Orbital involvement; chair-shaped transition states; stereochemical control; synthetic applications including the synthesis of α,β-unsaturated carbonyl compounds and the geometry of enolate formation.
6. Claisen-Ireland rearrangement
7. Stereochemical aspects and stereoselectivity / stereospecificity of above cited reactions.

Recommended Texts

1. Ansari, F. L., Qureshi, R., & Qureshi, M. L. (1999). *Electrocyclization reactions: from fundamentals to research*. (1st ed.). New York, USA: Wiley.
2. Kumar, S., Kumar, V., & Singh, S. P. (2017). *Pericyclic reactions*. USA: Academic Press.
3. Carruthers, W. (2013). *Cycloaddition reactions in organic synthesis*. Oxford, UK: Pergamon Publishers.

Suggested Readings

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Warren, S., (2008). *Organic synthesis*. New York: Wiley.

CHEM-7144 Advance By-Name Reactions 3 (3+0)

Current indexing schemes do not list reactions and reagents as commonly as they used to. The organic chemistry is famous among students for its long lists of 'name' reactions: Diels–Alder, Claisen, Wittig and so on. People in other subjects often gain the impression that the course consists mostly of committing these to memory, rather like memorising the names of bones and muscles in an anatomy class. Indeed, it's not like this. There is an International Named Reaction Committee meeting once a year in Zurich working under the umbrella of IUPAC. This course is an up-to-date and concise compilation of the most commonly used and widely known name reactions and reagents in modern synthetic organic chemistry. After the completion of this course the students shall be able to demonstrate miscellaneous knowledge of the organic reactions, which shall help them in devising strategies of disconnection (retrosynthetic analysis) of a big organic molecule to small synthons that would be readily synthesize by ordinary chemical protocols. With this knowledge acquired, the students can initiate projects and professional career in the related research areas.

Contents

1. By name reactions of current research interest that have wide application in synthetic chemistry
2. Heck / Keck reaction
3. Buchwald-Hartwig reaction
4. Stille, Suzuki coupling reactions
5. Mitsunobu reaction
6. Sharpless asymmetric epoxidation and dihydroxylation etc.
7. Recent most by name reactions in organic synthesis

Recommended Texts

1. Li, J. J. (2003). *Name reactions*. New York: Springer.
2. Hassner, A., & Namboothiri, I. (2011). *Organic syntheses based on name reactions*. (3rd ed.). Elsevier.

Suggested Readings

1. Li, J. -J., & Corey, E. L. (2004). *Name reactions in heterocyclic chemistry*. New York: John Wiley & Sons.
2. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). *Organic chemistry*. (2nd ed.). UK: Oxford University Press.
3. Related Journal Articles

CHEM-7145 Advanced Practicals in Organic Chemistry 3 (3+0)

This course is designed for hand-on training of organic chemists enabling them to use the routine equipments / instruments (hot plate with magnetic/mechanical stirring, heating mantle, rotary evaporator, aspirator/vacuum pumps, chillers, spotting agents etc.) used in an organic chemistry laboratory and high-tech instruments (IR, UV/Vis, HPLC, GC-MS, TGA etc.). The scholars shall be trained for the application of this knowledge in pharmaceutical industry in particular and other industry in general.
They will be given chance for hand on training through series of steps such as sample preparation, sample purification, pre-concentration, distilling off, and maintaining optimized concentrations. Moreover, they will be preliminarily trained for maintenance of these machines with problem solving skills. After the completion of this course the students shall be able to run these instruments of routine and can apply these instruments for characterization of various chemical, pharmaceutical, nutra-pharmaceutical and natural product samples with additional benefits of getting job opportunities in the relevantindustrial sector.

Contents

1. Practical / hand-on training related to organic chemistry enabling the students to use the high-tech instruments including routine instruments (rotary evaporator, heating mantle, hot plate with magnetic/mechanical stirring, aspirator/vacuum pumps, chillers, spotting agents etc.).
2. FT-IR spectrometer
3. UV/Vis spectrophotometer
4. TGA
5. Atomic absorption spectrometer
6. HPLC
7. CHNS analyzer
8. GC-Ms etc.

Recommended Texts

1. Vogel, A. I. (1989). *Practical organic chemistry*. (5th ed.). London: Longman Publisher.
2. Skoog, D.A., West, D.M., Holler, F.J., & Crouch, S. R. (2014). *Fundamentals of analytical chemistry*. (9th ed.). Philadelphia, Pennsylvania: Saunders College Publishing

Suggested Readings

1. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2014). *Analytical chemistry.* (7th ed.). New York, USA: Wiley.
2. Harris, D.C. (2016). *Quantitative chemical analysis*. (9th ed.) New York, USA: W.H. Freeman and Company.

Semester-II

Total credit: 12

Course Code	Course Title	Credits
CHEM-7146	Advance Organic Synthesis	3 (3+0)
CHEM-7147	Mass Spectrometry	3 (3+0)
CHEM-7148	Natural Product Chemistry	3 (3+0)
CHEM-7149	Organometallic Chemistry	3 (3+0)
CHEM-7150	Heterocyclic Chemistry	3 (3+0)
CHEM-7151	Polymer Chemistry	3 (3+0)
Total Credits		12

A student can opt four courses of 12 credit hours offered from the list depending upon the availability of the teacher. Each course will be of 3 credit hours.

CHEM-7146 Advance Organic Synthesis 3 (3+0)

This course is aimed to impart foundation as well as advanced knowledge. Synthetic organic chemists have the power to replicate some of the most intriguing molecules of living nature in the laboratory and apply their developed synthetic strategies and technologies to construct variations of them. Such molecules facilitate biology and medicine, as they often find uses as biological tools and drug candidates for clinical development. In addition, by employing sophisticated catalytic reactions and appropriately designed synthetic processes, they can synthesize not only the molecules of nature and their analogues, but also myriad other organic molecules for potential applications in many areas of science, technology and everyday life. It deals with the application of structure and theory to the study of organic reaction mechanisms: stereochemical features including conformation and stereoelectronic effects; reaction dynamics, isotope effects and molecular orbital theory applied to pericyclic and photochemical reactions; and special reactive intermediates including carbenes, carbanions and free radicals. After the completion of this course the students are supposed to be able to plan syntheses of organic molecules by proper choice of starting materials, reagents and reaction conditions, and plan simple synthetic routes based on retrosynthetic synthesis strategy.

Contents

1. Methods of C–C, C–N and C–O bond formation
2. Synthesis of aromatic compounds
3. Asymmetric synthesis (involving chiral substrate, chiral reagent and chiral catalyst) including Chiron (Chiral Pool) approach
4. Protective groups (protection of alcohols, amines, carboxylic acids, aldehydes and ketones)
5. Dummy groups and chiral auxiliaries
6. Functional group interconversion (FGI)
7. Introduction to reterosynthesis and disconnection approach
8. One and two group C–X disconnections.
9. Donar and acceptor synthesis and concepts of "Umpulung"
10. C-C disconnections and disfunctionalized compounds
11. Devising synthetic schemes for unknown molecules and some natural products.

Recommended Texts

1. Warren, S. (2008). *Organic synthesis*. New York: Wiley.
2. Hassner, A., & Namboothiri, I. (2011). *Organic syntheses based on name reactions*. (3rd ed.). Elsevier.
3. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). *Organic chemistry*. (2nd ed.). Oxford University Press.

Suggested Readings

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Smith, M. B. and March, J. (2019). *March's advanced organic chemistry*. (8th ed.). New York: John Wiley.

CHEM-7147 Mass Spectrometry 3 (3+0)

Mass spectrometry is an advanced analytical technique for accurate mass measurement. It does so by producing charged molecular species in vacuum followed by its separation under the magnetic and electric fields on the basis of their mass to charge (m/z) ratio. It is a powerful analytical technique used to quantify known materials, to identify unknown compounds within a sample, and to elucidate the structure and chemical properties of different molecules. The complete process involves the conversion of the sample into gaseous ions, with or without fragmentation, which are then characterized by their mass to charge ratios (m/z) and relative abundances. This technique basically studies the effect of ionizing energy on molecules. It depends upon chemical reactions in the gas phase in which sample molecules are consumed during the formation of ionic and neutral species. The MALDI and ESI- coupled with mass analyzers are commonly used mass spectrometer configuration in proteomics. The human proteome draft was decoded by using high-resolution liquid chromatography coupled with mass spectrometry. In this module, the basics of mass spectrometry, sample preparations, liquid chromatography, hybrid mass spectrometers and quantitative proteomics techniques such as iTRAQ, SILAC and TMT using mass spectrometry shall be discussed.

Contents

1. The mass spectrometer
2. Ionization and ionic source
3. Mass analyzers, metastsble ion, ion detection and recording
4. Ionization techniques [Electron impact (EI), chemical ionization (CI), atmospheric pressure chemical ionization (APCI), field ionization (FI), field desorption (FD), fast atom bombardment (FAB +ve and FAB –ve), plasma desorption, thermos-spray, electrospray ionization (ESI), matrix assisted laser desorption ionization (MALDI)]
5. Fragmentation pattern of common functional group
6. Structural elucidation using mass spectrometry in conjunction with other spectroscopic techniques (IR, UV/Vis, ^{1}H and ^{13}C-NMR).

Recommended Texts

1. Williams, D. H., & Fleming, I. (1995). *Spectroscopic methods in organic chemistry*. New York: McGraw-Hill Higher Education.
2. Davis, R., Frearson M., & Richard, F. E. (1987). *Mass spectrometry*. New York: John Wiley & Sons.
3. Silverstein, R. M., Bassler, G. C., & Morrill, T. C. (1991). *Spectrometric identification of organic compounds*. New York: John Wiley.

Suggested Readings

1. Kemp, W. (1975). *Organic spectroscopy*. London: Macmillan.
2. Braun, R.D. (1987). *Introduction to instrumental analysis*. New York: McGraw-Hill.

CHEM-7148 Natural Products Chemistry 3 (3+0)

This course (Natural Products Chemistry) focuses on the biosynthesis, isolation of new natural products, rational structural modifications of known natural products scaffolds for new lead discovery, total synthesis of complex natural products and green chemistry. Special emphasis is given to the development of synthetic methodologies to facilitate generation of diversity around the scaffolds, which can be utilized as key intermediates for total synthesis. Natural products have high structural diversity and unique pharmacological or biological activities due to the natural selection and evolutionary processes that have shaped their utility over hundreds of thousands of years. In fact, the structural diversity of natural products far exceeds the capabilities of synthetic organic chemists within the laboratory. Thus, natural products have been utilized in both traditional and modern medicine for treating diseases. Currently, natural products are often used as starting points for drug discovery followed by synthetic modifications to help reduce side effects and increase bioavailabilty. The new molecular entities generated are screened for pharmacological activities with focus on cancer and anti-bacterial properties. This course is based upon a foundation course (CHEM-6239, Natural Product Chemistry) and shall serve as foundation course for a doctoral course (CHEM-914, Steroids).

Contents

1. Introduction to alkaloids, steroids, terpenes, flavonoids, coumarins and saponins
2. Isolation, structure elucidation, biosynthesis, laboratory synthesis, industrial applications and biological activities of
   a. Terpenes
   b. vitamin D
   c. estrogens
   d. prostaglandins
   e. bile acids
   f. cholesterol
   g. quinine
   h. flavonoids

Recommended Texts

1. Finar, I. L. (2001). *Natural product chemistry*. Vol-I, London: Longman.
2. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). *Organic chemistry*. (2nd ed.). UK: Oxford University Press.
3. Dewick, P. M. (2008). *Medicinal natural products - a biosynthetic approach*. (3rd ed.). England: Wiley.

Suggested Readings

1. Bhat, S. V. (2005). *Chemistry of natural products*. (1st ed.). Berlin: Springer.
2. Cooper, R., & Nicola, G. (2014). *Natural product chemistry: sources, separations and structure*. UK: Taylor & Francis.

CHEM-7149 Organometallic Chemistry 3 (3+0)

The Inorganic Chemistry-I (CHEM-6103/6203) of BS/MSc curricula is the foundation course for having a keen understanding of this course. The organometallic chemistry is the study of organometallic compounds, chemical compounds containing at least one chemical bond between a carbon atom of an organic molecule and a metal, including alkaline, alkaline earth, and transition metals, and sometimes broadened to include metalloids like boron, silicon, and tin, as well. Aside from bonds to organyl fragments or molecules, bonds to 'inorganic' carbon, like carbon monoxide (metal carbonyls), cyanide, or carbide, are generally considered to be organometallic as well. Some related compounds such as transition metal hydrides and metal phosphine complexes are often included in discussions of organometallic compounds but they are not necessarily organometallic.
This course shall highlight the important transformations of organoboranes, ylides (organoP & organoS only) in addition to organotransition-metal (Li^{+}, Mg^{2+}, Cu^{+}, Zn^{0}, Zr^{0}, Sn^{4+}, Pd^{0}, Pd^{2+}, Ru^{2+} etc.) species with an emphasis on their synthesis, basic mechanism of action/catalysis, structure-reactivity relationships and applications in organic synthesis.

Contents

1. Historical perspective of organometallics
2. The eighteen-electron rule, classification of organometallics
3. Compounds with M–C & M=C
4. Ligand coordination & dissociation, oxidative addition and reductive elimination
5. Transmetallation, carbonylation, insertion and extrusion reactions
6. Preparation and applications of *s*-block organometallics; organoLi, organoMg (Grignard's reagent)
7. Synthesis and applications of *p*-block organometallics (organoSn, organoSi, organoB) with stereochemical outcomes
8. Synthesis and applications of *d*-block organometallics (organoCu, organoZn, organoZr, organoPd) with stereochemical outcomes
9. Ylides (organoS, organoP compounds)
10. Metathesis (both first and second generation Grubbs' and Schrock's catalysts).

Recommended Texts

1. Astruc, D. (2007). *Organometallic chemistry and catalysis*. Berlin (Heidelberg): Springer-Verlag.
2. Crabtree, R. H. (2005). *The organometallic chemistry of transition metals*. New York: John Wiley & Sons.
3. Spessard, G. O., & Miessler, G. L. (1997). *Organometallic chemistry*. New Jersey: Prentice Hall PTR.

Suggested Readings

1. Spessard, G. O. and Miessler, G. L. (1996). *Organometallic chemistry*. New Jersey: Upper Saddle River.
2. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2012). *Organic chemistry*. (2nd ed.). UK: Oxford University Press.

CHEM-7150 Heterocyclic Chemistry 3 (3+0)

Compounds classified as heterocyclic probably constitute the largest and most varied family of organic compounds. After all, every carbocyclic compound, regardless of structure and functionality, may in principle be converted into a collection of heterocyclic analogs by replacing one or more of the ring carbon atoms with a different element. Even if we restrict our consideration to oxygen, nitrogen and sulfur (the most common heterocyclic elements), the permutations and combinations of such a replacement are numerous. The heterocyclic compounds include many of the biochemical material essential to life. For example, nucleic acids, the chemical substances that carry the genetic information controlling inheritance, consist of long chains of heterocyclic units held together by other types of materials. Many naturally occurring pigments, vitamins, and antibiotics are heterocyclic compounds, as are most hallucinogens. Modern society is dependent on synthetic heterocycles for use as drugs, pesticides, dyes, and plastics. With this knowledge, students will have opportunity for starting heterocyclic chemistry research projects and build their professional career in the targeted direction.

Contents

1. Nomenclature and chemistry of heterocyclic compounds containing O, N and S with emphasis on their synthesis, reaction, stereochemistry and spectroscopical characterization
2. Conformational analysis of fused heterocycles
3. Fused ring systems involving furan, pyrrole and thiophene, heterocyclic analogues of quinoline, heterocyclic compounds with more than one heteroatom
4. Heterocyclic compounds with a seven membered ring.

Recommended Texts

1. Li, J. -J. & Corey, E. L. (2004). *Name reactions in heterocyclic chemistry*. USA: John Wiley & Sons.
2. Joul, J. A. & Mills, K. (2012). *Heterocyclic chemistry at a glance*. (2nd ed.). New York: John Wiley & Sons.
3. Eicher, T., Hauptmann, S. & Speicher, A. (2003). *The chemistry of heterocycles: structure, reactions, synthesis and applications*. (2nd ed.). New York: Wiley-VCH.

Suggested Readings

1. Clayden, J., Greeves, N., Warren, S. & Wothers, P. (2012). *Organic chemistry*. (2nd ed.). UK: Oxford University Press.
2. Smith, M. B. & March, J. (2019). *March's advanced organic chemistry*. (8th ed.). New York: John Wiley.

CHEM-7151 Polymer Chemistry 3 (3+0)

The course provides an introduction to polymer chemistry based in synthesis mechanisms associated with chain-growth and step-growth polymerization, including advanced mechanisms such as ATRP (atom transfer radical polymerization), living polymerization, and coordination polymerization. Basic knowledge is provided with regards to polymerization kinetics, network formation, and gelation. Industrial polymerization processes are considered in light of production rates as well as the form and properties of the product. Polymer structure/conformation and transitions from liquid (melt) to solid (polymer crystal or glass) states are discussed using equilibrium thermodynamic, kinetics and free volume considerations. Polymer solubility/miscibility and phase diagrams are determined based on Flory Huggin's theory. Knowledge is conveyed of molecular weight determination via osmotic pressure, viscometery and SEC (size exclusion chromatography).
At the end of the course the students shall be able to explain step-growth and chain-growth polymerization, with respect to synthesis mechanisms and kinetics; crystalline melting temperature and glass transition temperature, including the influence of kinetics; and the flow properties of polymer melts and polymer solutions, with respect to both temperature and molecular weight.

Contents

1. Introduction to polymer chemistry
2. Step-growth polymerization
3. Free radical addition polymerization
4. Ionic polymerization
5. Stereochemistry of polymers
6. Polymerization using Ziegler-Natta catalyst
7. Chain copolymerization composition equation and its applications
8. Monomer and radical reactivity (Q-e Scheme)
9. Block and graft polymers
10. Identification and characterization of polymers
11. Molecular weight determination
12. Reactions of synthetic polymers
13. Polymer degradation and stability with special emphasis on thermal and photo degradation.

Recommended Texts

1. Cowie, J. M. G., & Arrighi, V. (2007). *Polymers: chemistry and physics of modern materials*. (3rd ed.). CRC Press.
2. Koltzenburg, S., Maskos, M., & Nuyken, O. (2017). *Polymer chemistry*. Springer.

Suggested Readings

1. Saunders, K. J. (1973). *Organic polymer chemistry: An introduction to the organic chemistry of adhesives, fibres, paints, plastics, and rubbers*. Germany: Springer.
2. Lovell, P. A., & Young, R. (1981). *Introduction to polymers*. (3rd ed.). USA: CRC Press.

Semester-III & IV

Total Credit hour: 6 (Research/Thesis)

The research scholars are supposed to carry out research on any specialized topic as assigned by the research supervisor throughout semester-III and IV. The comprehensive examination will held before the viva voce examination. It is essential to pass the comprehensive examination before appearing for the viva voce examination.

Course Description of Biochemistry

SEMESTER-I

Course Code	Course Title	Credits
CHEM-7152	Protein Structure, Function and Engineering	3 (3+0)
CHEM-7153	Enzyme Kinetics and Mechanisms	3 (3+0)
CHEM-7154	Molecular Biochemistry	3 (3+0)
CHEM-7155	Blood Chemistry and Immunochemistry	3 (3+0)
CHEM-7156	Environmental Biochemistry and Toxicology	3 (3+0)
CHEM-7157	Biochemical Basis of Endocrinology	3 (3+0)
CHEM-7158	Neuro-Biochemistry	3 (3+0)
CHEM-7159	Nutritional Biochemistry	3 (3+0)
CHEM-7160	Biostatistics and Biomathematics	3 (3+0)
CHEM-7161	Biochemistry Laboratory Skills	3 (0+3)
CHEM-7162	Clinical Biochemistry Laboratory Techniques	3 (0+3)
Total Credits		**12***

CHEM-7152 Protein Structure, Function and Engineering 3 (3+0)

This course represents theoretical and practical aspects related to the structure and functions of proteins. Proteins are part of every biochemical pathway in the living organisms, where these biomolecules perform multiple functions along with regulation and catalysis of specific biochemical reactions. There are multiple techniques involved in biochemistry to elucidate structure and function of proteins including X-ray crystallography, NMR, Cryo electron microscopy, circular dichroism, analytical ultracentrifugation and calorimetry. Proteins can be tailored according to desired functions using site directed mutagenesis and making synthetic constructs. This course also emphasize on methods for production of recombinant proteins, gene reshuffling and designing of chimeric enzymes. Students will learn about protein three dimensional structures, native and denatured forms of proteins, structure-function relationships and engineering of proteins by various techniques. An understanding of molecular modelling will allow the student to solve the various protein structures and develop the models of other macromolecules including carbohydrates and DNA.

Contents

1. Overview of Protein Structures; Secondary, Tertiary, and Quaternary structures
2. Classification of proteins according to their functions , Protein families on basis of structure
3. Secondary and Tertiary Structure prediction
4. X-ray crystallography and NMR spectroscopy of proteins
5. Molecular modelling to solve structures and develop models of macromolecules
6. Genomes and Proteins
7. Protein folding pathways, Protein denaturation
8. Protein Engineering, Site directed mutagenesis
9. Production of Recombinant Proteins
10. Post translational and Post transcriptional modifications
11. Gene shuffling and chimeric enzymes
12. *In vitro* directed evolution of enzymes and other proteins.

Recommended Texts

1. Lesk, A. M. (2016). *Introduction to protein science: architecture, function, and genomics.* Oxford, UK: Oxford University Press.
2. Bujnicki, J. P. (2009). *Prediction of protein structures, functions, and interactions.* New York, USA: John Wiley & Sons.

Suggested Readings

1. Creighton, T. E. (2005). *Proteins: Structures and molecular properties*. New York, USA: John Wiley & Sons.
2. Whitford, D. (2005). *Proteins: structure and function*. New York, USA: John Wiley & Sons
3. Related Research Papers.

CHEM-7153 Enzyme Kinetics and Mechanisms 3 (3+0)

Enzyme kinetics deals with the rate of biochemical reactions under the influence of biological catalyst and explains the rate in terms of the reaction mechanism. This course provides an insight about the functions of enzymes in terms of kinetics and reaction mechanism. Studying the enzyme kinetics provide a better understanding of enzyme catalytic efficiency and inhibition. Students will be Introduced to computer graphics to use them as a tool to visualize enzyme structures, catalytic amino acids and enzyme-substrate/inhibitor complexes. This course also emphasize on planning, designing and performing laboratory exercises on enzyme catalysis by selecting a valid model based on experimental data and calculate kinetic parameters using non-linear curve fitting. Upon the completion of the course the students will be able to calculate different enzyme parameters from experimental data using selected models and examine, compare and explain the results. The students will summarize research literature about an enzyme in a reports/assignment regarding its chemical and kinetic mechanism of catalysis and enzyme-substrate interactions.

Contents

1. Fundamentals of enzyme kinetics
2. Steady state, stopped-flow, single and multi-substrate kinetics
3. Derivation of rate equations
4. Applications of Michaelis-Menton equation
5. Use of Lineweaver-Burk plot
6. Eddie Hofstee plot for determination of V_{max} and k_m
7. Free energy of activation and effects of enzymes
8. Mechanisms of enzyme catalyzed reactions
9. Allosteric control and regulation of enzymes
10. Effects of pH, temperature and inhibitors
11. Kinetics of competitive
12. Non-Competitive and mixed inhibition
13. Kinetics of displacement reactions, ordered and random double displacement reactions.

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

Suggested Readings

1. Eisenthal, R., & Danson, M. J. (2002). *Enzyme Assays: A Practical Approach (Practical Approach Series).* Oxford, UK: Oxford University Press.
2. Related Research Papers.

CHEM-7154 Advanced Molecular Biochemistry 3 (3+0)

This course provides a deep understanding of molecular biology central phenomenon including DNA replication, transcription and translation. Mainly, this course is concerned with the aim to educate students about gene regulation, controlled overexpression, operons, strong/weak promoters and junk DNA exclusion from functional part of genome during gene expression. The use of these concepts to understand the functions of biological molecules at the level of individual molecular interactions and at the level of complex processes will allow a better understanding of molecular biology. This course is designed to increase the understanding of students towards various aspects of the control of gene expression including genetic circuits, chromatin structure and re-modelling, gene promoter assembly, eukaryotic mRNA synthesis, processing and translation. The students will also learn specific skills in planning, performing, interpreting, quantitatively analyzing and communicating biochemical research using a variety of modern experimental techniques. This will enable student to design and perform their own molecular biology experiments.

Contents

1. Structural Organization of genes and chromosomes in prokaryotes and eukaryotes
2. Nucleosome, Properties of DNA and RNA, Replication of DNA
3. Replication theory of semi-conservative and conservative replication
4. Enzymes and proteins involved in replication
5. Molecular nature of mutations
6. DNA damage and repair
7. Synthesis and processing of RNA (Transcription)
8. Reverse Transcription and Replication of viral genomes
9. Genetic code and wooble hypothesis, Protein synthesis
10. Translational factors
11. Post transcriptional and post translational Modifications
12. Control of transcription and translation
13. Secretion and targeting of proteins
14. Genetic Diseases related to error in transcription and translation.

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

Suggested Readings

1. McKee, T., McKee, J. R., & Depra, P. (2008). *Biochemistry: The Molecular Basis of Life Student Study Guide / Solutions Manual*. (4th ed.). New York USA: Oxford University Press.
2. Related Research Papers.

CHEM-7155 Blood Chemistry and Immunochemistry 3 (3+0)

This course provides a comprehensive overview of multiple procedures and methods in blood chemistry including antibody interactions with antigens; drugs interactions with other blood proteins. Diagnostics methods for various blood proteins as biomarkers and their limitations. Phenomenon of innate and acquired immunity have been related to bacterial and viral infections will also be explained in the course. General concepts regarding development, design and use of immunoassays including ELISA-based immune assays, radio-immunoassay and chemilumiscence/fluorescence immunoassay will be elaborated to the students. The importance of cross disciplinary approaches in modern biomedical research will be illustrated. In the end of course student will be able to learn about clinical significance and manifestations of test results, applications of immunological functions in relation to analysis of electrolytes, acid-base balance, proteins, carbohydrates, lipids, enzymes, endocrine function, and toxicology. General and specific control mechanisms in immune response cytokines, complement system as well as types and importance of hypersensitivity reactions will be elaborated to the students in the course.

Contents

1. Introduction to the principles and procedures of various tests performed in blood Chemistry
2. Physiological basis, and clinical significance of test results
3. Basic biochemical laboratory techniques and safety
4. Analysis of electrolytes, acid-base balance, proteins, carbohydrates, lipids, enzymes
5. Endocrine function, and toxicology
6. Fundamentals of immune system, Introduction to different types of ELISA
7. Elements of innate and acquired immunity, immunogens and antigens
8. Antibody structure and function, antigen-antibody interactions, genetic basis of antibody structure
9. Monoclonal antibodies and biology of the B lymphocytes
10. Role of MHC in the immune system; biology of the T lymphocyte
11. Activation and function of T and B cells
12. Control mechanisms in immune response cytokines, complement
13. Hypersensitivity reactions; type I, II, III, IV, Autoimmunity
14. Resistance and immunization to infectious diseases
15. Applications of immunological functions.

Recommended texts

1. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2006). *Immunology*. (6th ed.). New York, USA: W.H. Freeman & Co.
2. Paul, W. E. (2008). *Fundamental immunology.* (6th ed.). Philadelphia, Pennsylvania, USA: Lippincott Williams & Wilkins.

Suggested Readings

1. Tips, J. (2007). *Blood chemistry & clinical nutrition.* London, UK: Apple-a-Day Press.
2. Sompayrac, L. M. (2008). *How the immune system works.* (3rd ed.). New York, USA: Wiley-Blackwell Publishers.

CHEM-7156 Environmental Biochemistry and Toxicology 3 (3+0)

Environmental biochemistry is a multidisciplinary field of science concerned with the study of the harmful effects of various toxins including chemical, biological and physical agents on living organisms including human beings. Various toxin sources and their prevalence have been overviewed in this course. This course broadly covers a multitude of possible topics within biochemistry and environmental sciences. In this course, students will learn how organisms cope with environmental stresses at the biochemical level and how biochemistry can be used to devise more environmentally "friendly" ways of using natural resources. One major objective of this course is to provide specific knowledge about environmental, organismal and sub-organismal aspects of toxicology, and an understanding of environmental toxicology with respect to biochemical reactions. At the end of course students are expected to have a better understanding anthropogenic chemicals and their reactions in troposphere and stratosphere with a knowledge of major atmospheric pollution issues, namely ozone depletion, the greenhouse effect and photochemical smog.

Contents

1. Toxic gases liberation and their effects on biochemical system
2. Noise Pollution
3. Green House effects and Global Warming
4. Biological surface effects of water pollution
5. Industrial waste water, sewage and other wastes
6. Radioactive waste in water and their effects
7. Soil and deeper earth pollution
8. Effects of pesticides on life
9. Toxication versus detoxication, bacterial Toxins
10. Toxic responses to foreign compounds
11. Teratogenesis, Immunotoxicity, Genetic toxicity, Chemical carcinogenesis
12. Biochemical mechanisms of toxicity
13. Tissue lesions: liver necrosis, kidney damage, lung damage,
14. Neurotoxicity, Exaggerated and unwanted pharmacological effects,
15. Physiological effects of multi-organ metals toxicity.

Recommended Texts

1. Hathway, D. E. (2005). *Molecular aspects of toxicology.* New Jersey, USA: Humana Press.
2. Pepper, I. L. (2006). *Environmental and pollution science.* (2nd ed.). New York, USA: McGraw-Hill.

Suggested Readings

1. Moon, T. W., & Mommsen, T. P. (2005). *Environmental toxicology.* Vol. 6, Amsterdam, Netherlands: Elsevier Science.
2. William, H. S. (1997). *Biogeochemistry: an analysis of global change.* (2nd ed.). California, USA: Acadamic Press.

CHEM-7157 Biochemical Basis of Endocrinology 3 (3+0)

Studying endocrine system will allow the students to integrate and better understand the functions of the hormones and related systems of the body. The relationship of the nervous system to the endocrine system will be explained to the students in the context of signaling within a multicellular organism. Also, investigations regarding the pathological conditions and diagnostic procedures associated with endocrine imbalance will be elaborated. This course provide details for functions and control of signaling pathway using the hormone that are chemical substance secreted by a ductless gland into blood that is transported to a distant target organ. Function of hormones specifically control the certain pathways in the cell by binding to their specific receptors will help to understanding the human metabolism. This course also overview various diseases related to endocrine dysfunctions. Satisfactory completion of this course will provide the student with the foundation necessary for understanding future clinical problems of the endocrine system.

Contents

1. General Principles of Endocrinology
2. Biochemical synthesis of hormones
3. Signal Transduction and Other Membrane Phenomena
4. Signal Transduction pathways, cAMP mediated pathways
5. Disorders of calcium and phosphate homeostasis
6. Disorders of the hypothalamus and pituitary gland
7. Hyperthyroidism, Hypothyroidism, Goiter
8. Thyroiditis; Tumors of the thyroid gland, Diseases of the parathyroid glands
9. Diseases of the adrenal cortex, Cushing's syndrome
10. Adrenocortical insufficiency, Endocrine hypertension
11. Gonadal diseases (hypogonadism, gonadal dysgenesis, disorders of sexual determination and differentiation
12. Multiple endocrine neoplasia, Polyglandular autoimmune syndrome
13. Osmoregulation and excretion and biological rhythms
14. Type 1 and Type 2 diabetes mellitus,

Recommended Texts

1. Guyton, A. C., & Hall, J. E. (2010). *Text book of medical physiology.* (12th ed.). Philadelphia, Pennsylvania, USA: W. B. Saunders Company.
2. Bolander, F. F. (2012). *Molecular endocrinology.* (5th ed.). Cambridge, USA: Academic Press.

Suggested Readings

1. Jameson, J. L., Kasper, D. L., Fauci, A. S., Braunwald, E., Longo, D. L., & Hauser, S. L. (2006). *Harrison's endocrinology.* New York, USA: McGraw Hill.
2. Gardner, D., & Shoback, D. (2007). *Greenspan's basic & clinical endocrinology.* (8th ed.). New York, USA: McGraw Hill Medical.

CHEM-7158 Neuro-Biochemistry 3 (3+0)

This course is designed to equip the students with an advanced knowledge of neuro-biochemistry enabling them to evaluate, critique and apply research findings in neuroscience. This course also provide a detailed overview of the biochemical reactions involving neurotransmitters and other molecules such as psychopharmaceuticals and neuropeptides. The Diseases related to neural processes including cortical plasticity, neurogenesis, and neural differentiation have also been a main theme for the course. One purpose of the course is to provide a critical mass of fundamental information about organization of nervous system-CNS, ANS & PNS, meninges. Satisfactory completion of this course will provide the student with the foundation necessary for understanding future clinical problems of the nervous system. The student will demonstrate an understanding of the neurological diseases/disorders, neurotransmitters, neuro-mediator and neural signalling. The student will be able to demonstrate the knowledge about major nervous system disorders including Multiple sclerosis, epilepsy, Alzheimer's and Parkinson's disease.

Contents

1. Molecular structure and function of nerve tissue
2. Intra and inter-neuronal communication mechanisms
3. Control of gene expression and membrane biogenesis in neurons and ganglions
4. RNA and protein synthesis in the neuron
5. Energy sources of the nerve cell, chemistry of electrogenic membranes, synaptic transmission,
6. Biochemistry of neuropeptides.
7. Biochemical basis of learning, memory, and various brain dysfunctions.
8. Organization of nervous system-CNS, ANS & PNS, meninges, Blood Brain Barrier
9. Cerebrospinal fluid– composition, function and circulation
10. Neuron & its cell biology, glial cells
11. Biochemical composition of brain tissue. Carbohydrate, lipid metabolism, transports of amino acids
12. Synapse- Synaptogenesis, myelination, synaptic function, biochemistry of developing and aging brain
13. Neural signalling, channels pumps and transporters, neurotransmitters, Neuro-mediators.
14. Neurological Diseases/Disorders
15. Molecular and biochemical basis of important neurological disease: traumas, stroke, multiple sclerosis, epilepsy, Alzheimer's disease, Parkinson's disease, and some behavioural and psychiatric disorders

Recommended Texts

1. Guyton, A. C. & Hall, J. E. (2010). *Text book of medical physiology.* (12th ed.). Philadelphia, Pennsylvania, USA: W. B. Saunders Company.
2. Vizi, S. E. & Lajtha, A. (2003). *Handbook of neurochemistry and molecular neurobiology: neurotransmitter systems.* Berlin, Germany: Springer Science & Business Media.

Suggested Readings

1. Chatterjee, C. C. (2002). *Human physiology.* New Jersey: Humana Press.
2. Gardner, D., & Shoback, D. (2007). *Greenspan's basic & clinical endocrinology*. (8th ed.). New York, USA: Hill Medical.

CHEM- 7159 Nutritional Biochemistry 3 (3+0)

This course includes the details aspects of food metabolism processes including digestion, absorption and excretion. Role of enzymes and hormones in the food metabolism. This course also demonstrates an understanding of the inter-relationship between the nutrients and their metabolites involved in metabolic and detoxification pathways. In the end of course, students are expected to learn the clinical relevance of nutritional biochemistry and the influence of dietary modification and nutritional intervention on physiology and physiological dysfunction. Essential biochemical pathways are explored in relation to the nutritional influences that moderate those pathways. Students further develop their understanding of the role that biological oxidation and the metabolic release of energy plays in disease processes. Students learn about the influence of nutritional biochemistry in liver detoxification, antioxidant pathways and immune function. This subject deepens students' understanding of nutrition and diet therapy while developing their investigative skills in a way that will augment later nutritional medicine and clinical practicum subjects.

Contents

1. Introduction to nutritional biochemistry
2. Biochemical mechanisms of digestion, absorption and metabolism
3. Transport of nutrients into the cell, active and passive transport mechanisms i.e. glucose transporters, ATPases transporter.
4. Energy values of food chemicals, effects of physical activity on energy consumption
5. Metabolic pathways, disorders of Carbohydrates, proteins, lipids and nucleotide metabolism
6. Protein score, assessment of protein quality status, protein calorie, malnutrition states,
7. Deficiency of amino acids and their effects
8. Specificity of amino acids in several physiological processes
9. Role of metals and non-metals in nutritional biochemistry with emphasis on the interaction with enzymes, proteins and nucleic acids, nutraceuticals, food toxins
10. Biochemistry of food infections and food toxins, microbiome, prebiotics and probiotics
11. Analysis of food including genomic analysis for GM food.
12. Dietary influence of food and influence of genes on diet-nutrigenomics and nutrigenetics.
13. Nutraceuticals and their appraisal in terms of gene expression and metabolite formation

Recommended Texts

1. Lori, A., Smolin, L. A., & Grosvenor, M. B. (2016). *Nutrition: science and applications*. (4th ed.). New York, USA: Saunders College Publishing.
2. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry.* (7th ed.). New York, USA: W. H. Freeman Publishers.

Suggested Readings

1. Murray, R. K., Grammer, D. K., Mayes, P. A., & Rodwell, V.W. (2000). *Harper's biochemistry*. (25th ed.). New York, USA: Appleton & Lange.
2. Garrow, J. S., & James, W. P. T. (2003). *Human nutrition and dietetic.* (9th ed.). London, UK: Churchill Livingstone.

CHEM- 7160 Biostatistics and Biomathematics 3 (3+0)

Organizing and analysis of experimental and statistical data in an accurate way is a fundamental aspect of research. This course is designed to have an enhanced knowledge and understanding of mathematical modeling and statistical methods in the analysis of biological systems. This course includes the basics as well as advanced statistical methods and mathematical methods and models that can be applied in biochemical research where it develops students' skills in algebraic manipulation, the calculus of linear and non-linear differential equations, mathematical modelling, matrix algebra and statistical methods. Upon the successful completion of the course, the students will be able to better assess biological inferences that rest on mathematical and statistical arguments and will be able to analyze the data from experiments and draw sound conclusions about the underlying processes using their understanding of mathematics and statistics. The students will be more aware of the use of computers to assist them in studying mathematical functions and carrying out statistical tests.

Contents

1. Organizing and summarizing data
2. Biostatistics, population samples, bio-statistical analysis
3. Ordered array, frequency distributions, polygons and curves
4. Histograms; measures of central tendency
5. Arithmetic mean; measures of dispersion, range, mean deviation
6. Standard deviation and error, coefficient of variation
7. Probability distributions, normal, binomial and Poisson distributions
8. Hypothesis testing, statistical decision, one and two-sample hypothesis, Z-and other tests
9. Simple linear regression and correlation; analysis of variance
10. Nonparametric and distribution free test
11. Biomathematics, algebraic expressions, polynomials
12. Factoring of polynomials, fractional expressions
13. The binomial theorem and its use; use of differentiation and integration highs and lows
14. Exponential growth curve, the definite integral
15. Properties and applications of definite integration.

Recommended Texts

1. Robeva, R. S., Kirkwood, J. R., Davies, R. L., Farhy, L., Kovatchev, B. P., Straume, M., & Johnson, M.L. (2007). *An invitation to biomathematics*. California, USA: Academic Press.
2. Zar, J. H. (2010). *Biostatistical analysis.* (5th ed.). Philadelphia, Pennsylvania, USA: Pearson Press.

Suggested Readings

1. Rosner, B. (2005). *Fundamentals of biostatistics.* (6th ed.). New York, USA: Duxbury Press.
2. Research papers for practice

CHEM- 7161 Biochemistry Laboratory Skills 3 (0+3)

This course designed to provide a practical training to the students. This course will enhance the knowledge of students for basic lab techniques as well as advanced biochemical and bioanalytical methods including chromatographic techniques like FPLC, HPLC. This course also emphasizes on modern biochemistry molecular biology methods including PCR, gene cloning, DNA sequencing, amino acid sequencing, SDS PAGE and 2-D PAGE. After completion of this course students will be able to demonstrate technical and analytical skills in the area of biochemistry, apply scientific reasoning to solve biochemical problems. Students will be able to analyze complex chemical problems and draw logical conclusions. This course will further enhance the understanding of Students to plan and carry out experiments. They will generate and test hypotheses, analyze data using statistical methods where appropriate, and appreciate the limitations of conclusions drawn from experimental data. Trouble-shooting, and practical problem solving will be stressed in classes and labs.

Contents

1. Quantitative tests for amino acids, proteins, carbohydrates, lipids and nucleic acids (DNA and RNA)
2. Estimation of proteins and carbohydrates using different methods.
3. Estimation of glucose by glucose oxidase method
4. Chromatographic separation of sugars.
5. Determination of chain length of polysaccharide
6. Fractionation of lipids. TLC separation of polar and non-polar lipids
7. Isolation and assays of enzymes to demonstrate the effect of various physical and chemical factors on enzyme activity employing enzymes like alkaline phosphatase and lactate dehydrogenase
8. Study of enzyme inhibition and enzyme kinetics
9. Dialysis, ultrafiltration and preservation of proteins by lyophilization
10. Estimation of vitamins A, B1, B2 and others in foods
11. Estimation of mineral constituents of foods by atomic absorption spectrophotometer
12. Determination of fatty acids
13. Analysis of amino acids, sugars, and other constituents by chromatographic techniques
14. Gene isolation and PCR
15. Cloning and protein expression

Recommended Texts

1. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.
2. Ausubel, F. M. (2010). *Short protocols in molecular biology.* (5th ed.). New Jersey, USA: John Wiley & Sons.

Suggested Readings

1. Swaminathan, R. (2011). *Handbook of clinical biochemistry.* (2nd ed.). Singapore: World Scientific Publishing Company.
2. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.

CHEM- 7162 Clinical Biochemistry Laboratory Techniques 3 (0+3)

This course is designed to understand the pathophysiological bases of the most relevant and prevalent diseases in our population, and to elaborate main biological properties of diseases that are examined in a clinical biochemistry laboratory. The procedures for the biological properties' measurement, test and an understanding of semiologist characteristics is a main objective of this course. Along with the theory classes students will get hands-on training on different clinical tests and tools/instruments. Principles and interpretations for the biochemical and microbiological methods is a main part of this course. In this course, students will design experiments, collect data, and interpret results so as to support or refute a hypothesis. At the end of course students will be able to demonstrate excellent critical thinking and problem-solving abilities. Students will be able to integrate chemical concepts and ideas learned in lecture courses with skills learned in laboratories to formulate hypotheses, propose and perform experiments, collect data, compile and interpret results and draw reasonable and logical conclusions.

Contents

1. Blood sampling Techniques
2. Microscopy
3. Complete blood count, Preparation of blood smear, staining, differential leukocytes count
4. Liver function tests; SGOT, SGPT, ALP, LDH, CPK, Bleeding and clotting time
5. Clinical tests including Renal test Profile Urea, Uric Acid, Creatinine, Lipid Profiles; LDL, VDL, Cholesterol, Cardiac Enzymes test, CKMB, kidney Function tests, A/G ratio, serum Na, K, Ca and $HClO_3$, Urine Analysis, bile pigments, bilirubin, urobilinogen, urobilin, albumin, urea
6. Pregnancy and fertility tests
7. Blood groups, sera-diagnosis of infectious diseases, tests for malaria and typhoid.
8. Assay of the various hormones including thyroid, growth, adrenal by radioimmunoassay (RIA).
9. Enzyme-linked immunosorbent assay (ELISA) methods for the assay of biological compounds.
10. Use of PCR in diagnosis and paternity tests, DNA Sequencing
11. Disease biomarkers especially different types of cancer and heart diseases.
12. Cultivation of microorganisms in laboratory using solid and liquid culture media
13. Isolation of pure culture; study of physical characteristics of microorganisms; bacterial growth curve; preservation of microbial strains.

Recommended Texts

1. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.
2. Swaminathan, R. (2011). *Handbook of clinical biochemistry.* (2nd ed.). Singapore: World Scientific Publishing Company.

Suggested Readings

1. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.
2. Cappuccino, J. G., & Sherman, N. (1996). *Microbiology: a laboratory manual.* (4th ed.). New York, USA: Benjamin/ Cummings Publishing Co. Inc.

SEMESTER-II

Course Code	Course Title	Credits
CHEM-7163	Recombinant DNA Technology	3 (3+0)
CHEM-7164	Drug Designing and Drug Metabolism	3 (3+0)
CHEM-7165	Clinical Biochemistry	3 (3+0)
CHEM-7166	Animal and Plant Tissue Culture	3 (3+0)
CHEM-7167	Bioinformatics and Comparative Genomics	3 (3+0)
CHEM-7168	Pathogens and Pathogenicity	3 (3+0)
CHEM-7169	Genomics and Proteomics	3 (3+0)
CHEM-7170	Cell Biology	3 (3+0)
CHEM-7171	Current Topic in Biochemistry	3 (3+0)
CHEM-7172	Techniques for Studying Bio-molecules	3 (0+3)
CHEM-7173	Molecular Biology Lab Skills	3 (0+3)
Total Credits		**12***

*A student may opt four courses of 12 credit hours in on semester offered from the list depending upon the availability of the teacher. Each course will be of 3 credit hours

CHEM-7163 Recombinant DNA and Related Techniques 3 (3+0)

This course focused on how biological processes can be exploited and manipulated for practical purposes in recombinant DNA technology, rather than how they operate in nature. The course also introduces some of the main problem solving skills used routinely in molecular biology. A wide range of methods and applications will be discussed including: polymerase chain reaction (PCR), DNA cloning, DNA sequencing, restriction enzymes, gene libraries, blotting techniques, expression of recombinant proteins, gene mapping, transgenic animals, and gene therapy. Upon the successful completion of this course students will be able to understand the steps, procedures and problems involved in the construction of recombinant DNA and cloning vectors. Student will also able to enhance their understanding of genomic library constructions including cDNA libraries and their applications. Students will also get an get insight in applications or recombinant DNA technology in agriculture, production of therapeutic proteins.

Contents

1. Potentials of recombinant DNA technology
2. DNA cloning methods
3. Cloning vectors including plasmids, bacteriophages, cosmids
4. YAC vectors, shuttle and expression vectors, Tumor inducing (Ti) plasmids
5. Gene splicing, genomic libraries, screening methods for gene libraries
6. DNA cloning restriction enzymes, DNA ligase
7. Southern and Northern blotting
8. Chromosome walking; PCR; site specific mutagenesis
9. Overexpression of proteins
10. Gene therapies
11. Restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis)
12. Human genome project
13. Somatic cell cloning, stem cell research, other future prospects
14. Social and commercial considerations.

Recommended Texts

1. Brown, T. A. (2016). *Gene cloning and DNA manipulation, an introduction.* (7th ed.). New Jersey, USA: Blackwell Publishing Inc.
2. Primrose, S. B. Twyman, R. M & Old, R.W. (2006). *Principles of gene manipulation.* (7th ed.). New Jersey, USA: Wiley-Blackwell.

Suggested Readings

1. Tanley, W. M. S., & Rapley, N. J. (2005). *Molecular bio-methods handbook*. Totowa, USA: Humana Press Inc.
2. Krawezak, M., & Schmidtke J. (2000). *DNA fingerprinting*. Oxford, UK: Oxford Press.

CHEM-7164 Drug Designing and Metabolism 3 (3+0)

This course incorporates metabolism and disposition of candidate drugs as well as it covers various aspects of the drug discovery, designing and properties. Drug development process interlinks multidisciplinary fields with sophisticated analytical technologies and expertise in mechanistic and kinetic enzymology, organic reaction mechanism, pharmacokinetic analysis, animal physiology, basic chemical toxicology, preclinical pharmacology, and molecular biology. Students will study in detailed mechanism of drug action at organ system/sub cellular/ macromolecular levels. Upon the completion of course student will be able to understand the drug metabolic pathways, adverse effect and therapeutic value of drugs. Students will learn structural activity relationship of different class of drugs, synthesis of important class of drugs, mechanism pathways of different class of medicinal compounds. This will also enhance the knowledge of students about basic knowledge of pharmaceutical suspensions and colloids with respect to physicochemical properties including solubility, distribution, adsorption, and stability. This course will also elaborate the effect of drugs on animals by simulated experiments.

Contents

1. Introduction to Drugs, Drug Discovery Techniques
2. Molecular Basis in Drug Design
3. Strategies and Principles in Rational Drug Design, Drug Development
4. Case Studies in Topics in Drug Discovery,
5. Drug Design and development
6. Use of recombinant DNA technology in drug development
7. Study of virulence factors of pathogenic agents and rational drug design.
8. Molecular diagnostics
9. Fundamental concepts and their application to human infectious agents.
10. CoMFACoMSIA and QSAR
11. Chemistry antibacterial, antiviral, antiprotozoal, antifungal and anthelminthic agents
12. Chemistry and mechanism of action of xenobiotics
13. Mechanisms of drug resistance
14. Biochemical transformation of drugs

Recommended Texts

1. Di, L., & Kerns E. H. (2016). *Drug-like properties: concepts, structure design and methods from ADMET to toxicity optimization*. (2nd ed.). New Jersey, USA: Academic Press.
2. Smith, D.A., Allerton, C., & Kalgutkar, A.S. (2012). *Pharmacokinetics and metabolism in drug design.* (3rd ed.). Weinheim, Germany: Wiley-VCH.

Suggested Readings

1. Cappuccino, J. G., & Sherman, N. (1996). *Microbiology: a laboratory manual*. (4th ed.). New York, USA: Benjamin/Cummings Publishing Co. Inc.
2. Research papers

CHEM-7165 Clinical Biochemistry 3 (3+0)

This course provides an in-depth of biochemistry knowledge related to health and explain the clinical significance of the laboratory tests in diagnosis of clinical disorders by estimating biomarkers and explaining the role of various substances including substrates, enzymes, hormones, etc in diagnosis and monitoring of disease. This course is also involved in elaboration of abnormalities which commonly occur in the clinical diagnostic field and reviews each category of tests and develop a protocol for disease diagnosis. The awareness of students will be enhanced towards different lifestyle diseases increasingly day by day in modern world. This course also incorporates laboratory medicines and methods that involves detection of various biomarkers in blood, urine and other body fluids and provides molecular basis of various metabolic diseases and their diagnosis. On the completion of course students are expected to have an enhanced understanding of how biochemical investigations are employed to develop a clinical correlation to biochemical studies.

Contents

1. General composition of blood
2. Mechanisms of blood clotting
3. Blood lipoproteins
4. Blood enzymes
5. Metabolites in clinical diagnosis, ELISA, Radioimmunoassay
6. Nature and functions of hormones, hormonal and other regulatory mechanisms.
7. Body defence mechanisms; the immune system
8. Antibody structure, monoclonal and polyclonal antibodies
9. Blood groups, practical applications
10. Introduction to molecular basis of diseases
11. Use of biochemical approaches in diagnostics and therapeutics
12. Diseases of calcium control; osteoporosis, endocrine control, Arthritis, Cancer, anticancer drugs
13. Biochemistry of the malignant cell, invasiveness and metastasis, growth factors in cancer
14. Microbial toxins
15. Gene therapy and therapeutic cloning.

Recommended Texts

1. Murphy, M., Srivastava, R., & Deans, K. (2018). *Clinical biochemistry: an illustrated colour text.* (6th ed.). Amsterdam, Netherlands: Elsevier.
2. Ahmed, N. (2017). *Clinical biochemistry (fundamentals of biomedical science).* (2nd ed.). Oxford, England: Oxford University Press.

Suggested Readings

1. Cappuccino, J. G., & Sherman, N. (1996). *Microbiology: a laboratory manual*. (4th ed.). New York, USA: Benjamin/ Cummings Publishing Co. Inc.
2. Murray, R. K., Grammer, D. K., Mayes, P. A., & Rodwell, V.W. (2000). *Harper's biochemistry*. (25th ed.). New York, USA: Appleton & Lange.

CHEM-7166 Animal and Plant Tissue Culture 3 (3+0)

The aim of the course is to create an approach on the animal and plant cell/tissue culture technology in general. It seeks to familiarize students to the basic principles of tissue culture, and to expose them to its many applications, the theory production of transgenic plants will be discussed. This course also provides a detailed overview of modern plant and animal biotechnology approaches and their pharmaceutical applications. It also introduces to various tools in molecular biology and conventional tissue culture approaches. At the end of course student will be able to understand protoplast culturing, embryo rescue, HEK cell culture in a better way. A successful completion of course will enable the students to comprehend the importance and application range of plant/animal cell and tissue culture techniques and make the students familiar to Perform supportive or episodic tasks relevant to cell culture, including preparation and evaluation of media, cryopreservation and recovery, and assessment of cell growth/health.

Contents

1. Introduction to tissue culture techniques
2. Cell Culture: Historical Background
3. Laboratory safety and tissue culture environment
4. Plant and animal Cell lines
5. Media components, cell culture theory, tissue types, selection strategies,
6. Virus elimination, micropropagation
7. Soma clonal variation, Haploid culture, Embryo rescue, Protoplast culture
8. Somatic hybridization, Embryonic stem cells
9. Genetic engineering of cultured animal and plant cells
10. Genetically modified organisms (GMO)
11. Biosafety guidelines.
12. Pollen and protoplast culture
13. Somatic hybridization and cryopreservation.
14. Application of tissue culture techniques in health, agriculture, Industries and medicine.

Recommended Texts

1. Smith, R. H. (2012). *Plant tissue culture: techniques and experiments*. (3rd ed.). New Jersey, USA: Academic Press.
2. Freshney, R. I. (2005). *Culture of animal cells: a manual of basic technique.* (5th ed.). New York, USA: Wiley-Liss.

Suggested Readings

1. Das S. K., & Thatoi, H. N. (2017). *Practical biotechnology: principles and protocols*. Delhi, India: I. K. International Publishing House.
2. Brown, T. A. (2016). *Gene cloning and DNA manipulation- an introduction.* (7th ed.). New Jersey, USA: Blackwell Publishing Inc.

CHEM-7167 Bioinformatics and Comparative Genomics 3 (3+0)

The course covers basic bioinformatics with focus on microbial genomic sequencing data with respect to comparative genomics and proteomics. This course will provide a better understanding of biological databases, their uses, mass data retrieval, deposition. The course also focuses on comparative sequence analyses using the available public databases and literature. On completion of the course, the student should be able to identify and choose appropriate biological databases to solve a given biological problem, perform and evaluate pairwise and multiple sequence alignment, outline the process from sequence data to an annotated genome and explain the principles behind the different steps, perform basic annotation, manage basic commands in a Unix or windows environment. The students will be able to choose and apply existing software on given biological problems, critically analyse, evaluate and compile received results. Student will also learn practical's aspects of protein modelling and their interactions with other biomolecules forms the basis of interactomes.

Contents

1. Computational techniques in Biochemistry
2. DNA and Protein Data bases
3. Comparison of different genome
4. Human Genome and Diseases
5. Secondary Structure prediction
6. Protein homology modelling
7. Gene modelling
8. Comparative and functional genomics and proteomics
9. SwissProt PDB viewer and Swiss-model server
10. Data mining, Argus Lab
11. Protein-Protein, Protein-DNA, Protein-Ligand interactions
12. Comparison of Human and mouse genome, Bacteria and Archaea genomes

Recommended Texts

1. Lesk, M. J. (2002). *Introduction to bioinformatics.* Oxford, UK: Oxford University Press.
2. Ussery, D., W. Wassenaar, T. M., & Borini, S. (2009). *Computing for comparative microbial genomics: bioinformatics for microbiologists (computational biology).* Berlin, Germany: Springer.

Suggested Readings

1. Das S. K., & Thatoi, H. N. (2017). *Practical biotechnology: principles and protocols*. Delhi, India: I. K. International Publishing House.
2. Kumar, D., & Antonarakis, S. (2016). *Medical and health genomics*. (1st ed.). New Jersey, USA: Academic Press.

CHEM-7168 Pathogens and Pathogenicity 3 (3+0)

This course focuses on methods/techniques used for identification, classification and characterization of pathogen from multiple sources. It will elaborate the molecular basis of interactions of microbial pathogens with their environment and various hosts, especially those which infect humans. Bacterial pathogens of global and medical significance that will be highlighted in detail. A host-pathogen relationship study will allow a better understanding of disease mechanisms. A particular emphasis has been given to molecular biological approaches of bacterial infections. This course also aims to provide the modern diagnostic methods and their applications to human infectious agents. On successfully completing the course students will be able to demonstrate an understanding and knowledge of the molecular basis of microbial pathogenesis in relation to bacterial, viral, parasitic and fungal pathogens and able to comprehend, assimilate and present data and concepts on a microbial pathogenesis. Students will also learn about pathogenic organisms of major public health importance, diseases caused, and their epidemiology.

Contents

1. Classification of pathogens: conventional non-conventional agents.
2. Structure and mode of infection pathogenic agents
3. Protozoa, fungi, bacteria, viral infection
4. Non-conventional pathogenic agents.
5. Host-pathogen relationship
6. Human infections
7. Classification of antimicrobial agents
8. Mode of action of antimicrobial agents at cellular and molecular level
9. Use of recombinant DNA technology
10. Study of virulence factors of pathogenic agents
11. Rational drug design
12. Disease models
13. Molecular diagnostics
14. Fundamental concepts and their application to human infectious agents.

Recommended Texts

1. Ahmed, N. (2017). *Clinical biochemistry (fundamentals of biomedical science)*. (2nd ed.). Oxford, England: Oxford University Press.
2. Paul, W. E. (2008). *Fundamental immunology.* (6th ed.). Pennsylvania, USA: Lippincott Williams & Wilkins.

Suggested Readings

1. Sompayrac, L. M. (2008). *How the immune system works.* (3rd ed.). New York, USA: Wiley-Blackwell Publishers.
2. Kumar, D., & Antonarakis, S. (2016). *Medical and health genomics*. New Jersey, USA: Academic Press.

CHEM- 7169 Genomics and Proteomics 3 (3+0)

This course provides a comprehensive overview of recent developments in the fields of Genomics and Proteomics including fundamentals, current techniques and applications. One of the specific objectives of the course includes elaboration of the following aspects the diversity and complexity of eukaryotic genomes, the historical and evolutionary perspective of genomic content, the meaning and consequences of intraspecific variability, techniques commonly employed in studies of genomics and transcriptomics and applications derived from the knowledge provided by this science. This course also details the techniques and methods of Proteomics, Interactomics and Metabolomics. Proteogenomics. The students are expected to learn about human genome, proteome proteomics-based biomarkers and pathogen identification. Understanding of genomics techniques will allow students to grasp information about gene annotations, genome organization and cDNA libraries. Proteomics allow the studies for all protein pool present in the cell at a specific time. In the end student will be able to use bioinformatics techniques to query examples of genomic and proteomic databases to analyse cell biology.

Contents

1. Proteomics; Strategies and methods,
2. Tools in proteomics
3. Application of proteomics
4. Two-dimensional gel electrophoresis (2D-PAGE), Property of proteins, 2D electrophoresis
5. HPLC, reverse-phase chromatography, multidimensional HPLC, Isoelecteric focusing
6. Mass Spectrometry Ionization Techniques, Mass analyzers
7. Peptide fragmentation mechanism
8. Interpretation of Mass Spectra, MALDI-TOF LC-MS/MS, peptide fingerprint, tandem MS search engines, Yeast 2-hybrid system.
9. Protein-protein interactions; experimental and computational method
10. Databases, Gene, Genome and Genomics annotations, Online genomics databases and tools
11. Analysis of genomic data, applications of genomics
12. Transcriptomics, Microarray, EST, SAGE.
13. Bioinformatical methods in transcriptomics, in metabolomics and nutrigenomics
14. Nuclear Magnetic Resonance Spectroscopy and Mass Spectrometry in metabolomics.

Recommended Texts

1. Lesk, M. J. (2002). *Introduction to bioinformatics.* Oxford, UK: Oxford University Press.
2. Brown, T. A. (2016). *Gene cloning and DNA manipulation, an introduction.* (7th ed.). New Jersey, USA: Blackwell Publishing Inc.

Suggested Readings

1. Das S. K., & Thatoi, H. N. (2017). *Practical biotechnology: principles and protocols*. Delhi, India: I. K. International Publishing House.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

CHEM- 7170 Cell Biology 3 (3+0)

Cell biology help to understand all the processes being occurred in a living cell from assembly o cytoskeleton and movement to cellulase communication and cell death. This course provide an overview of all these fundamental procedures and their disorders that may lead to serious consequences in human body and also applies a basic core of scientific and quantitative knowledge to enhance understanding of cell structure and function at the molecular level. This course also integrates the classical research findings to current hands-on experiences with the latest biotechnology and information technology. On the successful completion of this course, students will be able to understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles. Students will have an advanced understanding of how these cellular components are used to generate and utilize energy in cells and about cellular components which are actively involved in mitotic cell division, cancer and apoptosis.

Contents

1. Cytoskeleton and Microtubule structure and function, Dynamic instability
2. Motor proteins, Dynein, Kinesin
3. Drugs affecting microtubule structure, Extracellular matrix
4. Basement membranes, Proteoglycans
5. Collagen, Integrins, Fibronectin, Cell migration, Gap junction.
6. Study of EGF & TGF beta receptors-structure and function, genomic regulation and relation to clinical disorders including cancer, Endocrines, Paracrine, Autocrine
7. Hormones, Neuro-transmitters, Growth factors
8. Signalling via intracellular receptors e.g. steroid and steroid-like ligands
9. Signalling via cell surface receptors like GPCR, RTK, Jak-STAT, NF-kB mediated pathways.
10. Biochemical and genetic evidences that form a framework for cell cycle regulation
11. Highlighting the reversible phosphorylation mediated regulatory steps
12. Steps involving proteolysis
13. Concepts and examples of several checkpoints. Disorders of cell cycle
14. Cancer and Apoptosis, Intracellular Protein transport to Nucleus, Mitochondria/ Chloroplast peroxisome. Vesicular trafficking of protein to Golgi, plasma membrane, lysosome/endosome and secretory vesicles.

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Recommended Texts

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell,* (6th ed.). New York, USA: Garland Science.
2. Lodish, H., Berk, A., Kaiser, C., A. Krieger, M., Bretscher, A., Ploegh, H., & Martin, A. A., (2016). *Molecular cell biology*. (8th ed.). New York USA: W. H. Freeman.

Suggested Readings

1. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
2. Latest research papers

CHEM-7171 Current Topics in Biochemistry 3 (3+0)

This course overviews the latest developments, concepts and topics in research related to biochemistry and provides an advanced understanding of the core principles and topics of Biochemistry and their experimental basis, and to enable students to acquire a specialised knowledge and understanding of selected aspects by means of a stem/branch lecture series and a research project. Student are given a few short assignments, a series of debates and a major research group literature review project spanning the length of the course. Latest topics in biochemistry will be covered during the discussions and students will be asked to prepare their presentations with updated literature review. This course also help to understand all new techniques and procedures being developed in biochemistry and molecular biology. At the end of course students are expected to learn the connections between pure scientific research and practical, real world implications of biochemistry as well as course will enhance student skills related to oral & written communications.

Contents

1. Advanced topics in molecular biology
2. Developmental Molecular biology
3. Control of cell proliferation
4. Genetics basis of cancer
5. Evolution of the gene, Origins of human cancer
6. DNA rearrangements and amplification, mutability and repair of DNA,
7. The mitochondrial genome and genetic engineering.
8. Structural and conformational properties of macromolecules with emphasis on macromolecular function and recognition
9. Mechanism of enzymatic reactions, Sensory adaptation
10. Biochemistry of transcription.
11. Current advancement in major groups of bacteria, fungi, protozoa and yeast and their use in gene manipulation to obtain a specific goal related to agriculture, health and medicine

Recommended Texts

1. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell,* (6th ed.), Garland Science, New York, USA: John Wiley & Sons.
3. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.

Suggested Readings

1. Lodish, H., Berk, A., Kaiser, C., A. Krieger, M., Bretscher, A., Ploegh, H., & Martin, A. A., (2016). *Molecular cell biology*. (8th ed.). New York USA: W. H. Freeman.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.
3. Kumar, D., & Antonarakis, S. (2016). *Medical and health genomics*. New Jersey, USA: Academic Press.
4. Latest research papers

CHEM-7172 Techniques for Studying Bio-molecules 3 (3+0)

This course aims to give the students a better understanding of biophysical and bioanalytical techniques used to characterize biomolecules including protein, carbohydrates lipid, and nucleic acids. This course will also demonstration of some of techniques in the lab with emphasis on quantitative and qualitative estimation of biomolecules using various bioanalytical and assays. In this course, students will be introduced to several biochemical, biophysical and bioanalytical techniques including flame photometry, Atomic absorption, fluorescence spectroscopy; X-ray diffraction protein manipulation, purification and characterisation. As part of the course a series of lectures and tutorials have been arranged. On the successful completion of the course student will be able to gain proficiency in basic laboratory techniques in both chemistry and biology, and be able to develop and apply the scientific methods to the processes of experimentation and hypothesis testing using. Students will also learn about drug immunoassays, enzyme-immunoassays, fluorescent-immunoassays along with separation, identification, and quantification of drugs using GC and HPLC.

Contents

1. General methods of fractionation and characterization of proteins and nucleic acids
2. Dialysis, ultrafiltration, and lyophilisation
3. Principles and application of visible; UV, IR, mass,
4. NMR spectroscopy in biochemistry
5. Flame photometry, Atomic absorption, fluorescence spectroscopy; X-ray diffraction
6. Principle and applications of electrons microscopy, centrifugation
7. Principles and applications of adsorption, partition, ion-exchange, hydrophobic and affinity chromatography; chromate-focussing
8. Principles and application of gas chromatography and HPLC.
9. Protein characterization by salting out, dialysis, gel filtration, ion exchange chromatography and PAGE.
10. Isolation and estimation of DNA and RNA. Analysis of body fluids
11. Assay of enzymes of clinical significance
12. Drug assays: immunoassays, enzyme-immunoassays, fluorescent-immunoassays
13. Separation, identification, and quantification of drugs using GC and HPLC
14. Use of ultracentrifugation and density gradient centrifugation for the fractionation of biological compounds and molecular weight determination.

Recommended Texts

1. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

Suggested Readings

1. Ausubel, F. M. (2010). *Short protocols in molecular biology.* (5th ed.). New Jersey, USA: John Wiley & Sons.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell,* (6th ed.), Garland Science, New York, USA: John Wiley & Sons.

CHEM-7173 Molecular Biology Lab Skills 3 (0+3)

This is a practical course designed to provide a practical training for molecular biology experiments to the students before they start their research/thesis. This course will provide an advanced theoretical and practical understanding towards important methods and techniques in molecular biology including molecular cloning, PCR, plasmid propagation in bacteria, plasmid purification, restriction analysis, overexpression of genes in mammalian cell lines, microscopy, as well as gel electrophoresis and Western blotting. This course will also enhance students' practical skills regarding use of recombinant DNA technology in the lab. Furthermore, the students will get hands-on experience and consolidation of nucleic acid data bases and other bioinformatics tools. The students will learn the physical and chemical principles of the analytical methods. Lab experiments include basic techniques as well as advanced molecular biology methods including a short project involving gene cloning and protein overexpression. At the end of course students are expected to develop skills in experimental molecular biology thus establishing the basis for research in molecular biology.

Contents

1. Growth of bacteria on solid medium
2. Preparation of bacterial culture
3. Preparation of plasmid DNA, restriction enzyme digestion of DNA preparation
4. Separation and identification of DNA fragment by agarose gel electrophoresis
5. Purification of DNA fragment by electroporation after digestion and separation on agarose
6. PCR, sequencing, , preparation of prob for DNA fragment analysis
7. Southern blot and hybridization, RNA extraction and determination
8. RNA electrophoresis, probe preparation for RNA analysis, Northern blot.
9. A mini project to clone selected genes in *E. coli*;
10. Preparation of chromosomal DNA, mini preparation of plasmid DNA
11. Restriction of chromosomal and plasmid DNA and fractionation of DNA by agarose gel electrophoresis
12. Electro elution of selected DNA fragments
13. Alkaline phosphatase treatment of linearized plasmid DNA, Ligation to produce recombinant DNA
14. Transformation of *E. coli* by competent cell and electroporation methods
15. Screening for blue and white colonies on X-gal plates, detection of transformants
16. Isolation of the recombinant DNA, its subcloning and development of restriction mapping

Recommended Texts

1. Boyer R. F. (2000). *Modern experimental biochemistry.* (3rd ed.). London, England: Pearson Press.
2. Voet, D., & Voet, J. G. (2016). *Biochemistry.* (5th ed.). New York, USA: John Wiley & Sons.

Suggested Readings

1. Ausubel, F. M. (2010). *Short protocols in molecular biology.* (5th ed.). New Jersey, USA: John Wiley & Sons.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell,* (6th ed.), Garland Science, New York, USA.

SEMESTER-III & IV

Total Credit hour: 6 (Research/Thesis)

The research scholars are supposed to carry out research on any specialized topic as assigned by the research supervisor throughout semester-III and IV. The comprehensive examination will be held before the viva voice examination.

It is essential to pass the comprehensive examination before appearing for the *viva voce* examination.

REVISED SCHEME OF STUDIES & CURRICULUM
PhD CHEMISTRY
(Semester System)
(2020)

INSTITUTE OF CHEMISTRY
UNIVERSITY OF SARGODHA
SARGODHA

Revised Scheme of Studies and Curriculum for Ph.D. Chemistry with Programme in Analytical / Inorganic Chemistry, Organic Chemistry, Physical Chemistry and Biochemistry

Summary

Areas of Specializations

1. Analytical & Inorganic Chemistry
2. Physical Chemistry
3. Organic Chemistry
4. Biochemistry

- Ph.D. course work comprises of two semesters with 18 credit hours.
- Four courses of three credit hours will be compulsory for all students while two courses of three credit hours from optional courses in specific discipline or otherwise

Course work: 18 credits hours

1st Semester:

Total Credits: 9 Credit hrs

Course Code	Title of the Course	Credits
		Th.
CHEM-8101*	Literature Survey & Technical Writing	3(3+0)
CHEM-8102*	Advances in Chemical Analysis	3(3+0)
CHEM-8103*	Computer Applications & Statistical Analysis	3(3+0)
Total		**9 (9+0)**

2nd Semester

Total Credits: 9 Credit hrs

Course Code	Title of the Course	Credits
		Th.
CHEM-8104*	Experimental Techniques and Laboratory Safety Practices	3(3+0)
	Optional Course I ¶	3(3+0)
	Optional Course II¶	3(3+0)
Total		**9 (9+0)**

* **Compulsory Courses:** These courses can be offered in any order in semester I and II

¶ **Optional Courses:** Two courses of three credit hours each will be taken from the courses offered by the specific discipline as mentioned in optional list or any interdisciplinary courses as per requirement of the research of the students with the consent of supervisor concerned and approval of Chairman of the Department.

List of Optional Courses

Course Code	Course Title	Credits
CHEM-8105	Method Development in Chromatography and Spectroscopy	3(3+0)
CHEM-8106	Trends and Future Prospects of Metal based Drugs in Cancer Treatment	3(3+0)
CHEM-8107	Pericyclic Reactions	3(3+0)
CHEM-8108	Steroids	3(3+0)
CHEM-8109	Advances in Physical Chemical Chemistry	3(3+0)
CHEM-8110	Physical Chemistry for Organic and Inorganic Synthesis	3(3+0)
CHEM-8111	Recombinant DNA Technology	3(3+0)
CHEM-8112	Bioinformatics and Comparative Genomics	3(3+0)
	Total Credit Hours to include	**6(6+0)**

Note: A student may opt two courses of three credit hours each from the list or any interdisciplinary courses depending upon the availability of the teacher by the specific discipline with the consent of supervisor concerned and approval of Chairman of the Department.

CHEM-8101 Literature Survey & Technical Writing 3 (3+0)

This course acts as a map of research building and is aimed to provide comprehensive details and guidelines to PhD students, especially familiarizing and training them to design and prepare research proposals and technical writings. The course reveals the details about different sources of literature including primary and secondary sources of literature such as chemical abstracts, journal articles, books etc., digital libraries, multiple data bases, Scopus, Science Direct, Agricola etc.,) as well as printed copy sources of literature. The students will learn how to conduct a comprehensive literature survey and compile well-designed review of literature leading to shaping a strong research proposal with quantifiable objectives. Design, structural composition (title, abstract, key words, introduction, material and methods, results/ including tables, figures and graphs, and discussion, conclusion, acknowledgement and references) and importance of technical writings are also focused. Related issues such as plagiarism, impact factor, *h*-index and *i*-index are also described. After studying this course, students are expected to be able to conduct a comprehensive and updated literature survey and thus prepare strong research proposals and apply these readings to compile different technical writings (synopsis, thesis, journal articles, short communications, books, patents, monographs and technical reports etc.)

Contents

1. Primary and secondary sources of literature (chemical abstracts, research articles, review articles, books, etc.)
2. Online sources of literature such as search engines, data bases, digital libraries etc.,
3. Types and composition of technical writings: synopsis, thesis, research projects, articles, patents, monographs, technical reports etc.

Recommended Texts

1. Fink, A. (2013). *Conducting research literature reviews*: *from the internet to paper.* (3rd ed.). Thousand Oaks, CA, USA: SAGE Publications.
2. Disheroon, S., & Price, K.R. (2018). *Technical writing*. San Diego, CA: Cognella Academic Publishing.
3. Booth A., Papaioannou, D., & Sutton, A. (2012). *Systematic Approaches to a Successful literature review.* Thousand Oaks, CA, USA: SAGE Publications.

Suggested Readings

1. David, G., Sandy, O., & James, T. (2012). *An introduction to systematic reviews.* Thousand Oaks, CA, USA: SAGE Publications.
2. Torgerson, C. (2003). *Systematic reviews.* New York, USA: Bloomsbury Academic.
3. Jesson, J. K., Matheson, L., & Lacey, F. M. (2011). *Doing your literature review: traditional and systematic techniques.* Thousand Oaks, CA, USA: SAGE Publications.
4. Oliver, P. (2012). *Succeeding with your literature review: a handbook for students.* UK: McGraw-Hill Education.
5. Related Journal Articles

CHEM-8102 Advances in Chemical Analysis 3 (3+0)

This course is aimed to impart knowledge to PhD level students about important wet chemistry practices as well as advanced analytical methods/tools applicable to solve chemical problems and elucidate structures of various molecules. Especially, pre-analysis chemistry (sample processing steps involved prior to analysis), purification and derivatization methods along with principles and applications of vacuum distillation, fractional/steam distillation and eco-friendly green extractions such as supercritical fluid extraction (SCFE), microwave assisted extraction, ultrasound assisted extraction, enzyme-assisted extraction etc., are focussed. Recent trends in the isolation and characterization (qualitative and quantitative analysis) of phytochemicals /plant bioactives so called secondary metabolites are also comprehensively covered. As a part of structural elucidation of bioactives, representative spectra based on UV-Visible, FT-IR, NMR & MS analyses are also covered to assist students so that they can learn about spectral interpretation of their experimental data and understand chemistry and structure of chemical materials. After successful accomplishment of this course, students will be able to apply these chemical techniques and instrumental tools to solve chemical problems and characterize phytochemical compounds. These learnings are expected to impart students' technical skills for job opportunities in research and development as well as in the industrial sector.

Contents

1. Use of chemical tools for solution of chemical problems (pre-analysis chemistry, derivatization and purification etc.)
2. Experimental techniques (vacuum distillation, fractional/steam distillation, green extractions etc.)
3. New trends in isolation and characterization of plant bioactives
4. Selected UV-Visible, FT-IR, NMR & MS spectral interpretations

Recommended Texts

1. Harris, D.C. (2015). *Quantitative chemical analysis.* (9th ed.). Dallas, TX, USA: Freeman.
2. Ibanez, E., & Cifuentes, A. (2017). *Green extraction techniques: principles, advances and applications.* (1st ed.). London, UK: Elsevier.
3. de Hoffmann, E., & Stroobant, V. (2007). *Mass spectrometry: principles and applications.* (3rd ed.). New York, USA: Wiley.

Suggested Readings

1. Lunn, G. (2004). *Hand book of derivatization reactions for HPLC.* New York, USA: Wiley.
2. Tringali, C. (2003). *Bioactive compounds from natural sources: isolation, characterization and biological properties.* Boca Raton, Florida, USA: CRC Press.
3. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2014). *Analytical chemistry.* (7th ed.). New York, USA: Wiley.
4. Related Journal Articles

CHEM-8103 Computer Applications & Statistical Analysis 3 (3+0)

In line with the recent developments in the area of experimental analysis, compute technology and data handling, this course is aimed to impart technical skills and training to students about the use and applications of computer and modern statistical tools in experimental research. Applications of different computer and statistical tools towards data designing, presenting and validation are covered. The programs such as MS Words, MS Excel are included for the purposes of text & paragraph-editing, formatting, indenting, sectioning, header-footer, insertions (Figures & Tables) and preparation of graphs. The use of power point for preparation of lectures and animation is also focused. Drawing of structures of different compounds and scheme of equations using Chemdraw and Chemsketch is covered. The use of various internet databases such as chemical abstracts, drug bank and search engines is given to train the students for search of comprehensive literature. Various statistical tools and methods are covered to impart technical know-how to research students enabling them to apply such tools to present, compare and analyse their experimental research data on statistical grounds. After acquiring the above knowledge, the students are expected to apply computer and statistical skills to handle their experimental research data in best possible way..

Contents

1. MS Words: Text & Paragraph-editing, formatting, indenting, sectioning, header-footer, insertions (Figures & Tables)
2. MS Excel: Formula manipulation, Graphs—scatter, line and bar, Regression
3. MS Power Point: Presentation preparation, animations, applications of different tools;
4. Chemdraw: Structures, equations, schemes, basic drawing tools
5. Chemsketch: Structures, equations, schemes, basic drawing tools
6. Adobe Acrobat applications of reader and writer
7. Internet Databases: (Chemical Abstract, Drug Bank, IUCr, Journal-Publisher-Search Engines)
8. Statistical Analysis: mean, median, mode, standard deviation, t-test, f-test, Analysis of Variance (ANOVA), PCA
9. Regression, factorial design and response surface methodology

Recommended Texts

1. Soucie R. (2011). *Learn microsoft excel now: a step-by-step guide to Microsoft Excel that includes hands-on tutorials, practical ideas for spreadsheets, charts,* and *databases, time-saving tips*. USA: Microsoft Press.
2. Robey, C. (1995). *Chemoffice: drawing, modeling and information: user's guide*: version 2.0 for Microsoft Windows. (Pap/Dskt ed.). San Diego, California, USA: Harcourt College Publication.
3. Sprinthall, R. C. (2011). *Basic statistical analysis.* (9th ed.). Boston, MA. USA: Pearson.

Suggested Readings

1. Bhise, S. B., Dias, R. J., Mali, K.K. & Ghanwat, P. H. (2011). *Text book of computer applications and biostatistics*. Pune-Satara Road, India: Trinity Publishing House.
2. Steffen L. K. (1995). *Using Chemoffice with Brown: organic chemistry*. Toronto, Canada: Harcourt Canada Ltd.
3. Cowan, G. (1998). *Statistical data analysis*, Oxford, UK: Clarendon Press.
4. Related Journal Articles

CHEM-8104 Experimental Techniques and Laboratory Safety Practices 3(3+0)

A healthy work place environment, systematic lab management and lab safety measures are vital components for a productive research environment. As a part of capacity building and training, this course is designed with the objectives to impart technical skills and relevant knowledge to students related to lab safety, pit falls, first aid, lab management and other trouble shootings being required and/ or encountered in experimental laboratories. The students will learn how to manage and maintain healthy and safe working environment in the lab through following the laboratory safety measures, standard operating procedures and first aid practices. They will acquire training for glass blowing and maintenance and calibration of chromatographic (High Performance Liquid Chromatography, Gas Chromatography-Mass Spectrometry) and spectroscopic (Ultraviolet–Visible Spectroscopy, Fourier Transform Infrared Spectroscopy) instruments with the objectives of skill developments. Other routine laboratory process such as sublimation and distillation will also be covered. The students will use the acquired knowledge in experimental research and will apply these techniques and laboratory safety practices for shaping a productive research and development activities in their career.

Contents

1. Safety precautions
2. Common pitfalls in lab
3. First aid in Lab
4. Lab management
5. Different lab skills such as glass blowing
6. Maintenance of instruments such as chromatographic (HPLC, GC-MS) techniques
7. Maintenance of spectroscopic (UV, FT-IR) techniques
8. Lab techniques (sublimation, distillation)

Recommended Texts

1. Armour, M.A. (2003). *Hazardous laboratory chemical disposal guide*. Boca Raton, Florida, USA: CRC Press.
2. Rood, D. (2007). *The troubleshooting and maintenance guide for gas chromatographers.* (4th ed.). Weinheim, Germany: Wiley-VCH
3. Urban, P.G. (2006). *Bretherick's handbook of reactive chemical hazards*. (7th ed.). London, UK: Academic Press.

Suggested Readings

1. National Research Council (NRC) (2011). *Prudent practices in laboratory handling & disposal of chemicals*. Washington DC, USA: National Academic Press.
2. American Chemical Society (ACS) (2017). *Safety in academic chemistry laboratories.* (8th ed.). Washington DC, USA: American Chemical Society Press.
3. Harris, D.C. (2015). *Quantitative chemical analysis.* (9th ed.). Dallas, TX, USA: Freeman.
4. Related Journal Articles

CHEM- 8105 Method Development in Chromatography and Spectroscopy 3(3+0)

This course deals with methodological development in chromatographic and spectroscopic techniques and is aimed to impart technical knowledge to PhD scholars to strengthen their experimental and research potential and research & development activities. The course covers both pre-analysis chemical/chemistry aspects of samples and reagents along with opportunity of methodological developments during chromatographic and spectroscopic analyses. Optimization of different and pre-concentration of analytical samples/reactants/reagents is dealt. Optimization of various factors affecting the efficacy, cost-effectiveness, reproducibility, selectivity, sensitivity, signal to noise ratio, limit of detection and limit of quantification is covered. Validation of different methods using certified reference materials or reference standards as well as models of different samples is covered. The students will acquire comprehensive technical knowledge and will be able to apply experimental skills for solving their research and industrial problems. Such learnings ultimately will strengthen the research potential and competitiveness of students enabling them to gain job opportunities in public and private sector.

Contents

1. Optimization of concentrations of reactants
2. Optimization of concentrations of reagents
3. Factors affecting the efficacy of method
4. Optimization of parameters like economy of method, time of analysis
5. Reproducibility of results
6. Selectivity of method
7. Sensitivity of method, signal to noise ratio, limit of detection, limit of quantification
8. Validation of methods by using certified reference materials or standards
9. Validation of methods by applying on samples of different nature

Recommended Texts

1. Grushka, E., & Grinberg, N. (2008). *Advances in chromatography.* New York, USA: CRC Press.
2. Braithwaite, A., & Smith, F.J. (2001). *Chromatographic methods*. (5th ed.). Netherlands: Kluwer Academic Press.
3. Harris, D.C. (2015). *Quantitative chemical analysis.* (9th ed.). Dallas, TX, USA: Freeman.

Suggested Readings

1. Christian, G.D., Dasgupta, P.K., & Schug, K.A. (2014). *Analytical chemistry.* (7th ed.). New York, USA: Wiley.
2. Charles, W., Gehrke, R.L., & Wixom, E.B.(2001). *Chromatography: a century of discovery 1900-2000: The bridge to the scenes/technology.* Amsterdam, Netherlands: Elsevier
3. Riley, C.M., & Rosanske, T. W. (2014). *Development and validation of analytical methods*. Oxford, UK: Pergamon Press.
4. Related Journal Articles

CHEM-8106 Trends and Future Prospects of Metal based Drugs in Cancer Treatment 3 (3+0)

The course is mainly aimed to impart knowledge to students about the chemistry and biological applications, specifically, anticancer potential of selected metal complexes. The course focuses on recent developments and future prospects of metal based complexes as chemotherapeutic agents to treat certain cancers. Recently, there has been a growing research interest in the development of metal-based anticancer agents for treatment of cancer because of their cytotoxic effect. Infact with advancement in coordination chemistry, ligand substitution and alteration of chemical structures led to the synthesis of a wide array of metal-based compounds, some of which have promising cytotoxic and pharmacokinetic properties. With the new developments in chemotherapy, metal based drugs are coming to the forefront of research as effective anticancer agents to treat cancers. Inperticular, in this course, the past developments and present status as well as future prospects of Platinum and Ruthenium based anticancer agents are mainly covered. Anticancer activities and drug designing involving these metals is covered. The students will acquire knowledge about metal based anticancer drug developments and will be able to start their experimental research and professional career in this emerging area of coordination chemistry. Moreover, they will have opportunity for professional engagements in pharmaceutical industrial sector.

Contents

1. Present status of platinum based anticancer drugs
2. Ruthenium based anticancer agents, past, present and future
3. Anticancer activities of other metal based drugs
4. Drug designing in cancer treatment
5. Future prospects of metal based drugs in cancer treatment

Recommended Texts

1. Casini, A., Vessières, A., & Meier-Menches, S. M. (2019). *Metal-based anticancer agents.* London, UK: Royal Society of Chemistry.
2. Dabrowiak, J. C. (2009). *Metals in medicines.* NY, USA: Wiley Interscienc
3. Winterton, N., & Leigh, J. (2007). *Modern coordination chemistry: the legacy of Joseph Chatt.* London, UK: Royal Society of Chemistry.

Suggested Readings

1. Avendano, C., & Menendez, J. C. (2015). *Medicinal chemistry of anticancer drugs.* (2nd ed.). London, UK: Elsevier.
2. Meegan, M. J., & O'Boyle, N. M. (2019). *Anticancer drugs.* Basel, Switzerland: Multidisciplinary Digital Publishing Institute (MPDI).
3. Gielen, M., and Edward, R. T. (2005). *Metallotherapeutic drugs and metal-based diagnostic agents.* CA, USA: John Wiley & Sons.
4. Related Journal Articles

CHEM-8107 Pericyclic Reactions 3 (3+0)

Pericyclic reactions comprise a major strand of organic chemistry, including such commercially important synthetic reactions as the Diels-Alder reaction. This course focuses on different types of pericyclic reactions and related concepts, theories and is aimed to impart relevant knowledge to organic chemists enabling them to apply these aspects in the area of organic synthesis. It covers elaborations of electrocyclizations, cycloaddition, sigmatropic and chelotropic reactions using principles and approaches of molecular orbitals, orbitals symmetry, symmetry conservation, symmetry correlation and Huckle-Möbius. Moreover, Claisen-Ireland rearrangement; stereochemical aspects and stereoselectivity / stereospecificity of above cited reactions are also focussed. The synthetic products obtained through different pericyclic reactions, especially produced by cycloaddition reactions, are of significant industrial importance. The knowledge acquired through this course will be valuable for the students to successfully accomplish organic synthesis using various pericyclic reactions such as sigmatropic rearrangements and other cycloaddition reactions. This will ultimately strengthen their organic synthesis knowledge and skills leading to giving more job opportunities in pharmaceutical and chemical industrial sector.

Contents

1. Frontier molecular orbitals (HOMO-LUMO)
2. Elaboration of electrocyclization, cycloaddition, sigmatropic and chelotropic reactions by frontier orbital approach
3. Orbital symmetry/symmetry conservation approach, symmetry correlation approach and Huckle-Möbius approach
4. Claisen-Ireland rearrangement; stereochemical aspects and stereoselectivity / stereospecificity of above cited reactions

Recommended Texts

1. Sankararaman, S. (2005). *Pericyclic reactions - A textbook: reactions, applications and theory.* (1st ed.). Weinheim, German: Wiley-VCH.
2. Carey, F.A., & Sundberg, R. J. (2007). *Advanced organic chemistry: part B: reaction and synthesis.* (5th ed.). Berlin, Germany: Springer Science.
3. Ansari, F.L., Qureshi, R., & Qureshi, M.L. (1998). *Electrocyclization reactions: from fundamentals to research.* (1st ed.). Weinheim, German: Wiley-VCH.

Suggested Readings

1. Kumar, S., Kumar, V., & Singh, S.P. (2015). *Pericyclic reactions*. (1st ed.). Cambridge, UK: Academic Press
2. Fleming, I. (2015). *Pericyclic reactions*. Oxford, UK: Oxford University Press.
3. Mandal, D. (2018). *Pericyclic chemistry, orbital mechanisms and stereochemistry*. (1st ed.). Amsterdam, Netherlands: Elsevier.

CHEM- 8108 **Steroids** **3 (3+0)**

Steroids are man-made version of chemicals, known as hormones, which are also made naturally in the human body. Steroids can be synthetically designed and act like hormones to reduce inflammation and other health disorders. The course is aimed to provide knowledge to the students about structural features, biological and medicinal applications of different steroids. The course deals with classification, structure elucidation, biosynthesis and laboratory syntheses of steroids along with their biological potential. Classification of steroids on various bases along with their different classes is covered. Students will learn about structural elucidation of isolated compounds using state-of-the-art spectroscopic techniques such as 1-D and 2-D Nuclear Magnetic Resonance (NMR) spectroscopy, X-ray powder diffraction (XRD) and high resolution Mass Spectrometer (HR-MS). Potential uses of different steroids such as hormones, pheromones and automones are also covered. Different organic chemistry reactions/ methods for synthesis of steroids along with their biosynthetic pathways are also focused. Biological properties and medicinal potential of various steroidal compounds is also covered. The students will acquire related knowledge and be able to apply steroidal synthesis and characterization related skills in their experimental and industrial research. These skills will be valuable for their professional career as organic synthetic chemists.

Contents

1. Isolation of steroids
2. Classification of steroids on different basis
3. Structure elucidation of steroids with advance spectroscopic (1D & 2D-NMR, XRD) and spectrometric (HR MS) methods
4. Steroids as hormones, pheromones & automones
5. Nomenclature and conformational analysis of steroids
6. Biosynthesis of a variety of stroids
7. Different synthetic sequences (key step) for steroidal synthesis
8. Biological importance of steroids in chemotherapy

Recommended Texts

1. Lau, D. (2008). *Steroids.* New York, USA: Rosen Publishing Group Inc.
2. Litwack, G. (1994). *Steroids.* CA , USA: Rosen Academic Press.
3. Lenehan, P., & Miller, T. (2004). *Anabloic steroids.* Manchester, UK: Lifeline Publications.

Suggested Readings

1. Zeelan, F.J. (1990). *Medicinal chemistry of steroids*. Amsterdam, Netherlands: Elsevier.
2. Ostojic, S. M. (2012). *Steroids - from physiology to clinical medicine.* Rijeka, Croatia: InTech Janeza Trdine.
3. Perritano, J. (2016). *Performance-enhancing drugs: steroids, hormones, and supplements.* PA, USA: Mason Crest Publishers.
4. Related Journal Articles

CHEM- 8109 Advances in Physical Chemistry 3 (3+0)

This course deals with recent developments in the area of physical chemistry, especially with new concept of physical organic chemistry. The course is aimed to impart knowledge to PhD students about advanced level physical chemistry in connection with recent developments and applications of spectroscopic methods such as 1-D and 2-D Nuclear Magnetic Resonance (NMR) spectroscopy, Electron Spin Resonance Spectroscopy, Raman Spectroscopy and Scanning Electron Microscope (SEM). Theoretical aspects, instrumentation and applications of Mass Spectroscopy are also covered with perspective of physical chemistry. The use and applications of laser technology, computer based access to chemical information and information technology are focussed. Lastly, the physical chemistry aspects of atmosphere and space are given. Through acquiring advanced level physical chemistry knowledge, students will be able to apply these emerging aspects in practical research and other spheres of their professional career. Especially, the technical knowledge acquired by the students about various state-of-the-art spectroscopic techniques with perspective of physical chemistry will be worthwhile towards starting their professional career as physical-organic chemist and will facilitate them in ongoing research activities as well as to gain job opportunities in the industrial sector.

Contents

1. Advances in spectroscopic techniques (2-D NMR, Raman, ESR and SEM spectroscopic methods and applications)
2. Mass spectrometry (Theory, instrumentation and applications)
3. Lasers in chemistry
4. Computer based access to chemical information and information technology
5. Physical chemistry of atmosphere and space

Recommended Texts

1. Williams. I., & Williams, N. (2019). *Advances in physical organic chemistry*. (Vol. 50-53). Amsterdam, Netherlands: Elsevier.
2. Tidwell, T., & Richard, J. (2002). *Advances in physical organic chemistry*. London, UK: Academic Press.
3. Richard, J.P. (2006). *Advances in physical organic chemistry*. (1st ed.). London, UK: Academic Press.

Suggested Readings

1. Bajpai, D.N. (2015). *Advanced physical chemistry*. (Reprint ed.). Jalandhar, India: S. Chand & Company Ltd.
2. Bruckner, R. (2002). *Advanced organic chemistry: reaction mechanisms*. London, UK: Academic Press
3. Bigler, P. (2008). *NMR spectroscopy: processing strategies*. 2nd ed.). Weinheim, Germany: Wiley-VCH, Germany, (2008).
4. Gross, J.H. (2004). *Mass spectrometry.* Berlin, Germany: *Springer-Verlag*.
5. Related Journal Articles

CHEM-8110 Physical Chemistry for Organic and Inorganic Synthesis 3 (3+0)

This course is designed to elaborate and apply principles of physical chemistry to elucidate reaction mechanisms and chemistry of organic and inorganic synthesis /reactions. Especially, thermodynamics of proposed chemical reactions, kinetic and-non kinetic methods for reaction mechanisms and linear free energy relationship are covered. Thermodynamics and reaction kinetics are applicable in the various field of research particularly in the synthesis of organic and inorganic compounds. The reaction kinetics model application is highly use full for understanding the behaviour of various chemical entities. Moreover, the course also covers different purification techniques like solvent extraction, sublimation, Filtration, centrifugation, evaporation, crystallization, adsorption, chromatography, distillation, electrolysis and bioleaching. This course will provide the basic practical knowledge of different characterization techniques like melting point, thin layer chromatography, Fourier transformed Infra-red spectroscopy, Nuclear magnetic resonance spectroscopy and mass spectrometry. The knowledge of physical chemistry for organic and inorganic synthesis will equip the students with basic of thermodynamics along with the application of reaction mechanism on various newly developed organic and inorganic syntheses. This course will enable the students to apply various separation techniques and also skilled them with the application of various characterization techniques. After acquiring these skills the students will be able to apply this knowledge for the development of various new entities by using the organic and inorganic syntheses.

Contents

1. Ascertaining the thermodynamics of a proposed reaction
2. Kinetic and non-kinetic methods for reaction mechanism
3. Linear free energy relationships (LFER)
4. Purification techniques
5. Characterizations techniques

Recommended Texts

1. Williams, I. H., & Williams, N.H. (2107). *Advances in physical organic chemistry*. New York. USA: Academic Press Inc.
2. Sandler, S.I. (2006). *Chemical, biochemical & engineering thermodynamics*. NY, USA: Wiley Interscience.
3. Roy, B.N. (2002). *Fundamentals of classical and statistical thermodynamics*. Chichester, UK: Wiley and Sons

Suggested Readings

1. Stewart, A.W. (2008). *Recent advances in physical and inorganic chemistry*. NY. USA: Longmans, Green & Co.
2. Anslyn, E. V., & Dougherty, D. A. (2011). *Modern physical organic chemistry.* CA, USA: University Science Books.
3. Related Journal Articles

CHEM-8111 Recombinant DNA and Related Techniques 3 (3+0)

This course includes methods for DNA isolation from bacteria, animals and plants and provide an overview of gene cloning procedures. This course also covers hot topics in recombinant DNA technology including gene therapy and genetically modified food. In this course the students will learn about recombinant DNA technology broadly refers to the molecular cloning of foreign DNA into extrachromosomal DNA elements (ie, plasmids) that can be propagated in a bacterial host such as Escherichia coli. Plasmids are found in many bacterial species and can be transferred from one organism to another within a species by conjugation, resulting in transformation of the recipient cell. The students will acquire knowledge about DNA colonig, gene splicing, genomic libraries, screening methods for gene libraries, chromosome walking; PCR; site specific mutagenesis, restriction fragment length polymorphisms and disease detection. The acquiring of knowledge of this course will be helpful towards gaining various job opportunities by the students and to work in various biological laboratories and start professional career in research institutes.

Contents

1. Potentials of recombinant DNA technology
2. DNA cloning methods
3. Cloning vectors including plasmids, bacteriophages, cosmids
4. YAC vectors, shuttle and expression vectors
5. Gene splicing, genomic libraries, screening methods for gene libraries
6. DNA cloning restriction enzymes
7. DNA ligase
8. Tumor inducing (Ti) plasmids
9. Southern and Northern blotting
10. Chromosome walking; PCR; site specific mutagenesis
11. Overexpression of proteins
12. Gene therapies
13. Restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis)
14. Human genome project
15. Somatic cell cloning, stem cell research, other future prospects
16. Social and commercial considerations.

Recommended Texts

1. Brown, T.A. (2016). *Gene cloning and DNA manipulation- an introduction.* (7th ed.). New Jersey, USA: Blackwell Publishing Inc.
2. Primrose, S.B., Twyman, R.M., & Old, R.W. (2006). *Principles of gene manipulation*. (7th ed.). New Jersey, USA: Wiley-Blackwell.

Suggested Readings

1. Tanley, W.M.S. & Rapley, N.J. (2005). *Molecular bio-methods handbook*. Totowa, New Jersey, USA: Humana Press Inc.
2. Krawezak, M., & Schmidtke, J. (2000). *DNA fingerprinting*. UK: Bioscientific, Oxford.
3. Related Journal Articles

CHEM-8112 Bioinformatics and Comparative Genomics 3 (3+0)

This course focuses on concepts and methods for orthology and paralogy of protein-coding genes, complemented with practical examples of applications of comparative genomics approaches to investigate biological and/or evolutionary questions. Bioinformatics tools have become very popular in all fields of life sciences especially when it comes to genomics and proteomics. This course provides an in depth understanding of biological databases, their uses, mass data retrieval, and deposition. Protein modelling and their interactions with other biomolecules form the basis of molecular interactions. Comparative genomics is playing major role in extracting useful information from biological sequences. One important aspect of comparative genomics is the comparison of proteomes (the complete protein set) of two or more organisms. In addition, it involves the comparison of gene locations, relative gene order, and regulation. Functional bioinformatics uses structural and expression information to make inferences about the function of components of a given genome. Students will learn how to use these skills in their research particularly about the application of information technology to biological data, specially DNA sequence and genomic data and might start their professional career in bioinformatics.

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Contents

1. Computational techniques in Biochemistry
2. DNA and Protein Data bases
3. Comparison of different genome
4. Human Genome and Diseases
5. Secondary Structure prediction
6. Protein homology modelling
7. Gene modelling
8. Comparative and functional genomics and proteomics
9. SwissProt PDB viewer and Swiss-model server
10. Data mining, Argus Lab, PyMol
11. Phylogenetic analysis
12. Protein-Protein, Protein-DNA, Protein-Ligand interactions
13. Comparison of Human and mouse genome, Bacteria and Archaea genomes

Recommended Texts

1. Lesk, M.J. (2002). *Introduction to bioinformatics.* London, UK: Oxford University Press.
2. Ussery, D.W., Wassenaar, T.M., & Borini, S. (2009). *Computing for comparative microbial genomics: bioinformatics for microbiologists* (*Computational Biology*). New York, USA: Springer.

Suggested Readings

1. Dash, D. S.K., & Thatoi, H.N. (2017). *Practical biotechnology: principles and protocols*. New Delhi, India: I.K. International Publishing House.
2. Kumar, D., & Antonarakis, S. (2016). *Medical and health genomics*. New York, USA: Academic Press.
3. Related Journal Articles