Annexure A

SCHEME OF STUDIES & CURRICULUM
BS Chemistry
(Semester/Term System)
(2022)

INSTITUTE OF CHEMISTRY
UNIVERSITY OF SARGODHA
SARGODHA

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

Eligibility:

i) At least 45% marks in ADS or equivalent (semester / annual examination system) qualification and 25% marks contribution of Chemistry courses to total (like 200/800) is compulsory.
ii) At least 2.0 CGPA (out of scale 4) in ADS or equivalent (semester / annual examination system) qualification and 25% credit hours contribution of Chemistry courses to total credit hours (like 15 out of 60) is compulsory.

Merit:

i) Marks obtained in ADS out of 800 + marks obtained in Chemistry out of 200 + 20 marks for Hafiz-e-Quran (if applicable) for applicants with annual system examination
ii) [Marks obtained in ADS out of 800 + marks obtained in Chemistry out of 200 for applicants with semester system examination] × 0.85 + 20 marks for Hafiz-e-Quran (if applicable)

Deficiency Courses:

The deficiency courses (if applicable) will be determined by the Institute of Chemistry after admission to BS Chemistry, which could be variable for different universities students due to different scheme of studies offered to them. The deficiency courses shall be offered in the coming summer semester (first year of studies).

Summary:

BS Chemistry program comprises of 4 semesters with 66 credit hours.

1st Semester:

No. of Credits = 18 Credits

Course Code	Course Title	Credits
CHEM-6301	Basic Mathematics for Chemists	2(2–0)
CHEM-6302	Analytical Chemistry	4(3+1)
CHEM-6303	Inorganic Chemistry-I	4(3+1)
CHEM-6304	Organic Chemistry-I	4(3+1)
CHEM-6305	Physical Chemistry-I	4(3+1)
Total Credits		**18(14-4)**

2nd Semester

No. of Credits = 18 Credits

Course Code	Course Title	Credits
CHEM-6306	Basic Statistics for Chemists	2(2–0)
CHEM-6307	Biochemistry	4(3+1)
CHEM-6308	Inorganic Chemistry-II	4(3+1)
CHEM-6309	Organic Chemistry-II	4(3+1)
CHEM-6310	Physical Chemistry-II	4(3+1)
Total Credits		**18(14-4)**

Non-Credit course

Course Code	Course Title	
URCC-5110	Citizen Education and Community engagement	0
Total Credits		**0**

3rd Semester

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

List of Compulsory Courses

Course Code	Title of the Course	Credits
CHEM-6311	Forensic Chemistry	2(2+0)
CHEM-6312	Industrial Chemistry	3(3+0)

Semester with Research

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

Fields of Specializations

Every student shall opt any one of the following specializations.

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

i) Analytical Chemistry 3

Course Code	Title of Course	Credits
CHEM-6313	Research	4(4+0)
CHEM-6314	Advanced Spectroscopy – I (Minor)	4(3+1)
CHEM-6315	Advanced Chromatographic Techniques (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6316	Instrumental Methods of Analysis	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6313	Research	4(4+0)
CHEM-6317	Metabolism and Bioenergetics (Minor)	4(3+1)
CHEM-6318	Microbiology and Industrial Fermentation (Major)	3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		

CHEM-6319	Enzymes and Nutrition	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6320 CHEM-6321	Research Advance Inorganic Chemistry (Minor) Organometallic & Bio-inorganic Chemistry (Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6322	Inorganic Polymers & Chemical Forces	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6323 CHEM-6324	Research Reaction Mechanism, (Major) Spectroscopic Methods in Organic Chemistry (Minor)	4(4+0) 3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6325	Organometallics	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6326 CHEM-6327	Research Surface Phenomena (Minor) Molecular Spectroscopy (Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6328	Statistical and Quantum Mechanics	3(3+0)

Semester without Research

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

Fields of Specializations

Every student shall opt any one of the following specializations.

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

v) Physical chemistry

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6314 CHEM-6315	Advanced Spectroscopy – I (Minor) Advanced Chromatographic Techniques (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6316	Instrumental Methods of Analysis	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6317 CHEM-6318	Metabolism and Bio-Energetics (Minor) Microbiology and Industrial Fermentation (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6319	Enzymes and Nutrition	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6320 CHEM-6321	Advance Inorganic Chemistry (Minor) Organometallic & Bio-inorganic Chemistry (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6322	Inorganic Polymers & Chemical Forces	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6323 CHEM-6324	Reaction Mechanism, (Major) Spectroscopic Methods in Organic Chemistry (Minor)	3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6325	Organometallics	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6326 CHEM-6327	Surface Phenomena (Minor) Molecular Spectroscopy (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM- 6328	Statistical and Quantum Mechanics	3(3+0)

Semester- IV

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

Compulsory course

Course Code	Title of the Course	Credits
CHEM-6329	Environmental Chemistry	3(3+0)

Semester with Research

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

Field of Specialization

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

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6330 CHEM-6331	Research Advanced Spectroscopy – II (Major) FTIR, Raman Spectroscopy, ESR and Surface Analysis(Minor)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6332	Instrumental Methods of Analysis-II	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6333 CHEM-6334	Research Chemotherapy & Immunology (Major) Molecular Biology & Physical Techniques (Minor)	4(4+0) 3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6335	Endocrine System	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6336 CHEM-6337	Research Homogeneous Catalysis by Transition Metal Complexes (Minor) Inorganic Reaction Mechanism(Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6338	Physical Methods in Inorganic Chemistry	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6339 CHEM-6340	Research Chemistry of Natural Products (Minor) Organic Synthesis (Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member.		
CHEM-6341	Chemistry of Protective Groups & Reactive Intermediates	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6313 CHEM-6342 CHEM-6343	Research Advanced Approaches of Homogeneous and Heterogeneous Kinetics (Minor) Polymers and Photochemistry (Major)	4(4+0) 4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6344	Elementary Group Theory	3(3+0)

Semester without Research

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

Field of Specialization

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

i) Analytical Chemistry

Course Code	Title of Course	Credits
CHEM-6330 CHEM-6331	Advanced Spectroscopy – II (Minor) FTIR, Raman Spectroscopy, ESR and Surface Analysis(Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6332	Instrumental Methods of Analysis-II	3(3+0)

ii) Biochemistry

Course Code	Title of Course	Credits
CHEM-6333 CHEM-6334	Chemotherapy & Immunology (Major) Molecular Biology & Physical Techniques (Minor)	3(3+0) 4(3+1)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM- 6335	Endocrine System	3(3+0)

iii) Inorganic Chemistry

Course Code	Title of Course	Credits
CHEM-6336 CHEM-6337	Homogeneous Catalysis by Transition Metal Complexes (Minor) Inorganic Reaction Mechanisms (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6338	Physical Methods in Inorganic Chemistry	3(3+0)

iv) Organic Chemistry

Course Code	Title of Course	Credits
CHEM-6339 CHEM-6340	Chemistry of Natural Products (Minor) Organic Synthesis (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6341	Chemistry of Protective Groups & Reactive Intermediates	3(3+0)

v) Physical Chemistry

Course Code	Title of Course	Credits
CHEM-6342 CHEM-6343	Advanced Approaches of Homogeneous and Heterogeneous Kinetics (Minor) Polymers and Photochemistry (Major)	4(3+1) 3(3+0)
The following major course may also be substituted with the 3 credits Course (Major) subject to the interest & availability of the faculty member		
CHEM-6344	Elementary Group Theory	3(3+0)

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

List of Deficiency Courses (if required)

Course Code	Course Title	Credits
CHEM-5101	Physical Chemistry	4(3+1)
BOTN-5101	Diversity of Plants	4(3+1)
ZOOL-5101	Animal Diversity-I (Invertebrates)	4(3+1)
URCE-5101	Grammar	3(3+0)
URCI-5105	Islamic Studies	2(2–0)
CHEM-5102	Inorganic Chemistry	4(3+1)
BOTN-5102	Plant Systematic, Anatomy and Development/Embryology	4(3+1)
ZOOL-5102	Animal Diversity-II (Chordates)	4(3+1)
URCE-5102	Language Comprehension & Presentation Skills	3(3+0)
URCP-5106	Pakistan Studies	2(2–0)
CHEM-5103	Organic Chemistry	4(3+1)
BOTN-5103	Cell Biology, Genetics and Evolution	4(3+1)
ZOOL-5103	Animal Form and Function-I	4(3+1)
URCE-5103	Academic Writing	3(3+0)
URCI-5109	Introduction to Information and Communication Technologies	3(3+0)
CHEM-5104	Chemistry Special Topics	4(3+1)
BOTN-5104	Plant Physiology and Ecology	4(3+1)
ZOOL-5104	Animal Form and Function-II	4(3+1)
URCE-5104	Introduction to English Literature	3(3+0)
CHEM-5105	Introduction to Management	3(3+0)
CHEM-6206	Computer Applications in Chemistry	2(2+0)

SEMESTER-I

CHEM-6301 Basic Mathematics for Chemist 2(2+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6302 Analytical Chemistry 4 (3+1)

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

Contents

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

Analytical Chemistry Lab – I

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

Recommended Texts

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

Suggested Readings

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

CHEM-6303 Inorganic Chemistry – I 4(3+1)

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

Contents

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

Inorganic Chemistry Lab-I

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

Recommended Texts

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

Suggested Readings

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

CHEM-6304 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-6309, CHEM-6323 and CHEM-6340) of organic chemistry specialization. The nomenclature of organic molecules (both carbocycles and heterocycles), involvement of electronic (*–I*, *+I*)/resonance (*–R*, *+R*)/steric factors in reactions and stereochemical aspects are major focus of this course. The major part of this course is associated with the study of stereoisomers. Stereochemistry spans the entire spectrum of organic, inorganic, biological, physical and especially supramolecular chemistry. It includes methods for determining and describing these relationships; the effect on the physical or biological properties these relationships impart upon the molecules in question, and the manner in which these relationships influence the reactivity of the molecules in question (dynamic stereochemistry). A basic concept on 3D structures, conformations of molecules, asymmetric synthesis, other stereochemical principles and attributes are essential. The completion of this course shall enable the students to apply fundamental concepts in organic chemistry and stereoisomerism.

Contents

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

Organic Chemistry Lab. – I

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

Recommended Texts

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

Suggested Readings

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

CHEM-6305 Physical Chemistry – I 4(3+1)

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

Contents

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

Physical Chemistry Lab – I

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

Recommended Texts

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

Suggested Readings

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

SEMESTER-II

CHEM-6306 Basic Statistics for Chemists 2 (2+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6307 Biochemistry 4 (3+1)

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

Contents

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

Biochemistry Lab I

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

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

Recommended Texts

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

Suggested Readings

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

CHEM-6308 Inorganic Chemistry – II 4(3+1)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6309 Organic Chemistry–II 4 (3+1)

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

Contents

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

Organic Chemistry Lab.–I

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

Recommended Texts

1. March, J. (1992). *Advanced organic chemistry*. New York: Wiley.
2. Pine, S. H. (1987). *Organic chemistry*. New York: McGraw-Hill.
3. Clayden, J., Greeves, N., and Warren, S. (2012). *Organic chemistry*. (2^{nd} 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-6310 Physical Chemistry – II 4 (3+1)

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

Contents

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

Physical Chemistry Lab – II

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

Recommended Texts

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

Suggested Readings

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

SEMESTER-III

a) Compulsory Papers (Total 05 credits)

CHEM-6311 Forensic Chemistry 2 (2+0)

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

Contents

1. History of Forensic science/forensic chemistry
2. Applications of forensic chemistry in relation to other sciences e.g. Botany, Zoology, Geology, Odontology, Pathology etc
3. Types and classification of evidence, Physical, chemical biological evidence, Classifications of forensic evidences
4. Fingerprint analysis, history, types, latent vs visible fingerprints
5. Chemical tests for latent and visible fingerprints
6. AFIS, fingerprint database.
7. Hair as a forensic physical evidence, composition and structure of hair, differences between human and animal hair and identification.
8. Fiber as a forensic evidence, composition, chemical composition of fiber, microscopic analysis, chemical tests for fiber analysis.
9. Glass as a forensic evidence, Physical and chemical properties of glass, chemical analysis
10. Trace evidences, Physical and chemical properties, qualitative and quantitative
11. Metal analysis
12. Microscopic analysis
13. Trace evidence types, characterization, chemical tests, collection, analysis, exhibiting in court. Analysis of paints, vehicles, fire, bullet and cartridge analysis,
14. Tests for explosive residues, glass comparisons. Anthropometry, body measurement.
15. Toxicology, History, relation with other sciences
16. Introduction to drugs, narcotics, toxins, laws related to poisons
17. Classification of poisons, organic, inorganic and mechanical poisons,
18. Corrosives, irritants, neurotics, and miscellaneous poisons
19. Mechanisms of poisons, methods of administration, routes of excretion. Diagnosis of poisons. Analytical chemistry techniques for drug and poison analysis, narcotics analysis.
20. Serology, forensic analysis of blood patterns, and chemical tests for identifications.
21. Forensic biology and DNA analysis; DNA CODIS databases, PCR, blotting, RE digestion, RFLP, STRs, VNTRs analysis, DNA Fingerprinting, paternity tests.
22. 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-6312 Industrial Chemistry 3(3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

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

CHEM-6314 Advanced Spectroscopy – I 4(3+1)

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

Contents

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

Analytical Chemistry Lab. III

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

Recommended Texts

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

Suggested Readings

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

CHEM-6315 Advanced Chromatographic Techniques 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6316 Instrumental Methods of Analysis 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

ii) Biochemistry

CHEM-6317 Bioenergetics and Metabolism 4 (3+1)

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

Contents

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

Biochemistry Lab. II

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

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

Recommended Texts

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

Suggested Readings

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

CHEM-6318 Microbiology & Industrial Fermentations 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6319 Enzymes and Nutrition 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

iii) Inorganic Chemistry

CHEM-6321 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-6322 Inorganic Polymers & Chemical Forces 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

iv) Organic Chemistry

CHEM-6323 Reaction Mechanism 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6324 Spectroscopic Methods in Organic Chemistry 4 (3+1)

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

Contents

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

Spectroscopic Methods in Organic Chemistry Lab.

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

Recommended Texts

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

Suggested Readings

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

CHEM-6325 Organometallics 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

v) Physical Chemistry

CHEM-6326 Surface Phenomena 4(3+1)

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

Contents

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

Surface Phenomena Lab

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

Recommended Texts

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

Suggested Readings

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

CHEM-6327 Molecular Spectroscopy 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6328 Statistical and Quantum Mechanics 3(3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

SEMESTER-IV

- **Compulsory Courses**

CHEM-6329 Environmental Chemistry 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

b) Specialization

i) Analytical Chemistry

CHEM-6330 Advanced Spectroscopy –II 4 (3+1)

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

Contents

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

Analytical Chemistry Lab

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

Recommended Texts

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

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

Suggested Readings

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

CHEM-6331 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-6332 Instrumental Methods of Analysis-II 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

ii) Biochemistry

CHEM-6333 Chemotherapy and Immunology 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6334 Molecular Biology & Physical Techniques 4 (3+1)

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

Contents

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

Biochemistry Lab III

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

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

Recommended Texts

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

Suggested Readings

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

CHEM-6335 Endocrine System 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

iii) Inorganic Chemistry

CHEM-6336 Homogeneous catalysis by transition metal complexes 4 (3+1)

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

Contents

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

Inorganic Chemistry Lab-IV

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

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

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

Recommended Texts

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

Suggested Readings

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

CHEM- 6337 Inorganic Reactions Mechanism 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6338 Physical Methods in Inorganic Chemistry 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

iv) ORGANIC CHEMISTRY

CHEM-6339 Chemistry of Natural Products 4 (3+1)

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

Contents

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

Chemistry of Natural Products Lab.

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

Recommended Texts

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

Suggested Readings

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

CHEM-6340 Organic Synthesis 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6341 Chemistry of Protective Groups and Reactive Intermediates 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

v) Physical Chemistry

CHEM-6342 Advanced approach of homogeneous and heterogeneous kinetics 4 (3+1)

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

Contents

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

Advanced Approach of Homogeneous and Heterogeneous Kinetics Lab

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

Recommended Texts

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

Suggested Readings

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

CHEM-6343 Polymers and Photochemistry 3 (3+0)

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

Contents

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

Recommended Texts

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

Suggested Readings

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

CHEM-6344 Elementary Group Theory 4 (3+1)

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

Contents

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

Recommended Texts

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

Suggested Readings

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