UNIVERSITY OF SARGODHA
OFFICE OF THE REGISTRAR
(ACAD BRANCH)

NOTIFICATION

On the recommendations of Academic Council made in its 19th (4/2023) meeting held on 13.09.2023, the Syndicate in its 64th (4/2023) meeting held on 03.11.2023 has approved the revised curriculum of BS in Chemistry (5th Semester Intake) for implementation w.e.f. **Fall 2025** (Annex-'**A**').

(WAQAR AHMAD)
Additional Registrar (General)

No. SU/Acad/25/ 1253 Dated: 18.11.2025

Distribution:

- Director Institute of Chemistry
- Controller of Examinations
- Director Academics

C.C:

- Dean Faculty of Sciences
- Director, QEC
- Additional Registrar (A & R) *{With the request to forward the notification alongwith curriculum to all Principals of affiliated colleges concerned}*
- Secretary to the Vice-Chancellor
- PA to Registrar
- Notification File

1. **Title of Degree Program:** BS Chemistry (5th Semester In-Take)

2. **Program Learning Objectives:** The Department of Chemistry was established in 1991 as a separate institution for post-graduate studies at the Government Postgraduate College, Sargodha, while it was affiliated with the University of Punjab, Lahore. After the up-gradation of this postgraduate college to University of Sargodha, Sargodha in November 2002, this department was working without any extension in the building and up-gradation of the general/research laboratories. This Department of Chemistry was upgraded by University of Sargodha in 2020 to Institute of Chemistry after necessary expansion of infrastructure. The institute is offering BS (Chemistry), MPhil (Chemistry) and PhD (Chemistry) programs designed to meet the ever-emerging needs in the field of chemical sciences. The Institute of Chemistry aims at following PLOs for BS (Chemistry) program.
   a) Comprehensive curriculum comparable to national and international standards
   b) Peer review of curriculum and its continuous updating
   c) Conducive environment for teaching and discussion
   d) Expand infrastructure for study, research/practical understanding through experiments and research
   e) Seek collaboration with industry and research organizations.

3. **Program Structure:**

Duration	Minimum 2-Years (4-Semesters) Maximum 3-Years (6-Semesters)
Admission Requirements: (For Candidates having Associate Degree (ADS Chemistry) or equivalent in same field)	Atleast 45%marks in biannual/annual (BSc, ADP) or semester (ADS etc.) system qualification. 1. Minimum 20% or higher marks contribution of Chemistry subject to total (e.g., 200/800) is compulsory (with at least 50% marks) for graduates with biannual / annual examination system. Minimum 20% or higher credit hours (CRs) contribution of Chemistry subjects to total CRs (e.g., 12 out of 60 CRs; 19.45% shall be rounded to 20%) is compulsory (with at least 50% marks in each course) For graduates with semester system examination.
Admission Requirements: (For candidates where disciplines of Associate Degree or equivalent and Undergraduate program are different)	The following deficiency course(s) (if applicable) will be determined after admission to BS Chemistry (After14-Years Education), which is variable for different university students due to different scheme of studies offered to them. The deficiency courses shall be offered in the running Fall and Spring semesters of first year of studies. Deficiency course(s) (determined by the Postgraduate Committee of the Institute) shall be carried out throughout the study. However, the candidates of other than the University of Sargodha shall pass the following deficiency courses in different semesters of BS Chemistry (after14-years of education) program.

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Deficiency Courses	CHEM-5101	Inorganic Chemistry	4(3-1)	Nil
	CHEM-5102	Basic Mathematics for Chemists	2(2-0)	Nil
	CHEM-5103	Physical Chemistry	4(3-1)	Nil
	CHEM-5104	Organic Chemistry	4(3-1)	Nil
	CHEM-5105	Analytical Chemistry	4(3-1)	Nil
	CHEM-5106	Chemistry Special Topics	4(3-1)	Nil
	CHEM-5107	Basic Statistics for Chemists	2(2-0)	Nil
	CHEM-5108	Laboratory Safety Measures	2(2-0)	Nil
	CHEM-5109	Industrial Chemistry	3(3-0)	Nil

Degree Completion Requirements:	Minimum2.00CGPAout of4.0scalewith following minimum breakup		
	General Education courses	GE	2 Credit hours
	Interdisciplinary courses	ID	8 Credit hours
	Disciplinary/Major courses	D	49 Credit hours
	Internship	I	3 Credit hours
	Capstone Project	R	3 Credit hours
	Total	**65**	Credit hours

4. General Education (Gen Ed) Requirements:(Mandatory/Core Courses):

SR. No	Course Code	Course Title	Credit Hours	Prerequisite
1.	URCG-5129 URCG-5131	Understanding of Holy Quran / Fehm-e-Quran-I or ethics-I	1(1-0)	Nil
2.	URCG-5130 URCG-5132	Understanding of Holy Quran / Fehm-e-Quran-II or ethics-II	1(1-0)	
Total Credit Hours			**2**	

5. Single Major Courses:

	Course Code	Course Title	Credit Hours	Prerequisite
1.	CHEM-6101	Inorganic Chemistry-I	4(3-1)	Nil
2.	CHEM-6102	Organic Chemistry-I	4(3-1)	
3.	CHEM-6103	Physical Chemistry-I	4(3-1)	CHEM-5102
4.	CHEM-6104	Inorganic Chemistry-II	4(3-1)	Nil
5.	CHEM-6105	Organic Chemistry-II	4(3-1)	
6.	CHEM-6106	Physical Chemistry-II	4(3-1)	CHEM-5102 CHEM-5107
7.	CHEM-6107	Forensic Chemistry	2(2-0)	Nil
8.	CHEM-6108	Spectroscopic Techniques –I	4(3-1)	
9.	CHEM-6109	Chromatographic Techniques	3(3-0)	
10.	CHEM-6110	Instrumental Methods of Analysis -I	3(3-0)	
11.	CHEM-6111	Bioenergetics and Metabolism	4(3-1)	
12	CHEM-6112	Microbiology and Industrial Fermentation	3(3-0)	
13.	CHEM-6113	Introduction to Bioinformatics	3(3-0)	
14.	CHEM-6114	Advanced Inorganic Chemistry	4(3-1)	
15.	CHEM-6115	Inorganic Polymers & Chemical Forces	3(3-0)	
16.	CHEM-6116	Organoicmetall & Bio-inorganic Chemistry	3(3-0)	
17.	CHEM-6117	Spectroscopic Methods in Organic Chemistry	4(3-1)	
18.	CHEM-6118	Reaction Mechanism	3(3-0)	
19.	CHEM-6119	Reactive Intermediates and Protective Groups	3(3-0)	
20.	CHEM-6120	Surface Phenomena	4(3-1)	
21.	CHEM-6121	Molecular Spectroscopy	3(3-0)	
22.	CHEM-6122	Quantum Chemistry and Statistical Thermodynamics	3(3-0)	
23.	CHEM-6123	Environmental Chemistry	3(3-0)	Nil
24.	CHEM-6124	Spectroscopic Techniques –II	4(3-1)	
25.	CHEM-6125	FTIR, Raman Spectroscopy, ESR and		

		Surface Analysis	3(3-0)
26.	CHEM-6126	Instrumental Methods of Analysis-II	3(3-0)
27.	CHEM-6127	Molecular Biology & Physical Techniques	4(3-1)
28.	CHEM-6128	Chemotherapy& Immunology	3(3-0)
29.	CHEM-6129	Introduction to Recombinant DNA Technology	3(3-0)
30.	CHEM-6130	Homogeneous Catalysis by Transition Metal Complexes	4(3-1)
31.	CHEM-6131	Inorganic Reaction Mechanism	3(3-0)
32.	CHEM-6132	Physical Methods in Inorganic Chemistry	3(3-0)
33.	CHEM-6133	Chemistry of Natural Products	4(3-1)
34.	CHEM-6134	Organic Synthesis	3(3-0)
35.	CHEM-6135	Stereochemistry	3(3-0)
36.	CHEM-6136	Kinetics of Heterogeneous Reactions	4(3-1)
37.	CHEM-6137	Polymers and Photochemistry	3(3-0)
38.	CHEM-6138	Nuclear Chemistry	3(3-0)
Total Credit Hours of Major Courses: 49			

6. **Interdisciplinary/Allied courses: minimum 12 credit hours:**

	Course Code	Course Title	Credit Hours	Prerequisite
1.	ZOOL-5102 /PHYS-5102	Animal Diversity-II Chordates) / Introduction to Electromagnetism	4(3-1)	Nil
2.	BOTN-5101 /MATH-5102	Diversity of Plants / Techniques of Integration and its Applications	4(3-1)/ 4(4-0)	
Interdisciplinary Courses Credit Hours Total 08				

7. **Field experience/internship** (Minimum 03 credithours):

	Course Code	Course Title	Credit Hours	Pre-requisite
1	CHEM-6139	Field Experience/Internship	3(3-0)	Nil

8. **Capstone project**(Minimum 03credithours):

	Course Code	Course Title	Credit Hours	Pre-requisite
1.	CHEM-6140	Capstone project	3(3-0)	Nil

Semester-I

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
Major-1	CHEM-6101	Inorganic Chemistry-I	4(3-1)	Nil
Major-2	CHEM-6102	Organic Chemistry-I	4(3-1)	Nil
Major-3	CHEM-6103	Physical Chemistry-I	4(3-1)	CHEM-5102
Interdisciplinary	ZOOL-5102 /PHYS-5102	Animal Diversity-II (Chordates) /Introduction to Electromagnetism	4(3-1)	Nil
Deficiency-1*	CHEM-5101	Inorganic Chemistry	4(3-1)	Nil
Deficiency-2*	CHEM-5102	Basic Mathematics for Chemists	2(2-0)	Nil
Deficiency-3*	CHEM-5103	Physical Chemistry	4(3-1)	Nil
Semester Total Credit Hours:			**16**	

Semester-II

Category	Course Code	Course Title	Credit Hours	Pre-Requisite
General Education	URCG-5129 URCG-5131	Understanding of Holy Quran Fehm-e-Quran-I or ethics-I	1(1-0)	Nil
Major-4	CHEM-6104	Inorganic Chemistry-II	4(3-1)	
Major-5	CHEM-6105	Organic Chemistry-II	4(3-1)	
Major-6	CHEM-6106	Physical Chemistry-II	4(3-1)	CHEM-5102 CHEM-5107
Interdisciplinary	BOTN-5101/MATH-5102	Diversity of Plants / Techniques of Integration and its Applications	4(3-1)/ 4(4-0)	Nil
Deficiency-4*	CHEM-5104	Organic Chemistry	4(3-1)	Deficiency
Deficiency-5*	CHEM-5105	Analytical Chemistry	4(3-1)	
		Semester Total Credit Hours:	**17**	

Summer Semester

Category	Course Code	Course Title	Credit Hours	Specialization
Compulsory	CHEM-6139	Field Experience/Internship	3(3-0)	Nil
		Semester Total Credit Hours:	**3**	

Semester-III

Category	Course Code	Course Title	Credit Hours	Specialization
Major-7	CHEM-6107	Forensic Chemistry	2(2-0)	Nil
Major-8	CHEM-6108	Spectroscopic Techniques –I	4(3-1)	Analytical Chemistry
Major-9	CHEM-6109	Chromatographic Techniques	3(3-0)	
Major-10	CHEM-6110	Instrumental Methods of Analysis-I	3(3-0)	
Major-11	CHEM-6111	Bioenergetics and Metabolism	4(3-1)	Biochemistry
Major-12	CHEM-6112	Microbiology and Industrial Fermentation	3(3-0)	
Major-13	CHEM-6113	Introduction to Bioinformatics	3(3-0)	
Major-14	CHEM-6114	Advanced Inorganic Chemistry	4(3-1)	Inorganic Chemistry
Major-15	CHEM-6115	Inorganic Polymers & Chemical Forces	3(3-0)	
Major-16	CHEM-6116	Organoicmetall & Bio-inorganic Chemistry	3(3-0)	
Major-17	CHEM-6117	Spectroscopic Methods in Organic Chemistry	4(3-1)	Organic Chemistry
Major-18	CHEM-6118	Reaction Mechanism	3(3-0)	
Major-19	CHEM-6119	Reactive Intermediates and Protective Groups	3(3-0)	
Major-20	CHEM-6120	Surface Phenomena	4(3-1)	Physical Chemistry
Major-21	CHEM-6121	Molecular Spectroscopy	3(3-0)	
Major-22	CHEM-6122	Quantum Chemistry and Statistical Thermodynamics	3(3-0)	
Deficiency-6*	CHEM-5106	Chemistry Special Topics	4(3-1)	Deficiency
Deficiency-7*	CHEM-5107	Basic Statistics for Chemists	2(2-0)	
Deficiency-8*	CHEM-5108	Laboratory Safety Measures	2(2-0)	
		Semester Total Credit Hours:	**12**	

Semester-IV

Category	Course Code	Course Title	Credit Hours	Specialization
Mandatory	URCG-5130 URCG-5132	Understanding of Holy Quran / Fehm-e-Quran-II or ethics-II	1(1-0)	
Major-23	CHEM-6123	Environmental Chemistry	3(3-0)	
Major-24	CHEM-6124	Spectroscopic Techniques –II	4(3-1)	Analytical Chemistry
Major-25	CHEM-6125	FTIR, Raman Spectroscopy, ESR and Surface Analysis	3(3-0)	
Major-26	CHEM-6126	Instrumental Methods of Analysis-II	3(3-0)	

Major-27	CHEM-6127	Molecular Biology & Physical Techniques	4(3-1)	Biochemistry
Major-28	CHEM-6128	Chemotherapy& Immunology	3(3-0)	
Major-29	CHEM-6129	Introduction to Recombinant DNA Technology	3(3-0)	
Major-30	CHEM-6130	Homogeneous Catalysis by Transition Metal Complexes	4(3-1)	Inorganic Chemistry
Major-31	CHEM-6131	Inorganic Reaction Mechanism	3(3-0)	
Major-32	CHEM-6132	Physical Methods in Inorganic Chemistry	3(3-0)	
Major-33	CHEM-6133	Chemistry of Natural Products	4(3-1)	Organic Chemistry
Major-34	CHEM-6134	Organic Synthesis	3(3-0)	
Major-35	CHEM-6135	Stereochemistry	3(3-0)	
Major-36	CHEM-6136	Kinetics of Heterogeneous Reactions	4(3-1)	Physical Chemistry
Major-37	CHEM-6137	Polymers and Photochemistry	3(3-0)	
Major-38	CHEM-6138	Nuclear Chemistry	3(3-0)	

*Variable for each student depending upon the scheme of study taught in AD (Chemistry) program

Semester Total Credit Hours: 17

Degree Program Total: 65

SEMESTER I

CHEM-6101 **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. An overview of theories of Bonding: VBT, MOT (LCAO method, Examples of molecular orbital treatment for homonuclear diatomic molecules, heteronuclear diatomic molecules, molecules involving delocalized π- bonding), VSEPR (Effect of lone pairs, Effect of electronegativity lsoelectronic principle. Hybridization, The extent of d orbital participation in molecular bonding.
2. Chemistry of Coordination Compounds: Introduction of d–block elements
   a. Nature of Bonding: Valence bond theory, Crystal field and Ligand field theory
   b. Molecular orbital theory and Jahn-Teller Theorem
   c. The spectrochemical series, color, isomerism and stereochemistry of metal complexes
   d. Geometry of complexes having coordination number 2 to 6
   e. Applications of coordination compounds in chemistry, life and industry
   f. Stability constants, Factors that influence complex stability, Stabilization of unusual oxidation states by coordination, Determination of stability constants
   g. Chelates
3. Chemistry of Lanthanides and Actinides: Structure, occurrence and preparation
   Separation, electronic configuration and oxidation states
   Spectral and magnetic properties and Complex formation and their applications
4. Non – aqueous Solvents:
   a. Introduction and classification of solvents
   b. Types of reactions in non-aqueous solvents
   c. Effect of physical and chemical properties of solvents
   d. Study of reactions in liq. NH_3 and liq. SO_2
   e. Reactions in Liq. HF and liq. BrF_3 and in molten salt system

Inorganic Chemistry Lab-I

1. Aqueous acid-base titrations:
   (a) Estimation of SO_2 and SO_3 in air and discharged from an industrial process.
   (b) Estimation of CO_2 (c) Estimation of oxalic acid and H_2SO_4 in a mixture.
   (d) Estimation of H_3BO_3 and NaH_2BO_3 in a mixture.
   (e) Determination of %age composition of a mixture containing H_3BO_3 and CH_3COOH.
2. Precipitation Titrations: Estimation of following anions with the help of adsorption indicators:
   (i) Chloride (ii) Bromide (iii) Sulphate (iv) Chloride and Iodide in a mixture.
3. Qualitative Analysis of inorganic mixture (six radicals) by micro and semi-micro techniques.
4. Analysis of ores (iron, copper, marble)

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.
3. Shaheen, M.A. Advance Inorganic Chemistry (2003), Jilani Notes, Sargodha-Lahore
4. Fred Basolo, Ronald C. Johnson (2003) Coordination Chemistry, W.A. Benjamin, Inc
5. Shaheen, M.A. Manual of Advanced Practical Chemistry (2003), Jilani Notes, Sargodha-Lahore
6.

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-6102 **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-6111, CHEM-6125, CHEM-6242 and CHEM-6243) 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. A 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 (bicyclic, tricyclic etc.) organic compounds: concept of principal and subordinate functional groups, prefix, suffix etc.
2. Application of inductive, resonance, hyperconjugation effects, classification of tautomers. Effect of structure, medium and steric factors 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.
7. Baeyer's strain theory, conformational isomerism in acyclic, alicyclic compounds (cyclobutane, cyclopentane, cyclohexane), mono / di-substituted cyclohexanes and condensed rings, locking groups.
8. Configurational isomerism in biphenyls, allenes and spiranes; relative (*D/L* convention) and absolute configuration (CIP / modified CIP rules & *R/S, r/s, aR/aS* conventions).
9. Racemization, resolution of racemic modification and introductory asymmetric synthesis.

Organic Chemistry Lab.– I

1. Separation & identification of two component mixture of organic compounds [containing functional group(s) like COOH, OH, NH_2, C=O] by physical and chemical methods.
2. Preparation of simple organic compounds (Ethyl benzoate, benzoic acid, tribromophenol, aspirin, nitrobenzene).

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. Shaheen, M.A. (2023) Jilani Manual of Practical Chemistry, Vol.III, Jilani Notes, Sargodha-Lahore

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-6103 **Physical Chemistry – I** **4(3+1)**

This course is mainly comprised of knowledge related to electrochemistry. As electrical potential caused by a chemical reaction or other way around is an important direction towards energy production. The course is designed to have a vast knowledge based on basic principles of electrochemistry, electrical conductivity and interionic interactions. Course content include conductance, its measurement, Arrhenius theory, Debye Huckel theory and impact of ionic environment of reaction. It includes the concepts of electrical potentials and electric current, electrochemical reactions, electrode and electrolytes: Working electrodes, Reference electrodes, electrolytes, electrochemical methods for the study of the electrode/electrolyte interface. Moreover, knowledge about phase equilibrium is also important in Physical chemistry. To meet this area of thrust for physical chemistry students, phase equilibrium, phase diagram, claperyon equation, single component, phase diagram for binary mixture, Raoults law and Henery's law etc. are offered in this course. Practical portion also has very informative and useful content which may lead interest in the field of research related to energy and electrochemistry.

Contents

Electrochemistry: Introduction to Electrochemistry, Conductance & Resistance, Factors affecting conductance, Measurement of conductance, Arrhenius Theory of electrolytic dissociation, Ostwald's Dilution Law, Theory of strong electrolytes, Kohlrausch's law and its applications, Debye Huckel Theory, Debye Huckel Limiting law, Activity and activity coefficients of electrolytic solutions, Determination of activities, Concentration cells, Determination of e.m.f. of concentration cells with and without transference, Fuel cells and hydrocarbon fuel cells.

Phase Equilibrium: Introduction to Phase Equilibrium, Single Component Phase Diagrams, Criterion for Phase Equilibrium, The Clapeyron Equation, The Clausius-Clapeyron Equation, Phase Diagrams for Binary Mixtures, Liquid-Vapor Systems - Raoult's Law, Non-ideality - Henry's Law and Azeotropes, Solid-Liquid Systems - Eutectic Points, Cooling Curves

Physical Chemistry – I Lab

1. Determination of pK_a and K_a value of a weak acid.
2. Determine the solubility of a sparingly soluble salt in water by conductivity measurement.
3. Determine the strength of a solution of NaOH by titrating against standard HCl solution using conductivity meter.
4. Determination of strength of HCl and CH_3COOH in the given mixture of both, by titrating it against solution of any base conductometrically.
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 activity coefficients by measuring electromotive force

Recommended Texts

1. Lehigh S.M. *Electrochemistry.* Volume 15. UK: Craig Banks Manchester
2. Patrick Fleming,*Physical Chemistry,* California State University East Bay
3. Mats Hillert, *Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic*
4. *Basis* 2nd Edition
5. Shaheen, M.A. (2023) Jilani Manual of Practical Chemistry, Vol.I, Jilani Notes, Sargodha-Lahore

Suggested Readings

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

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-5103 **Introduction to Electromagnetism** **3(3-0)**

PHYS-5103 gives an introduction in electromagnetism with emphasis on the following topics: Electric fields and currents, magnetic fields and induction, simple electrical circuits and electromagnetic oscillations.

Course Contents

1. Coulomb's law in vacuum, Electric field due to discrete/continuous charges distributions, Electric dipole, Electric flux, Gauss's law and its applications.
2. Electric potential due to discrete/continuous charges distributions.
3. Work and Electric potential energy.
4. Capacitors and capacitance, Capacitance for various geometries, Capacitance with Dielectrics, Energy transfer in electric circuit.
5. Power in electric circuits, Calculating current in a single loop and multiple loop by using Kirchhoff laws, Circuit analysis.
6. Growth and decay of current in RC-circuits and its analytical treatment. Magnetic field, Magnetic forces on a single point charge/current carrying conductor.
7. Torque on a current carrying loop and magnetic dipole, Biot & Savart Law and its analytical treatment and application.
8. Ampere's law and its applications, Electromagnetic induction and its laws.
9. Inductance,Inductance for various configurations, LR circuits, Growth and decay of current in RL circuits.
10. Electromagnetic Oscillation (Qualitative and Quantitative analysis using differential equations), Forced electromagnetic oscillations and resonance.
11. Alternating current circuits, Single loop RLC circuits (series and parallel), Power in AC circuits and phase angles
12. Measurement of resistance using a Neon flash bulb and condenser
13. Conversion of a galvanometer into Voltmeter & an Ammeter
14. To determine the self inductance of given coil.
15. To determine the mutual inductance b/w two coils.
16. To determine frequency of AC supply by electromagnetic sonsmeter/ Melde's experiment.
17. Measurement of low resistance coil by a Carey Foster Bridge.

Recommended Texts

1. Halliday, D., Resnick, R. & Walker, J. (2014). *Fundamental 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. Young, H. D., Freedman, R. A. & Ford, A. L. (2019). *University physics* (15th ed.). New York: Pearson.
2. Ohanian, H. C. & Markert, J. T. (2006).*Physics for engineers and scientists* (3rd ed.). New York: W. W. Norton.
3. Serway, R. A. & Jewelt, J. W. (2014). *Physics for scientist and engineers* (9th ed.). New York: Brooks/Cole.

SEMESTER II

URCG-5129 Understanding of Holy Quran / Fehm-e-Quran-I

Model Course Outline
for the Course Understanding of Quran – I

Course Title: Understanding of Quran – I
Course Book: Muallim ul Quran (Volume 1, 2 & 3) by Dr Ubaid ur Rahman
Credit Hours: 1 (0-1)
Contact Hours: 3 per week
Weeks: 15-16 (45-48 hours)

Course Learning Outcomes:

By the end of this course, students will be able to:

1. Develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs (unit 1 to 5 of Muallim ul Quran Book) and then sentences having present tense (first half of unit 6 of Muallim ul Quran Book).
2. Acquire a strong foundation for understanding long verses of the Quran with clarity.
3. Comprehend Quranic vocabulary, particles (operative & non operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plural through hundreds of Quranic sentences.
4. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.
5. Strengthen understanding of fundamental Quranic linguistic styles, expressions and idioms.
6. Understand at least 30 to 40 % of each page of the holy Quran.

Provision of material, content and books:

- **Paper book:** All volumes are available in printed book form.
- **Tutorial videos:** Teaching video of each lesson available on YouTube.
- **Confirmation Videos:** A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
- **A flipbook:** A flipbook edition is also accessible.
- **Helping material:** Helping material for the teachers like quizzes, question papers and images is available on website.

Course Outline:

Weeks	Lectures (1.5 hrs)	Units	Lessons	Assignments/Home Task	Linguistic Rules
1	1.	1	1-6	Writing the meaning of Quranic words Lesson 1-8	Proper Noun Masculine & Feminine
	2.	1	9-14	Writing the meaning of Quranic words 9-14	Two kinds of plural Concept of (ل) "And" Common Noun
2.	1.	1	15-17	Writing the meaning of Quranic words, phrases & translation of Sentences 15-17	Demonstrative Noun (This & That for Masculine (هذا- ذلك) Demonstrative Noun (This & That for Feminine) (هذه- تلك)
	2.	1	18-19 & Revision (Unit 1)	Writing the meaning of Quranic words, phrases & translation of Sentences 17-19 Quiz	Laam for emphasis (لام التاكيد) Superlative Degree like اكبر Revision of all Quranic Sentences
3.	1.	Unit 2	1-3	Writing the meaning of Quranic words, phrases & translation of Sentences 1-3	Emphatic Particle (ان) Preposition "For" (لام) Preposition (في)
	2.	2	4-6	Writing the meaning of Quranic words, phrases & translation of Sentences 4-6	Preposition (على- من- الى)
4	1.	2	7- 9	Writing the meaning of Quranic words & Translation of Sentences 7-9	Preposition (الباء) Absolute Negation Particle (لا النافية للجنس) Excepctive Particle (إلا)
	2.	2	10-13 & Revision (Unit 2)	Writing the meaning of Quranic words, phrases & translation of Sentences 10-13 Quiz	Subordinating Conjunction(أن), Was (كان), Vocative Particle(حرف النداء)

5.	1.	Unit 3	1-2	Writing the meaning of Quranic phrases 1-2	Quranic Adjective Compounds (بسملة وموصوف)
	2.	3	3-5	Writing the meaning of Quranic phrases & translation of sentences 3-5	Quranic Possessive Construction (مضاف ومضاف إليه)
6.	1.	3	6-7	Writing the meaning of Quranic phrase translation of sentences 6-7	Quranic Possessive Construction (مضاف ومضاف إليه)
	2.	3	8-10 & Revision (Unit 3)	Writing the meaning of Quranic phrase & translation of sentences 8-10 Quiz	Active Participle (اسم الفاعل) Passive Participle (اسم المفعول) Dual (مثنى)
7.	1.	Unit 4	1-2	Writing the meaning of Quranic phrase & translation of sentences 1-2	Personal Pronoun He (هو المنفصل) Possessive Pronoun His (ه المتصل)
	2.	4	3-4	Writing the meaning of Quranic phrase & translation of sentences 3-4	Possessive Pronoun with prepositions like في بيته Pronoun "His" with prepositions like إلى منه
8.	1.	4	5-8	Writing the meaning of Quranic sentences 5-8	Personal Pronoun You (انت المنفصل) Possessive Pronoun Your (ك المتصل) Possessive Pronoun with prepositions like في بيتك Pronoun "Your" with prepositions like إلى منك
	2.	Mid-Term			

9.	1.	4	9-12	Writing the meaning of Quranic phrases & sentences 9-12	Personal Pronoun She(هي المنفصل) Possessive Pronoun Her ها المتصل) Possessive Pronoun with prepositions like لها في بها Pronoun "Her" with prepositions like لها
	2.	4	13-15	Writing the meaning of Quranic phrases & sentences 13-15	Personal Pronoun I (انا المنفصل) Possessive Pronoun Her ي المتصل) Possessive Pronoun with prepositions like بي في Pronoun "My" with prepositions like لي
10.	1	4	17 & Revision Unit 4	Revision of all Quranic sentences of Unit 4 Quiz	Adverb (حال)
	2.	Unit 5	1-2	Writing the meaning of Quranic phrases & sentences 1-2	Masculine Plural جمع المذكر السالم و جمع المذكر السالم المسبوق بحرف الجر
11.	1.	5	3-4	Writing the meaning of Quranic phrases & sentences 3-4	Possessive Construction with Plurals جمع المذكر السالم المسبوق بالاضافة
	2.	5	5-6	Writing the meaning of Quranic phrases, sentences & verses 5-6	Personal Pronoun They (هم المنفصل) Possessive Pronoun Their هم المتصل)
12.	1.	5	7-8	Writing the meaning of Quranic phrases, sentences & verses 7-8	Possessive Pronoun with prepositions like بهم في Pronoun "Their" with prepositions like لهم
	2.	5	9-11	Writing the meaning of Quranic phrases, sentences & verses 9-11	Personal Pronoun You (انتم المنفصل) Possessive Pronoun Your كم المتصل) Possessive Pronoun with prepositions

					like في بيتكم
13.	1.	5	12-14	Writing the meaning of Quranic phrases & sentences & verses 12-14	Pronoun "Your" with prepositions like لكم Personal Pronoun We (نحن المنفصل) Possessive Pronoun Our (نا المتصل)
	2.	5	15-16	Writing the meaning of Quranic sentences & verses 15-16	Possessive Pronoun with prepositions like في بيتنا Pronoun "Our" with prepositions like لنا
14.	1.	5	17-18	Writing the meaning of Quranic sentences & Verses 17-18	Demonstrative Pronoun These, Those (هؤلاء- أولئك)
	2.	5	19-23	Writing the meaning of Quranic sentences & Verses 19-23	كلّا، لا، إن / إلّا، إنما، ليس، ما) (لم، لن، بل، كان (ذلك، ليس، نعم، يومئذ، سبحان، عليهم، قل، لن، بشر، نعم، كلا، ما أمر الله، حسب، أكثرهم، مصير، مرجع، ليلا(تمييز)
15.	1.	5	Revision Unit 5	Quiz	
	2.	5	1-3 (till Page 16)	Writing the meaning of Quranic Verbs &Translation of Quranic Sentences & Verses (1-3)	Introduction of Present Tense(الفعل مضارع) & Verbal Sentence (جملة فعلية) Present Tense الفعل المضارع صيغة المفرد يعلم
16.	1.	6	3 (From Page 17) & 4-5	Translation of Quranic Sentences & Verses 3-5	Present Tense الفعل المضارع صيغة المفرد يعلم
	2.	6	6	Translation of Quranic Sentences & Verses	Present Tense الفعل المضارع صيغة الجمع يعلمون

Director
Institute of Chemistry
University of Sargodha

1-Course Description

The Ethics-I course is designed to provide students with a comprehensive understanding of ethical principles, practices, and theories in various societal contexts. Throughout this degree program, students will explore the complexities of ethical theories of semitic and non-semitic religions along with decision-making and develop critical thinking skills to navigate moral dilemmas. This course will also enable the students to interact with others religious identities with humanistic, inclusive and holistic approach

2- Learning Objectives

This course aims to:

1. Introduce students to the fundamental concepts, scope, and importance of ethics.
2. Explore the relationship between law, morality, and social values.
3. Develop a clear understanding of virtuous and immoral ethics and their impact on individual and collective life.
4. Study the role of major religious figures in the moral development of human society and enable students to apply ethical principles for personal development, conflict resolution, and social harmony.

3- Learning Outcomes

By the end of the course, students will be able to:

1. Students will be able to identify and analyze major ethical theories, values, and their scope in social and individual life.
2. Differentiate between law and ethics, and analyze their interrelationship.
3. Identify types of virtuous and immoral ethics and assess their social impacts.
4. Examine the ethical teachings of major religions and their relevance in contemporary society.
5. Apply ethical principles to address modern challenges in personal and professional life.

4-Course Structure

1. Interactive lectures, Group discussions and debates
2. Reflection papers and presentations
3. Assignments and Quiz

Course Contents

Unit 1: Introduction and Fundamentals of Ethics

1. Literal and terminological definition of ethics
2. Literal and terminological definition of values
3. Relationship between law and ethics
4. Need, importance, and scope of ethics

Unit 2: Types of Ethics and Their Impact on Society

- Virtuous ethics: concept, types, benefits, and outcomes
- Immoral ethics: concept, types, and harms
- Role of ethics in social refinement and establishment of peace

Unit 3: Virtuous Ethics (Akhlaq-e-Hasanah)

- Concept, need, and importance of virtuous ethics
- Scope of virtuous ethics in the light of religions
- Major virtues in revealed and non-revealed religions
- Impact of virtuous ethics on individual and collective life

Unit 4: Immoral Ethics (Akhlaq-e-Razilah)

- Concept of immoral ethics
- Social problems caused by immoral ethics
- Practical consequences of immoral ethics
- Major vices in revealed and non-revealed religions

Unit 5: Role of World Religious Figures in Moral Development

- Prophet Moses (AS): introduction, miracles, and role in moral refinement
- Prophet Jesus (AS): introduction, miracles, and role in moral refinement
- Prophet Muhammad (ﷺ): introduction, miracles, and role in moral refinement

Textbook

1. Izutsu, T. (2002). *Ethico-Religious Concepts in the Qur'an*. McGill-Queen's University Press.

Suggested Readings

1. Gert, B. (2005). *Morality: Its Nature and Justification*. Oxford University Press.
2. MacIntyre, A. (2007). *After Virtue: A Study in Moral Theory*. University of Notre Dame Press.
3. Al-Ghazali, Abu Hamid (2001). *The Alchemy of Happiness*. Islamic Texts Society.
4. Nasr, S. H. (1994). *The Heart of Islam: Enduring Values for Humanity*. Harper One.
5. Beauchamp, T. L., & Childress, J. F. (2019). *Principles of Biomedical Ethics*. Oxford University Press.
6. Hasan, Z. (2010). *Ethics in Islam: Key Concepts and Contemporary Challenges*. Islamic Research Institute.

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CHEM-6104 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:
   a. Introduction & measurements
   b. Implications of dipole moment in inorganic molecules and dipole-dipole forces.
   c. Dipole-induced dipole forces, London (dispersion) forces & other intermolecular force
   d. Hydrogen bonding
   e. Metallic Bonding (Free electron theory, Valence bond theory, Molecular orbital or band theory of metallic bonding Conductors, insulators and semiconductors)
2. pi – acceptor Ligands
   a. Transition metal carbonyls (Mononuclear, Binuclear, Polynuclear).
   b. The eighteen-electron rule as applied to metal carbonyls.
   c. Evaluation of structures based on spectroscopic evidence
   d. General methods of Preparation of Metal carbonyls.
   e. Chemistry of metal carbonyls of Group VI-VIII (Preparation, Properties, structures and applications.
   f. Nitrosyls (Preparation, Properties, structures and applications.
   g. Applications of metal carbonyls and their derivatives to catalysis and organic synthesis.
3. Organic Reagents used in Inorganic Analysis:
   a. Introduction, Types of reagents, their specific nature and methods of applications with specific examples [DMG, 8-Hydroxyquinoline, diphenylcarbazide, anthranilic acid, salicylaldoxime, cupron, nitron, cupferon, quinaldic acid, alizarin (1,2-dihydroxy anthraquinone)]
   b. Advantages and disadvantages of organic reagents
   c. Masking and demasking agents.
   d. Complexometric titrations involving various reagents (EDTA etc.).
   e. Chelates and chelate effect: Role of organic reagents in different analytical techniques.
4. Inorganic Chains, rings, cages and Clusters

   Chains: Catenation, heterocatenation, silicates minerals, silicones, intercalation, one dimensional conductors, isopoly anions, Heteropoly anions, borazines, phosphazenes, phosphazenes polymers, other heterocyclic ring systems.

Inorganic Chemistry Lab-I

1. Redox titrations [Cu(II) by Potassium iodate]
2. Estimation of Al by using 8-Hydroxiquinoline
3. Estimation of Cr by using 1,5-diphenylcarbazide

4. Preparation of 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. Preparation of coordination compound of $[Ni(NH_3)_6$
e. Synthesis of N,N'-disalicylaldehyde-1,3-propanediiminenickel(II

5. Complexometric Titrations:

(a) Estimation of Mg^{+2}, Zn^{+2} with EDTA (Direct titration).
(b) Estimation of Ni^{+2} with EDTA (Back titration).
(c) Determination of Ca^{+2} and Zn^{+2} in mixture (Masking)
(d) Determination of Cd^{+2} and Zn^{+2} in a mixture (Demasking).
(e) Determination of SO_4^{2-} and PO_4^{-3} with EDTA (Indirect titration).

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.
3. James E. Huheey, (1993) Inorganic Chemistry: Principles of Structure and Reactivity (4th Ed) Harper & Row, UK
7. Shaheen, M.A. Manual of Advanced Practical Inorganic Chemistry (2003), Jilani Notes, Sargodha-Lahore

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-6105 **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) and 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
6. Electrophilic and nucleophilic substitution reactions at aromatic systems, mechanisms involved (Arenium ion, SE_1, 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. Introduction to 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,
11. Classification of elimination reactions (a,b,g-eliminations). Syn, anti and E_1cB eliminations.
12. Eliminations vs substitutions, E_1 vs E_2, factors affecting eliminations.

Reaction Mechanism-I Lab.

1. Estimation of phenol (PhOH), acetone (Me_2CO), amino (NH_2) groups.
2. Synthesis of azodyes, iodobenzene (PhI), iodoform (CHI_3), sulphanilic acid ($PhSO_2NHPh$), cinnamic acid, benzil & benzilic acid.

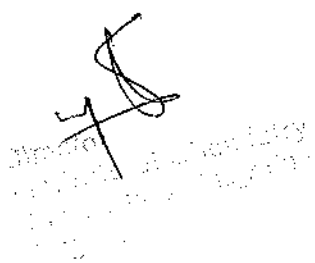
Recommended Texts

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-6106 **Physical Chemistry – II** **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. Chemical kinetics: Introduction to Kinetics and factors affecting rate of reaction, Concept of order of reaction, Zero, 1st order reactions, 2nd order of reaction & cases, Kinetics of third order reactions with all possible cases (same concentration, different concentrations, some reactants with same and some with different concentrations), Kinetics of opposing reactions (1st order opposed by 1st and 2nd order reactions, 2nd order opposed by 1st and 2nd order reactions), Rate constants of consecutive reactions, Parallel reactions and their rate constant. Arrhenius Equation, Activation Energy, Theories of reactions.
2. Thermodynamics, Introduction to Thermodynamics, First law of thermodynamics, Second law of thermodynamics and its applications, Third law of thermodynamics and determination of absolute entropy, Entropy of mixing. Partial molal quantities, Interpretation of Maxwell's law of distribution of velocities, derivation of average velocity, most probable velocity and root mean square velocity from the law. Barometric formula, effect of altitude, temperature and molecular mass on vertical distribution of particles.

Physical Chemistry– II Lab

1. Determination of percentage purity of an optically active compound.
2. Determination of specific and molar rotations of optically active substance in solution by polarimetry.
3. Determine the order of reaction and rate constant for the inversion of cane sugar in the presence of an acid.
4. Determine order of reaction of the saponification of ethyl acetate.
5. Determination of activation energy of a chemical reaction
6. Determination of heat of solution of a substance from solubility measurements and to determine thermodynamic quantities like $\Delta G°$, $\Delta H°$, $\Delta S°$ of the solution.
7. Determine partial specific volume and partial molar volume in mixture of water & methanol.

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.

Bhatti, H. N. (2019). *Modern physical chemistry.* Pakistan: Caravan Book House Lahore.

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.

MATH-5102 **Techniques of Integration and its Applications** **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.

SEMESTER-III

CHEM-6107 Forensic Chemistry 2 (2+0)

This course provides a comprehensive knowledge about applications of forensic procedures in chemistry. Students will learn about types of evidence and methods to collect them. This course will provide a detailed knowledge about toxicology and forensic biology and 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 other sciences e.g. Botany, Zoology, Geology, Odontology, Pathology etc
3. Types and classification of evidence, Physical, chemical biological evidence, Classifications of forensic evidence
4. Fingerprint analysis, history, types, latent vs visible fingerprints
5. Chemical tests for latent and visible fingerprints, AFIS, fingerprint database.
6. Hair as a forensic physical evidence, composition and structure of hair, differences between human and animal hair and identification.
7. Fiber as a forensic evidence, composition, chemical composition of fiber, microscopic analysis, chemical tests for fiber analysis.
8. Glass as a forensic evidence, Physical and chemical properties of glass, chemical analysis
9. Trace evidence, Physical and chemical properties, qualitative and quantitative
10. Metal analysis
11. Microscopic analysis. Trace evidence types, characterization, chemical tests, collection, analysis, exhibiting in court. Analysis of paints, vehicles, fire, bullet, and cartridge analysis,
12. Tests for explosive residues, glass comparisons. Anthropometry, body measurement.
13. Toxicology, History, relation with other sciences
14. Introduction to poisons, narcotics, toxins, laws related to poisons.
15. Classification of poisons, organic, inorganic and mechanical poisons,
16. Corrosives, irritants, neurotics, and miscellaneous poisons
17. Mechanisms of poisons, methods of administration, routes of excretion. Diagnosis of poisons. Analytical chemistry techniques for drug and poison analysis, narcotics analysis.
18. Serology, forensic analysis of blood patterns, and chemical tests for identifications.
19. Forensic biology and DNA analysis; DNA CODIS databases, PCR, blotting, RE digestion, RFLP, STRs, VNTRs analysis, DNA Fingerprinting, paternity tests.
20. 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-6108 **Spectroscopic Techniques – 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.

Spectroscopic Techniques – I Lab.

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-6109 **Chromatographic Techniques - I** **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-6110 **Instrumental Methods of Analysis - I** **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.

CHEM-6111 **Bioenergetics and Metabolism** **4 (3+1)**

This course aims at providing a better understanding of metabolic pathways, their control mechanisms, and disorders. This 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. Net ATP consumption. Energy calculations
4. Gluconeogenesis; dedicated reaction, regulations, and net energy calculations.
5. Non oxidative metabolism; Fermentation, types
6. Pentose Phosphate Pathway; relationship to glycolysis, gluconeogenesis
7. Metabolism of carbohydrates other than glucose; fructose, galactose, mannose starch and Glycogen.
8. The Citric Acid Cycle; regulations, reaction mechanism.
9. Fatty Acid Metabolism; Beta oxidation of even and odd chain fatty acids, Lipid Biosynthesis
10. Oxidative Phosphorylation, Electron transport chain and Photophosphorylation.
11. Protein Metabolism; amino Acid Oxidation and production of Urea,
12. Biosynthesis of Amino Acids
13. Nucleotide metabolism, synthesis, and degradation.

Bioenergetics and Metabolism Lab.

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 urea, creatinine triglycerides Glutathione, ammonia and cholesterol
6. Liver function tests and lipid profiles from human serum
7. Estimation of Sodium (Na+), Potassium (K+) and Chloride (Cl-) from serum using flame photometer.
8. Estimation of heavy metals in human serum using atomic absorption.
9. Isolation and enzymatic hydrolysis of Glycogen from Liver
10. Sterilization and Preparation of culture media i.e use of autoclave
11. Steak, pour and spread plate methods.
12. Testing sensitivity to antimicrobial substances, Preparing serial dilutions of cultures
13. Use of microscope and differential staining: Gram's staining method
14. 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-6112 **Microbiology and Industrial Fermentations** **3 (3+0)**

This course is offered to the students who adapt Biochemistry as a major subject and provides a comprehensive understanding of industrial applications of microorganisms in production and fermentation processes. This course 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. Types of fermentations and their limitations
8. Industrial Uses of Bacteria, Molds, Yeast and viruses.
9. Industrial designs of fermenters
10. Microbial production of Cheese, Alcohol, Citric acid, Acetic acid, Antibiotic, enzyme production, Fermented Foods, Vinegar production, Amino Acid.
11. Petroleum Microbiology and Deterioration of Materials (Paper, Textile and Cordage, Painted Surface).
12. Use of microbial enzymes in industry
13. 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-6113 **Introduction to Bioinformatics** **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. Introduction, Review of DNA replication, transcription, and translation, Genome organization
2. DNA and Protein Databases, data storage, file formats, information retrieval
3. Database queries, sequence retrieval, Creation of restriction endonuclease maps
4. Dot plots, Sequence alignment, Local alignment, Global alignment, Multiple alignments
5. Genetic distances, Distance based phylogenies, Phylogenetic tree construction.
6. Consensus sequences, Finding genes and open reading frames in DNA sequences
7. Protein Secondary Structure prediction and Protein homology modelling
8. SwissProt PDB viewer and Swiss-model server
9. Data mining
10. Introduction to Python
11. Protein-Protein, Protein-DNA, Protein-Ligand interactions
12. Microarray analysis and applications of microarrays
13. Comparative genomics continued, Future directions of bioinformatics.

Hands-on-training

1. Introduction to NCBI, databases, usages
2. Data retrieval, file formats conversions
3. Basic Python programming
4. Use of python for data retrieval
5. Restriction endonuclease mapping
6. BLAST, interpretation.
7. Construction of distance and character based phylogenetic trees.
8. Determination of consensus sequences, locating genes (gene prediction) and open reading frames in DNA sequences
9. Protein Secondary structure prediction
10. Protein Tertiary structure prediction
11. Protein model assessment and refinement
12. Introducing MD simulations

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-6114 **Advanced Inorganic Chemistry** **4(3+1)**

Stereochemistry Periodicity: Concepts of Stereochemistry and Periodicity (Periodic Properties), Introduction, First and Second row anomalies, the use of d-orbitals by non-metals, Reactivity and d-orbital participation, The use of p-orbitals in pi-bonding, Periodic anomalies of non-metals and post transition metals.

Nuclear Chemistry: Introduction, classification of Nuclides, Radioactivity and radioactivite series, artificial radioactivity, units of radioactivity, Determination of Half-life, Nuclear Fission and Fusion reactions, Applications of radio Isotopes as traces.

Structure of Inorganic Solids: Introduction, The close packing of spheres, the structure of ionic solids, Ionic radii, Crystal structures and defect solid state.

Thermal Methods of analysis: Introduction, instrumentation and applications.

Advanced Inorganic Chemistry Lab.

1. Use of some organic reagents for the estimation of various elements
   a) 8–Hydroxyquinoline Al (III) and Fe (III)
   b) Nitron (NO_3^{-1})
   c) Salicyladoxine Ni (II) in presence of Cu (II)
   d) Anthranilic acid Co (II) and Zn (II)
   e) Pyrogallol Bi^{3+}
2. Chromatographic Techniques –
   - Column, Thin layer and Paper chromatographic techniques for the qualitative separation of inorganic compounds
   - Applications of Solvent extraction and ion exchange technique
1. 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. $[Co(NH_3)_5$
   d. ONO]Cl
   e. $[Co(en)_3]Cl_3$

Recommended Books

1. Huheey, J. E., Keiter, E. A. and Keiter, R. L., "Inorganic Chemistry: Principles of Structure and Reactivity", 4th Ed., Harper and Row, New York, (2001).
2. Cotton, F. A., Wilkinson, G. and Gaus, P. L., "Basic Inorganic Chemistry", 3rd Ed., Wiley, New York, (1995).
3. Atkins, P. and Jones, L., "Chemicals Principles" Freeman & Co., NY (2002).
4. Cotton, F.A., Wilkinson, G., Murillo C.A. and Bochmann, M. "Advanced Inorganic Chemistry", 6th Ed., Wiley-Intersceince, New York, (1999).

CHEM-6115 Inorganic Polymers and 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. Cyclophosphazines & Polyphosphazines
4. Boranes
5. Silicones, Classification of silicones
6. Polyionic species: Isopropyl ions
7. Heteropoly anions of transition elements
8. Polysilicates
9. Polyphosphates
10. Metal cluster compounds

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.

CHEM-6116 **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-6117 **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, factors affecting IR absorbance and applications of IR spectroscopy.
4. Mathematical relationship between absorbance (A) and transmittance (T) in UV-Vis spectroscopy. Chromophore, bathochromic / hypsochromic shifts, factors affecting λ_{max} and importance of ε value.
5. Woodward-Fieser rule for calculating λ_{max} of cyclic conjugated dienes, carbonyls and acyclic systems. Absorption by aromatic compounds. Applications of UV-Vis spectroscopy
6. Difference between spectroscopy and spectrometry; radical cations and radical anions *vs* cabonium ion.
7. Parts of a mass spectrometer (MS); basic principle, instrumentation, different methods of ionization in MS [EI, CI, 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) and instrumentation
11. Chemical shift (δ in ppm) and coupling constant (*J* in Hz) factors affecting them
12. Spin-spin splitting, multiplicity (*s, d, t, q, dd, ddd, dddd*) of ^{1}H signals. Interpretation of ^{1}H-NMR spectra.
13. First and second order ^{1}H-NMR spectrum, introductory broad band, DEPT-45°, DEPT-90° and DEPT-135° ^{13}C-NMR spectra.
14. Structure elucidation of organic compounds (containing 10-15 Cs with a variety of functional groups) by joint applications of IR, UV, ^{1}H-NMR, ^{13}C-NMR spectroscopy and mass spectrometry.

Spectroscopic Methods in Organic Chemistry Lab.

1. Experimental purification techniques e.g., distillation, solvent extraction, chromatography etc.
2. Multi-step synthesis of some organic compounds
3. Characterization of above synthesized compounds by joint applications of spectroscopic and mass spectrometric methods of analyses

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-6118 **Reaction Mechanism** **3 (3+0)**

This course is the continuity of study of organic reaction mechanisms in which rest of the polar mechanism (redox, molecular rearrangements and pericyclic cyclization) are addressed. This course is a foundation course for Organic Synthesis and Advance Organic Synthesis. 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 shifting and movements of electrons and atoms. At the end of this course the students 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 (using $KMnO_4$, OsO_4, ozonolysis and epoxidation). Mild oxidation of 1°-ols → CHO, 2°- ols → ketone.
2. Harsh oxidation of alcohols, amines and nitriles.
3. Reduction involving metal/metal complexes (Wilkinson's vs Crabtree catalysts), hydrides [$NaBH_4$, $LiAlH_4$, DIBAlH, Red-Al and $NaB(CN)H_3$] 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, of pericyclic reactions.
8. Electrocyclization involving 4n / 4n+2 π electron systems.
9. Cycloadditions including Diels-Alder, Alder-ene and 1,3-dipolar additions
10. Frontier orbital and symmetry conservation approaches in respect to electrocyclic and cycloaddition reactions
11. Sigmatropic reactions, Cope, Ireland-Claisen rearrangements.

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 organicchemistry.*(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-6119 **Reactive Intermediates and Protective Groups** **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, LiAlH4 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. Introduction and classification of reactive intermediates
2. Generation, detection, reactions and synthetic applications of following reactive intermediates
   Free radicals, carbenes, carbenoids, nitrenes, carbocations, carbanions, and arynes
3. Concept of chemoselectivity and role of protecting groups
4. Protection, deprotection and retention conditions of following functional groups
   a. alcohols / phenols (acetals, ethers, silylethers and esters)
   b. amines (carbamates and amides)
   c. aldehydes / ketones (acetals / ketals, thioacetals / thioketals, and functionalized ketals)
   d. carboxylic acids (esters and functionalized esters)
5. Applications of protecting groups in organic synthesis
6. Phase transfer reagents, calixarenes, homogenous and heterogeneous catalysis, organocatalysis, click chemistry, microwave assisted synthesis, sonochemistry etc.

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*. (4th ed.). New York: Macmillan.
2. Warren, S. (2008). *Organic synthesis*. New York: Wiley.

CHEM-6120 **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, 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 solutions 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

Surface tension and interfaces, Adsorption at liquid surface, Physical and Chemical Adsorption, Derivation of Adsorption isotherms (Freundlich and Langmuir adsorption isotherm, BET Equation), Colloids and classification, Preparation of sols, Purification of sols, Optical and electrical properties of solutions, Hardy Schulz Rule & Flocculation of Sols, Emulsions and types, Emulsification & Demulsification, Surfactants, micellization, Gels, Classification and preparation, Determination of particle size, Sedimentations of suspensions, Stability of suspensions, The cause of semi-permeability, Mechanism of osmotic pressure, Molecular wt. determination of macromolecules, Determination of the molecular weight by osmometry

Surface Phenomena Lab

1. Verification of Freundlich adsorption isotherm for organic acids
2. Experimental verification of Langmuir adsorption isotherm.
3. To prepare As_2S_3 sol and verification of Tyndall effect
4. Preparation of $Fe(OH)_3$ and observing the scattering of incident light.
5. Determination of flocculation value of a sol by using monovalent, divalent and trivalent ions of electrolytes to verify Hardy-Schulze rule.
6. Preparation of buffer solution and measurement of exact pH-value by pH meter.

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-6121 **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. Moreover, 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, the 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

Introduction of Spectroscopy and Energy regions, Classification of spectroscopy, Classification of molecules on the basis of relative I_A, I_B, I_C, Rotational spectra of rigid linear molecules, Effect of Isotopic substitution on spectra, Determination of bond lengths, Rotational spectra of symmetric, asymmetric, spherical tops, Instrumentation for MW spectroscopy, Harmonic and inharmonic oscillator models for the energy of a diatomic molecule, Types of vibrational modes, Interpretation of IR spectra of simple molecules
Fermi resonance, applications and sampling techniques, Types of electronic transition, H–atom spectrum, energies of atomic orbital, Electronic angular momentum and the fine structure, Idea of Raman scattering Rayleigh scattering and molecular polarizability, Rotational Raman spectra of linear molecules, Symmetric top molecules and spherical top molecules, Vibrational Raman spectra, 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-6122 **Quantum Chemistry and Statistical Thermodynamics** **3(3+0)**

Quantum Mechanics and Statistical Thermodynamics is a comprehensive course for the students having interest in Physical Chemistry as their specialization. This course covers two major areas (i.e. Quantum Chemistry and Statistical Thermodynamics) of Physical Chemistry. The objective includes to make the students able to 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 are important part of the syllabus to be covered. As course covers two main directions i.e. Quantum Chemistry and Statistical Thermodynamics, 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.

Contents

Quantum Chemistry: Introduction to Quantum Mechanics, Electromagnetic Theory of Radiations, Plank's Quantum Theory, Schrodinger's wave equation, Interpretation of wave function (ψ), Observable, operators and functions, Eigen value, Eigen function, Orthogonality and normalized wave functions, Motion of particle in three-dimensional box and idea of degeneracy, Application of Schrodinger wave equation to derive magnetic, azimuthal and principal quantum number, Postulates of quantum Mechanics, Mathematical treatment of rigid rotator and calculation of bond length of simple molecule,
Statistical thermodynamics: Probability, statistical treatment of entropy, Sterling approximation and probability, Maxwell's law of distribution of velocities, The Boltzmann distribution law and partition function, Partition function and thermodynamics functions like internal energy and entropy. Translational, rotational, vibrational and electronic partition function and their comparison.

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-IV

URCG-5130 Understanding of Holy Quran / Fehm-e-Quran-II

Model Course Outline
for the Course Understanding of Quran – II

Course Title: Understanding of Quran – II
Course Book: Muallim ul Quran (Volume 3, 4 & 5) by Dr Ubaid ur Rehman
Credit Hours: 1 (0-1)
Contact Hours: 3 per week
Weeks: 12-16 (48-48 hours)

Course Learning Outcomes:

By the end of this course, students will be able to:

1. Directly comprehend hundreds of Quranic sentences & verses.
2. Understand at least 80 to 85 % of each page of the holy Quran.
3. Understand common verses across different Quranic topics.
4. Achieve proficiency in the basic and advance linguistic aspects of the Arabic language.
5. Understand the difference between Quranic verbs in various forms, such as present, past and imperative.
6. Develop the ability to understand long verses of the holy Quran independently and then comprehend their interpretation.

Provision of material, content and books:

- **Paper book:** All volumes are available in printed book form.
- **Tutorial videos:** Teaching video of each lesson available on YouTube.
- **Confirmation Videos:** A complete series of confirmation videos of all lessons is available in which the student can confirm his answers.
- **A flipbook:** A flipbook edition is also accessible.
- **Helping material:** Helping material for the teachers like quizzes, question papers and images is available on website.

Course Outline:

Weeks	Lectures	Units	Lessons	Assignments/Home Task	
1.	1.	6	6	Understanding & Translation of Verses	Present Tense صیغہ جمع مذکر غائب مثال یعلمون
	2.	6	7-8	Understanding & Translation of Verses	Present Tense صیغہ واحد مذکر غائب مثال یعلمون
2.	1.	6	9-10	Understanding & Translation of Verses	Present Tense صیغہ واحد مذکر مخاطب (تعلم) صیغہ جمع مذکر مخاطب (تعلمون)
	2.	6	11-12	Understanding & Translation of Verses	Present Tense صیغہ جمع متکلم مفاعلہ (نعلمون)

		6	3	Understanding & Translation of Verses	Present Tense
	2.	6	3 (sec 3-4)	Understanding & Translation of Verses	Present Tense
	1.	6	3 (sec 3-4)	Understanding & Translation of Verses	Conditional Sentences
	2.	6	3 (sec 3-4)	Understanding & Translation of Verses	Learn Surahs & Learn
	2.	6	3 (sec 1-2)	Understanding & Translation of Verses	Present with Object pronouns & Present Tense
	2.	6	Revision (sec 1-5)	Tests	
	1.	7	1 (sec 1-3)	Understanding & Translation of Verses	Past Tense
	2.	6	1 (sec 4-5)	Understanding & Translation of Verses	Past Tense
	1.	6	1 (sec 6-8)	Understanding & Translation of Verses	Past Tense
	2.	6	1 (sec 7-9)	Understanding & Translation of Verses	Past Tense
	1.	7	Revision	Understanding & Translation of Verses Quiz	Past Tense
	2.	MID-TERM			
	1.	7	2 (sec 1-2)	Understanding & Translation of Verses	Past Tense
	2.	7	2 (sec 3)	Understanding & Translation of Verses	Past Tense
	1.	7	2 (sec 4-5)	Understanding & Translation of Verses	Past Tense
	2.	7	2 (sec 6-7)	Understanding & Translation of Verses	Past Tense
	1.	7	3 (sec 1-2)	Understanding & Translation of Verses	Past Tense

	2.	7	3 (sec 2-3)	Understanding & Translation of Verses	Past Tense صيغة المتكلم جمعا
12.	1.	7	3 (sec 3-4)	Understanding & Translation of Verses	Past Tense صيغة الجميع للمتكلم جمعا
	2.	7	3 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجميع للمتكلم جمعا
13.	1.	7	4 (sec 1-2-3)	Understanding & Translation of Verses	Past Tense صيغة لجميع للمخاطب جمعا
	2.	7	4 (sec 4-5)	Understanding & Translation of Verses	Past Tense صيغة الجميع للمخاطب جمعا
14.	1.	7	5-6	Understanding & Translation of Verses Quiz	Past Tense صيغة المتكلم والمخاطب جمعا
	2.	7	7	Understanding & Translation of Verses	Past Tense صيغة المؤنث الغائب جمعا
15.	1.	7	8	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل مجهول للمفرد
	2.	7	9	Understanding & Translation of Verses	Passive Voice (Past Tense) فعل مجهول للجمع
16.	1.	8	1-4	Understanding & Translation of Verses	Imperative Verb for singular فعل الامر للمفرد
	2.	7	5-8	Understanding & Translation of Verses	Imperative Verb for plural فعل الامر للجمع

Ethics-II

URCG-5132

1 (0-1)

1-Course Description

The course *Ethics-II* is designed to provide students with a deeper understanding of ethical principles and practices from both Semitic and non-Semitic religions, as well as their application in professional and social contexts. Students will engage with Jewish, Christian, Islamic, Hindu, Buddhist, Sikh, Confucian, and Jain ethical traditions. The course emphasizes moral reasoning, decision-making, tolerance, and peacebuilding. It aims to cultivate an inclusive, humanistic, and holistic approach towards ethical living and interfaith engagement.

2- Learning Objectives

The course objectives are to:

1. Understand the fundamental principles and theories of ethics.
2. Introduce the ethical and moral teachings of Judaism, Christianity, Islam, and Hinduism.
3. Explore the ethical teachings of non-Semitic religions such as Buddhism, Sikhism, Confucianism, and Jainism.
4. Develop critical thinking skills to evaluate ethical arguments and theories.
5. Promote ethical leadership and interfaith harmony.

3- Learning Outcomes

By the end of this course, students will be able to:

1. Identify and analyze major ethical theories and teachings from world religions.
2. Understand the role of religions in improving moral values and social behavior.
3. Demonstrate ethical decision-making in various personal and professional contexts.
4. Recognize the impact of ethical decisions on individuals, communities, and society.
5. Apply skills of ethical leadership, including communication, conflict resolution, and inclusive engagement.

4-Course Structure

1. Interactive lectures, Group discussions and debates
2. Reflection papers and presentations
3. Assignments and Quiz

~~Course Title: Ethics-II (For Non-Muslim Students) Course Code: URCG-5130~~

Course Contents

Unit 1: Ethical Teachings of Semitic Religions

- Judaism and its ethical teachings
- Christianity and its ethical teachings
- Islam and its ethical teachings

Unit 2: Ethical Teachings of Non-Semitic Religions

- Hinduism and its ethical teachings
- Sikhism and Buddhism: ethical values and practices
- Confucian and Jain ethical traditions

Unit 3: Professional Ethics

- Ethics for students and teachers
- Ethics in doctor–patient relationships
- Ethics in trader–customer interactions

Unit 4: Concept and Significance of Tolerance

- Definition, need, and importance of tolerance
- Teachings of Semitic religions on tolerance and their contemporary relevance
- Teachings of non-Semitic religions on tolerance and their contemporary relevance

Unit 5: Foundational Values and Ethics for Peacebuilding in Society

- Respect for sacred scriptures, personalities, places of worship, and religious symbols
- Promotion of tolerance and broadmindedness
- Encouragement of dialogue and harmony
- Benevolence towards humanity
- Establishment of justice and fairness
- Patience, forbearance, and forgiveness

Textbook

- Kidder, R. M. (2009). *How Good People Make Tough Choices: Resolving the Dilemmas of Ethical Living*. Harper.

Suggested Readings

1. Barash, D. P., & Webel, C. P. (2014). *Peace and Conflict Studies*. Sage.
2. Smart, N. (1998). *The World's Religions*. Cambridge University Press.
3. Nasr, S. H. (2003). *The Heart of Islam: Enduring Values for Humanity*. HarperOne.
4. Sharma, A. (2006). *Hindu Ethics: Purity, Abortion, and Euthanasia*. SUNY Press.
5. Harvey, P. (2000). *An Introduction to Buddhist Ethics: Foundations, Values and Issues*. Cambridge University Press.
6. Coward, H., & Perkinson, J. (2013). *A Cross-Cultural Dialogue on Ethical Leadership*. Wilfrid Laurier University Press.
7. Confucius. (1998). *The Analects*. Oxford University Press.

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CHEM-6123 **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.

CHEM-6124 **Spectroscopic Techniques – 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

Spectroscopic Techniques – II 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-6125 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-6126 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 temperature 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.

CHEM-6127 Molecular Biology & Biophysical 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, introduction to types and function of DNA
2. Structure of Chromatin and its functions.
3. DNA replication in prokaryotes and Eukaryotes
4. Type of DNA polymerases and functions
5. DNA damage; types of mutations. DNA repair; NER, MMR, homologous DNA repair.
6. Virus DNA/RNA replication and its protein regulation
7. Transcription in prokaryotes and Eukaryotes
8. Differences and types of DNA polymerases, operons
9. Splicing; introns, exons and ribozymes. Gene regulation, post transcriptional modifications.
10. Translation; tRNA structure and functions, activation, protein synthesis, regulation
11. Post translational modifications.
12. Protein characterization using different biophysical methods.
13. UV/Vis Spectrophotometry, FT-IR, Circular Dichroism (CD), Surface Plasmon Resonance (SPR)
14. Gel electrophoresis (SDS-PAGE, and agarose gel electrophoresis)
15. Ultra-, analytical and gradient centrifugation
16. Cryo-electron microscopy, protein NMR, X-ray crystallography/Diffraction.
17. Applications of PCR and DNA sequencing
18. Mass spectrometry and use of isotopes in molecular biology.

Molecular Biology & Biophysical Techniques Labs

1. Isolation of proteins from plant and animal samples using various cell disruption methods e.g., amylase
2. Protein precipitation by NH_4SO_4 method, using acid and organic solvent methods.
3. Protein dialysis and ultrafiltration
4. Estimation of proteins using UV, Braford and Lowry's methods.
5. Characterization of proteins i.e., amylase activity assays
6. Plasma proteins separation by SDS PAGE
7. Chromatographic (Ion exchange and size exclusion) separation and purification of proteins
8. Estimation and Isolation of total DNA/RNA form bacteria/tissues
9. Preparation of plasmid DNA from bacteria.
10. Restriction enzyme digestion
11. Characterization/separation of DNA by Agarose Gel Electrophoresis
12. Primer designing and amplification of sample DNA by PCR (PCR demonstration)

13. Understanding to DNA sequencing (sequencing analysis by a demo sample file)
14. Characterization of proteins using online tools i.e Protpram

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-6128 **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.
Dawis, B. D., Dulbecco, R., Eisen, H. N., & Ginsbery, H.S. (2002). *Microbiology.* New York, USA: Harper & Row.

CHEM-6129 **Introduction to Recombinant DNA Technology** **3 (3+0)**

The course also introduces introduction to various methods and applications involved in recombinant DNA technology 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. Student will learn about the genomic libraries, cDNA libraries and their applications with emphasis to their role in agriculture, production of therapeutic proteins.

Contents

1. DNA Cloning and applications.
2. Restriction enzymes, restriction maps,
3. Enzymes in recombinant DNA technology
4. Gene vectors including plasmids, bacteriophages, cosmids
5. DNA vectors, shuttle and expression vectors
6. Gene splicing, genomic libraries, screening methods for gene libraries
7. DNA and RNA blotting
8. Chromosome walking; PCR; site specific mutagenesis
9. Overexpression of proteins
10. Restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis)
11. Stem cell technology
12. 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. Walker, J. M. (1994). *The basic protein and peptide protocols*. New Jersey, USA: Humana Press.
2. Lodish, H., Berk, A. Kaiser, C. A., (2016). *Molecular cell biology*. (8th ed.). New York USA: W. H. Freeman.

CHEM-6130 **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 ligands.

Contents

Reaction of CO and Hydrogen (Hydroformylation, Reductive Carbonylation, Reduction of CO by hydrogen, Synthesis gas and the water gas shift reaction)
Carbonylation reaction (Synthesis of methanol and methyl acetate, Adipic ester, other Carbonylation reactions, Decarbonylation reactions)
Catalytic addition of molecules to C–C multiple bonds (Homogeneous hydrogenation, Hydrocylation and Hydrocynation)

Homogeneous Catalysis by Transition Metal Complexes Lab.

Instrumental Methods of Analysis
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

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

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]
4. Determination of Fe[II]

Recommended Books

1. Edition, Oxford University Press, UK (1998).
2. Kotz, J.C. and Treichel, P. Chemistry and Chemical Reactivity, 4th Edition, Saunders College Publishing, NY (1999).
3. Angelici, R.J. Synthesis and Technique in Inorganic Chemistry, 1st Edition, University Science Books, CA (1986).
4. Garry L. Miessler, D. and Tarr, A. "Inorganic Chemistry" 3rd Edition, Pearson Education, Inc. NY (2004).
5. Purcell K.F. and Kotz, J.C. "An Introduction to Inorganic Chemistry" Saunder, College, Philadelphia (1980).

CHEM- 6131 **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

Kinetics and Mechanisms of Inorganic Reactions: Rate law, Stationary State approximation, Inert and labile complexes, Substitution reaction

i) Octahedral Complexes (Acid hydrolysis, Acid catalyzed equation, Anation reactions, Base hydrolysis, Attack on ligands, Steric effects of inert ligand)

ii) Square planar Complexes (Nucleophilic reactivity, Trans effect, Cis effect, effect of leaving group. Electron transfer processes (outer and inner sphere reactions). Complimentary and Non - Complimentary reactions.

Mechanism of Oxidative Addition and Reductive Eliminations: Oxidative Addition, One electron oxidative addition, Addition of Oxygen, Addition of bimetallic species, Hydrogen addition, HX addition, Organic halides, Reductive Elimination.

Recommended Books

1. Jordan, R. B., Reaction Mechanisms of Inorganic and Organometallic Systems, 2nd Edition, Oxford University Press, (1998).
2. Kotz, J. C. and P. Treichel, Chemistry and Chemical Reactivity, 4th Edition, Saunders College Publishing, (1999).
3. Garry L. Miessler, Donald A. Tarr, "Inorganic Chemistry" 3rd Edition, Pearson Education, Inc. (2004).
4. Keith F. Purcell and John C. Kotz, "An Introduction to Inorganic Chemistry" Saunder, College, Philadelphia (1980).

CHEM-6132 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

Thermogravimetric Analysis, Thermogravimetry (TG), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC), Separation Methods (Solvent Extraction, Column, TLC and Ion Exchange Chromatography), Potentiometry, Conductometry.

Recommended Books

1. Structure and Reactivity", 4th Ed., Harper and Row, New York, (2001).
2. Jordan, R.B., Reaction Mechanisms of Inorganic and Organometallic Systems, 2nd Edition, Oxford University Press, UK (1998).
3. Kotz, J.C. and Treichel, P. Chemistry and Chemical Reactivity, 4th Edition, Saunders College Publishing, NY (1999).
4. Angelici, R.J. Synthesis and Technique in Inorganic Chemistry, I st Edition, University Science Books, CA (1986).

CHEM-6133 **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; isolation of different secondary metabolites exploiting their boiling point, molecular size, solubility and polarity
2. Hormones (endocrines, exocrines, paracrines), pheromones (chemical communication) and allomones (chemical defense)
3. Classification, biosynthesis, biological importance, laboratory synthesis and structure elucidation of alkaloids (ephedrine, adrenaline, atropine, indole, quinine, morphine etc.) by chemical and spectroscopic methods
4. Classification, biosynthesis, laboratory synthesis and structure elucidation of terpenoids (limonene, carvone, pinene, menthol, camphor, pentacyclic triterpenoid, tetraterpenoid) by chemical, spectroscopic and spectrometric methods
5. Basic nomenclature, classification, biosynthesis, biological importance, laboratory synthesis and structure elucidation of steroids (ecdysteroid, corticocoid, gonadal, AAS & neuro steroid, phytosterol, brassinolide, withanolide etc.) by chemical, spectroscopic and spectrometric methods of analyses
6. Classification, biosynthesis, RDA, bioavailability, laboratory synthesis and metabolic role of vitamins (A, B, C, D, E and K)
7. Classification, biosynthesis, biological importance, laboratory synthesis and structure elucidation of flavonoids by chemical, spectroscopic and spectrometric methods.

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-6134 **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 stereo controlled 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 stereo control in pericyclic reactions (cycloadditions, sigmatroptic 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 C–C bond formations
2. Different methods for carbanion generation (organometallics, active methylene, ylides)
3. Effect of medium (solvent, bases, temperature, additives etc.)
4. Alkylation of esters, aldehydes, ketones and carboxylic acid using enolate chemistry.
5. Regioselctivity in enolate formation,
6. C-alkylation vs O-alkylation.
7. Role of active methylenes as synthetic equivalents
8. Specific enol equivalents and their merits and demerits
9. Aldol condensation, Claisen condensation, Mannich reaction
10. Direct vs conjugation addition to α,β-unsaturated carbonyls (Michael additions, Robinson's annulation)
11. C–N bond formation (synthesis of amides, amines, imines), reductive amination for the synthesis of amines
12. C–O bond formation (oxidation of olefins using different reagents)
13. Introduction to retrosynthesis, Functional group inter-conversion (FGI)
14. One group and two group disconnections
15. Disconnection of simple alcohols, and their derivatives, α,β-unsaturated carbonyl compounds, 1,3-dicarbonyl compounds and 1,5-dicarbonyl compounds, Functionalized aromatic systems
16. Concept of umpolung, acyl anion equivalents

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-6135 **Stereochemistry** **3 (3+0)**

Stereochemistry is the study of the relative arrangement of atoms or groups in a molecule in 3D space. These days' chiral drugs have become an integral part of pharmaceutical industry and replacing racemic (enantio impure) drugs. 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. Instrumentation of a polarimeter; derivation and calculation of specific rotation [α]; chirality and symmetry; symmetry, asymmetry and dissymmetry; elements of chirality and symmetry (C_n, σ, S_n)
2. Projections of a 3D molecule to 2D (Wedge-head, saw-horse, Newman & Fischer projections)
3. Stereochemical notations (+/-, *d / l, D / L, R / S, r / s, aR / aS, pR / pS, M / P*)
4. Conformational isomerism in mono-, di-, tri- and polysubstituted cyclohexanes; conformations of *cis / trans* decalene systems
5. Calculating the absolute configuration through CIP and modified CIP rule
6. Configurational isomers with 3 asymmetric centres and no asymmetric centre (allenes, spiranes, biphenyls etc.), mutarotation
7. Study of conformational and configurational isomers through spectroscopic methods
8. Stereocontrol in addition, elimination and aliphatic nucleophilic substitution (on C, Si and Sn) reactions on acyclic molecules
9. Stereoselective (introductory Cram's rule, Prelog's rule and Felkin-Anh's model) and stereospecific syntheses
10. Elucidating the configuration of a chiral molecule through ORD / CD.
11. Introduction to racemization and resolution

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-6136 **Kinetics of Heterogeneous Reactions** **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

Introduction of adsorption, Liquids and gaseous systems of inorganic and organic reactions, Single systems, Double systems, Study of reactions on solid surfaces, Kinetics of Single reacting gas, retardation by reaction products, Kinetics of two reacting gases, Retardation by reactants, Adsorb-heterogeneous reaction, Theory of absolute reaction rate, Reactions in solution, Influence of solvents involving ions, primary and secondary salt effect on kinetics of the reactions, Comparison between homogeneous and heterogeneous kinetics

Kinetics of Heterogeneous Reactions 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 distribution coefficient of I_2 between H_2O and CCl_4.
4. Determination of Molar extinction coefficient.
5. Verification of Beer–Lambert's law by using spectrophotometer
6. Determination of λ_{max} and unknown concentration of $KMnO_4$ solution by colorimeter
7. Determination of λ_{max} and unknown concentration of $K_2Cr_2O_7$ solution using spectrophotometer

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-6137 **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 Nano-dots because of their unique optical properties which is applied in imaging the biological process.

Contents

Polymers: Introduction of Polymers, basic concepts of Kinetic chain length, average molecular weight of polymer & polydispersity, Classification of polymers, Kinetics of condensation polymerization, Kinetics of free radical addition polymerization, Kinetics of Anionic addition polymerization, Kinetics of Cationic addition polymerization, Kinetics of co-polymerization reactions, Molecular mass determination by different methods

Photochemistry: Laws of photochemistry (Grotthuss–Draper law, Stark-Einstein law, Beer-Lambert Law), Deviations of Laws of Photochemistry, Quantum efficiency, Methods to determine quantum yield and quantum efficiency, Photochemical reactions, Photosensitized reactions, Phosphorescence, Fluorescence, Joblonski Diagram, Chemiluminescence, 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-6138 **Nuclear Chemistry** **3(3+0)**

This course is designed to have a comprehensive knowledge about nuclear energy and nuclear reactions. It gives understanding about the principles, kinetics and mechanism of nuclear reactions. It gives an intensive sight of tracers and their applications. Course content makes the students enable to understand the mechanism of radioactive decay and energy associated. Important portion related with reaction, mechanism, kinetics and radolytic and radioactive reactions, fission and fusion. It gives brief understanding of radiation hazard and radiation dose as well. 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

Atom & Nucleus, Nuclear Models, Radioactivity and Radioisotopes, Method of detection of radioactivity, Measurement of radioactivity, Radioactive Decay, Kinetics of radioactive decay, Half-life and Decay Constant, Nuclear Fission, Nuclear Fusion, Nuclear Fusion and Stellar Energy, The Atomic Bomb, The Hydrogen Bomb, Nuclear Reactor, Charged Particles accelerators, Radiation Dose, Radiation Hazards and safety measures, Applications of tracers

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.