Annexure 14.1

Avinashilingam Institute for Home Science and Higher Education for Women
Deemed to be University Est. u/s 3 of UGC Act 1956, Category 'A' by MHRD
Re-accredited with A^{++} Grade by NAAC, CGPA 3.65/4, Category I by UGC
Coimbatore - 641 043, Tamil Nadu, India
Department of Chemistry

B.Sc. Chemistry

Programme Outcomes

PO1 Fundamental knowledge of basic concepts of Science

PO2 Capacity to identify problems and suggest suitable scientific and technological solutions

PO3 Ability to apply the acquired knowledge and inculcate lifelong learning

PO4 Research fervor to inquire, synthesize and articulate solutions for the community

PO5 Familiarization of ICT skills and their applications

PO6 Capability for critical thinking

PO7 Competence in effective communication

PO8 Professional ethics and norms pertaining to societal development

PO9 Ability to work independently and in a team

PO10 Entrepreneurial skills

Programme Specific Outcomes

PSO1 In depth knowledge in fundamentals of Chemistry and effective skills to analyze and solve problems in Chemistry (comprehension)

PSO2 Effective skills to qualify for Competitive / service commission / Professional Career

PSO3 Environmental and socio economic awareness

Scheme of Instruction and Examinations
(For Students admitted from 2023-2024 & onwards)

Part	Subject Code	Title of Paper/Component	Hours of Instructions/ week	Scheme of Examination				
				Duration of Exam (h)	CIA	CE	Total	Credit
	First Semester							
I	23BLT001/ 23BLH001/ 23BLF001	பொதுத்தமிழ் தாள் I - இக்கால இலக்கியம் / Prose and Non Detailed Texts / French I	2	3	50	50	100	2
II	23BAEEC1	**Ability Enhancement Compulsory Course I** English for Communication	4	3	50	50	100	4
	Generic Elective							
		Generic Elective I	5+1/ 4+4	3	50	50	100	6
III	**Discipline Specific Core Courses**							
	23BCHC01	Inorganic Chemistry-I	4	3	50	50	100	4	6
	23BCHC01P	Inorganic Chemistry Practical-I	4	3	50	50	100	2	
	23BCHC02	Organic Chemistry-I	4	3	50	50	100	4	6

	23BCHC02P	Organic Chemistry Practical-I	4	3	50	50	100	2		
IV	23BVBNC1/ 23BVBNS1/ 23BVBSP1	**Skill Enhancement Course** **Value Based Course Elective I** NCC/NSS/Sports	3/2	2	60	40	100	4/1/1		
		Games - Practical	1							
				Total				**28/25**		
	Second Semester									
I	23BLT002/ 23BLH002/ 23BLF002	பொதுத்தமிழ் தாள் II அற இலக்கியம் / Grammar, Translation and General Essay / French II	2	3	50	50	100	2		
II	23BAEES1	**Ability Enhancement Compulsory Course –II** Environmental Studies	4	3	50	50	100	4		
	Generic Electives									
	23BENGE2A/ 23BENGE2B/ 23BENGE2C/ 23BENGE2D	**Generic Elective –II** Introduction to Literature / British Literature / Modern Indian Literature / New Literatures in English	5+1	3	50	50	100	6		
III	**Discipline Specific Core Courses**									
	23BCHC03	Physical Chemistry-I	4	3	50	50	100	4	6	
	23BCHC03P	Physical Chemistry Practical-I	4	3	50	50	100	2		
	23BCHC04	Organic Chemistry-II	4	3	50	50	100	4	6	
	23BCHC04P	Organic Chemistry Practical-II	4	3	50	50	100	2		
IV		**Skill Enhancement Course**								
	23BVBNC2/ 23BVBNS2/ 23BVBSP2	**Value Based Course Elective I** NCC/NSS/Sports	3/2	2	60	40	100	4/1/1		
		Games - Practical	1							
					Total			**28/25**		
	Internship during summer vacation for 15 days									
	Third Semester									
I	23BLT003/ 23BLH003/ 23BLF003	பொதுத்தமிழ் தாள் III - சமய இலக்கியம் / Ancient and Modern Poetry / French III	2	3	50	50	100	2		
II	**Generic Elective**									
		Generic Elective -III	5+1/ 4+4	3	50	50	100	6		
III	**Discipline Specific Core Courses**									
	23BCHC05	Physical Chemistry-II	4	3	50	50	100	4	6	
	23BCHC05P	Physical Chemistry Practical-II	4	3	50	50	100	2		
	23BCHC06	Organic Chemistry-III	4	3	50	50	100	4	6	
	23BCHC06P	Organic Chemistry Practical-III	4	3	50	50	100	2		
IV	**Skill Enhancement Courses**									
	23BSBCS1	**Skill Based Compulsory Course – I** Communication Skill	4P	3	50	50	100	2		
		Skill Based Elective Course – II	4P	3	50	50	100	2		
	23BVBNC3/ 23BVBNS3/ 23BVBSP3	**Value Based Course Elective I-** NCC/NSS/Sports	3/2	2	60	40	100	4/1/1		
		Value Based Course Elective - II	2		100	—	100	2		

						Total		**30/27**	
	Fourth Semester								
I	23BLT004/ 23BLH004/ 23BLF004	பொதுத்தமிழ் தாள் IV - சங்க இலக்கியம் / Introduction to Functional Hindi and Journalism / French IV	2	3	50	50	100	2	
II	**Generic Elective**								
		Generic Elective -IV	5+1/ 4+4	3	50	50	100	6	
III	**Discipline Specific Core Courses**								
	23BCHC07	Inorganic Chemistry-II	4	3	50	50	100	4	6
	23BCHC07P	Inorganic Chemistry Practical-II	4	3	50	50	100	2	
	23BCHC08	Physical Chemistry-III	4	3	50	50	100	4	6
	23BCHC08P	Physical Chemistry Practical-III	4	3	50	50	100	2	
IV	**Skill Enhancement Courses**								
	23BSBSS1	**Skill Based Compulsory Course – III** Soft Skill	4P	3	50	50	100		2
		Skill Based Elective Course – IV	4P	3	50	50	100		2
	23BVBNC4/ 23BVBNS4/ 23BVBSP4	**Value Based Course Elective- I** NCC/NSS/Sports	3/2	2	60	40	100		4/1/1
		Value Based Course Elective - III	2		100	—	100		2
						Total		**30/27**	
	Internship during summer vacation for 15 days								
	Fifth Semester								
III	**Discipline Specific Core Courses**								
	23BCHC09	Introduction to Quantum Chemistry	4	3	50	50	100	4	6
	23BCHC09P	Introduction to Quantum Chemistry Practical	4	3	50	50	100	2	
	23BCHC10	Inorganic Chemistry-III	4	3	50	50	100	4	6
	23BCHC10P	Inorganic Chemistry Practical-III	4	3	50	50	100	2	
	Discipline Specific Elective Courses								
	23BCHDE1	**DSE-I** Internship (duration 6 weeks)	1	-	50	50	100	6	
	23BCHDE2-5	**DSE -II** Theory+ Practical	4+4	3	50	50	100	6	
IV	**Skill Enhancement Courses**								
	23BVBNC5/ 23BVBNS5/ 23BVBSP5	**Value Based Course Elective I-** NCC/NSS/Sports	3/2	2	60	40	100	4/1/1	
	23BCHPD1	Professional Development Course	5		100	—	100	**Remarks**	
						Total		**28/25**	
	Sixth Semester								
III	**Discipline Specific Core Courses**								
	23BCHC11	Molecular Spectroscopy and Photochemistry	4	3	50	50	100	4	6
	23BCHC11P	Molecular Spectroscopy and Photochemistry Practical	4	3	50	50	100	2	
	23BCHC12	Analytical Chemistry	4	3	50	50	100	4	6
	23BCHC12P	Analytical Chemistry Practical	4	3	50	50	100	2	

	Discipline Specific Elective Courses							
	23BCHDE6-9	**DSE -III** Theory+ Practical	4+4	3	50	50	100	6
	23BCHDE10-13	**DSE -IV** Theory+ Practical	4+4	3	50	50	100	6
IV	**Skill Enhancement Courses**							
	23BVBNC6/ 23BVBNS6/ 23BVBSP6	**Value Based Course Elective I-** NCC/NSS/Sports	3/2	2	60	40	100	4/1/1
							Total	**28/25**
							Overall total	**172/154**

- **Ability Enhancement Compulsory Courses**
  - English for Communication
  - Environmental Studies
- **Skill Enhancement courses**, are Skill Based and / or Value Based which are aimed at providing hands on training, competencies, skills etc. and may be opted by the students from the electives offered by the departments or from SWAYAM MOOCs / NPTEL

Skill Based courses

- **Skill Based Compulsory courses I – 23BSBCS1 – Communication Skill** during 3rd semester
- **Skill Based Compulsory courses III - 23BSBSS1 – Soft Skill** during 4th semester
- **Skill Based Elective courses (II /IV) offered by Department of Chemistry**

S.No.	Skill Based Elective Courses (II/IV)		Semester	Hours of Instruction	Credits
1.	23BCHSE1	Personality Development	3	4 (P)	2
2.	23BCHSE2	Computer Applications for Chemistry			
3.	23BCHSE3	Science Communication and Popularization			
4.	23BCHSE4	Biofertilizers			
5.	23BCHSE5	Herbal Science and Technology			
6.	23BCHSE6	Fermentation Science and Technology	4	4 (P)	2
7.	23BCHSE7	Environmental Impact Analysis			
8.	23BCHSE8	IT Skills for Chemists			
9.	23BCHSE9	IPR and Business Skill for Chemists			
10.	23BCHSE10	Analytical Clinical Biochemistry			
11.	23BCHSE11	Mushroom Culture Technology			

- **Value Based Courses - Elective I**

Value Based Courses Elective I	Subject Code	Semester	No of .Credits
NCC/	23BVBNC1-6/	1-6	24 Credits
NSS/	23BVBNS1-6/		6 Credits
Sports	23BVBSP1-6		6 Credits

- **Value Based Courses - Elective II/III offered by Chemistry Department**

Value Based Courses Elective II/III	Subject code	Semester	Hours of Instruction	Credits
Food Chemistry	23BCHVB1	3&4	2	2

* **Discipline Specific Elective Courses** should be related to their own core which may be from SWAYAM MOOCs / NPTEL also
    - All the courses have 6 credits with 4 hours of theory and 4 hours of practical or 5 hours of theory and 1 hour of Tutorials

S.No	DSE Courses	Semester	Hours of Instruction	Credits
	Discipline Specific Elective (DSE)-I			
1.	23BCHDE1 Internship	5	1	6
	Discipline Specific Elective (DSE)-II			
2.	23BCHDE2 Medicinal Chemistry	5	4+4	6
3.	23BCHDE3 Electro Chemistry	5	4+4	6
4.	23BCHDE4 Polymer Chemistry	5	4+4	6
5.	23BCHDE5 Environmental Chemistry	5	4+4	6
	Discipline Specific Elective (DSE)-III			
6.	23BCHDE6 Advanced Materials Chemistry	6	4+4	6
7.	23BCHDE7 Advanced Analytical Chemistry	6	4+4	6
8.	23BCHDE8 Nuclear and Radiation Chemistry	6	4+4	6
9.	23BCHDE9 Organic Spectroscopy	6	4+4	6
	Discipline Specific Elective (DSE)-IV			
10	23BCHDE10 Heterocyclic Chemistry	6	4+4	6
11.	23BCHDE11 Biomolecules	6	4+4	6
12.	23BCHDE12 Organometallic and Bioinorganic Chemistry	6	4+4	6
13	23BCHDE13 Introduction to Nanochemistry and Applications	6	4+4	6

- **Generic Elective Courses** offered for other disciplines / departments

S.No.	Generic Elective Course	Semester	Hours of Instruction	Credits
1.	23BCHGE1Basics of Chemistry –I	1,3,4	4+4	6
	23BCHGE1P Basics of Chemistry –I Practical			
2.	23BCHGE2 Basics of Chemistry – II	1,3,4		
	23BCHGE2P Basics of Chemistry – II Practical			
3.	23BCHGE3 Basics of Chemistry -III	1,3,4		
	23BCHGE3P Basics of Chemistry –III Practical			
4.	23BCHGE4 Bioorganic Chemistry and Metabolites	1,3,4		
	23BCHGE4P Bioorganic Chemistry and Metabolites Practical			

A Core Course offered in a Discipline / Subject may be offered as a Generic Elective for other departments.

Total credits to earn the degree

1. Part I components – 8 Credits (Languages)
2. Part II components – 32 Credits (Ability Enhancement Compulsory Courses – 8 Credits and Generic Elective Courses – 24 Credits)
3. Part III components - 96 Credits (Discipline Specific Core Courses – 72 Credits and Discipline Specific Elective Courses - 24 Credits)
4. Part IV components - 36/18 Credits (Skill Enhancement Courses –Skill Based Courses 8 Credits, Value Based Courses Elective I (NCC/NSS/Sports) –24 / 6 / 6, Value Based Elective Courses II & III – 4 Credits)
5. Minimum One Course should be from SWAYAM MOOCs/ NPTEL.

One to 4 Courses may be from SWAYAM MOOCs/NPTEL for Credit Transfer in DSE, Generic Elective.

Inorganic Chemistry – I

Semester I **Hours of Instruction/Week: 4**
23BCHC01 **No. of Credits: 4**

Objectives

1. Learning scientific theory of atoms, concept of wave function
2. To understand the periodic properties of elements
3. To comprehend the theoretical aspects of chemical bonding and molecular structure

Unit I Atomic Structure

Bohr's theory, its limitations and atomic spectrum of hydrogen atom, Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance, Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves, Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. (Electronic configuration of various elements in periodic table- **Self Study**) 15h

Unit II Periodicity of Elements

Atomic and ionic radii-determination of covalent radii and ionic radii- factors influencing the magnitude of ionic radii, periodic variation of atomic radii, ionic radii and ionization potential -applications of ionization potential concept, Ionic crystals coordination number, radius ratio. Electron affinity- influencing the magnitude of electron affinity- periodic variation of electron affinity factors - impact of electron affinity on chemical behavior, electro negativity- scales of electro negativity - Pauling's bond energy scale-Mulliken scale, Allred and Rochow's electrostatic approach, relation between oxidation state of the element and its electro negativity, correlation of ionization potential and electron affinity with electro negativity- applications of electro negativity concept 15h

Unit III Chemical Bonding I

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations, packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy,Madelung constant, Born-Haber cycle and its application, Solvation energy 10h

Covalent bond: Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiplebonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy. (Shapes of molecules-examples- Self Revision)

Unit IV Chemical Bonding II

Molecular orbital theory: Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability, Fajan rules, polarization. Ionic 10h

character in covalent compounds: Bond moment and dipole moment, Ionic character from dipole moment and electro negativity

Unit V Metallic Bonding and Weak Chemical Forces

Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators. Weak Chemical Forces: van'der Waals, ion-dipole, dipole-dipole, induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution. (Significance of weak forces and application to material fabrication- **Self Study**) 10h

Textbooks **Total hours: 60**

1. Madan, R.D. Sathyaprakash's Modern Inorganic Chemistry, S. Chand and Co Ltd. (2020)
2. Puri, B.R., Sharma, L.R. and Madhan, S. Pathania Principles of Physical Chemistry, Vishal Publishing Co. (2020)
3. Puri B.R., Sharma L.R. and Kalia K.C. Principles of Inorganic Chemistry, Vallabh Publications (2020)

Reference Books

1. Soni, P.L. and Mohan Katyal, Text Book of Inorganic Chemistry, S. Chand and Co Ltd. (2006)
2. Soni, P.L. and Dharmha, O.P. Text Book of Physical Chemistry, Sulthan Chand & Sons (2023)
3. Emeléus, H. J. and Sharpe, A. G. Advances in Inorganic Chemistry and Radiochemistry, Academic Press Inc., New York (1964)
4. Lee, J. D. Concise Inorganic Chemistry, Wiley, (2008)
5. Douglas, B.E., McDaniel, D.H. and Alexander, J.J. Concepts & Models of Inorganic Chemistry, 3rd Ed., John Wiley & Sons (2006)
6. Atkins, P. W. and DePaula, J. Physical Chemistry, 11th Ed., Oxford University Press (2018)
7. Rodger, G. E. Inorganic and Solid State Chemistry, Cengage Learning (2008)

Course Outcomes

After the completion of the course, the student will be able to gain

1. Knowledge on atomic structure and periodic properties of elements
2. Realization of the trends in physical and chemical properties of elements
3. Theoretical knowledge of shapes of molecules and hybridization
4. Predict the atomic structure, chemical bonding, and molecular geometry based onaccepted models
5. Appreciate the significance of metallic bonding and weak forces

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	M	M			M			H	M	M
CO 2	H	M	M	M			M				H	M	
CO 3	H	H	M	M	M			M			H	M	
CO 4	H	M	M	M	M			M			H	M	
CO 5	H	M	M	M			M				H	M	M

Inorganic Chemistry Practical – I

Semester I **Hours of Instruction/Week: 4**

23BCHC01P **No. of Credits: 2**

Objectives

1. To familiarize with the principles and procedure of safe lab practices
2. To gain hands on experience on the use of lab ware and chemical balance
3. To gain skills in volumetric analysis

Unit I Apparatus in Chemistry Laboratory and Hygiene and Safety

General items, glassware and equipments in the Chemistry laboratory, Storage and handling of chemicals- carcinogenic chemicals-handling of chemicals-toxic and poisonous chemicals-waste disposal-precautions for avoiding accidents-rules to avoid poisoning- laboratory safety measures — 3h

Unit II Weighing and Analytical Balance

Double pan balance- care and use, weighing process-calibration of weights-errors in weighing-requirements of a good balance- single pan balance- weighing in a single pan balance- rules for use-electronic balance-weighing bottle — 5h

Unit III Titrimetric Analysis

- Calibration and use of apparatus
- Preparation of solutions of different Molarity/Normality of titrants — 12h
- Use of primary and secondary standard solutions

Unit IV Acid-Base Titrations

- Estimation of carbonate and hydroxide present together in mixture — 20h
- Estimation of carbonate and bicarbonate present together in a mixture
- Estimation of free alkali present in different soaps/detergents

Unit V Oxidation-Reduction Titrimetry

- Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution. — 20h
- Estimation of oxalic acid and sodium oxalate in a given mixture.
  Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator

Total hours: 60

Reference Books

1. Mendham, J. and Sivasankar, B. Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson (2009)
2. Svehala, G. and Sivasankar, B. Vogel's Qualitative Inorganic Analysis, Pearson, India (2012)

Course Outcomes

After the completion of the course, the student will be able to gain

1. Knowledge on laboratory safety measures
2. Experience in handling Analytical Weighing balance
3. Calibrate the volumetric apparatus for quantitative analysis
4. Calculate the unknown concentration of acid or alkali
5. Estimate Fe(II) and oxalic acid in the given solution

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	M	H	H	M	M			H	M	M
CO 2	H	M	M	M	H	H	M				H	M	
CO 3	H	H	M	M	H	H	M	M			H	M	
CO 4	H	M	M	M	H	H	M	M			H	M	
CO 5	H	M	M	M	H	H	M				H	M	M

Organic Chemistry – I

Semester I **Hours of Instruction/Week: 4**

23BCHC02 **No. of Credits: 4**

Objectives

1. To gain knowledge in Organic Chemistry
2. To understand stereochemistry of compounds
3. To learn chemistry of select class of organic compounds

Unit I Basics of Organic Chemistry

Organic Compounds: Classification, Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic displacements - Inductive, electromeric, resonance and mesomeric effects, hyper conjugation and their applications; Dipole moment; Organic acids and bases; their relative strength; Homolytic and Heterolytic fission with suitable examples; Curly arrow concept, formal charges; Electrophiles and Nucleophiles - nucleophlicity and basicity; Types, shape and relative stabilities of reaction intermediates - Carbocations, Carbanions, Free radicals and Carbenes - Organic reactions and their general mechanism: Addition, Elimination and Substitution reactions, (Classification of Organic compounds and IUPAC nomenclature – Self Study) 12h

Unit II Stereochemistry

Concept of asymmetry, Fischer Projection, Newman and Sawhorse projection formulae and their inter conversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with Cahn-Ingold-Prelog rule, Optical Isomerism: Optical Activity, Specific Rotation, chirality/symmetry, enantiomers, molecules with two or more chiral - centres, distereoisomers, meso structures,racemic mixtures, relative and absolute configuration: D/L and R/S designations 14h

Unit III Chemistry of Aliphatic Hydrocarbons

Carbon-Carbon sigma bonds: Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity, Carbon-Carbon pi-bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1CB reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration- demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels- Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene,ethyl benzene, Reactions of alkynes: Acidity of alkynes, electrophilic and nucleophilic additions 12h

Unit IV Cycloalkanes and Conformational Analysis

Cycloalkanes and stability, Baeyer's strain theory, conformation analysis, energy diagrams of cyclohexane - Chair, Boat and Twist boat forms 12h

Unit V Aromatic Hydrocarbons

Aromaticity - Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism, directing effects of substituent groups 10h

Total hours: 60

Textbooks

1. Bahl, B.S. and Arun Bahl A Text Book of Organic Chemistry, S.Chand and Co. Ltd. (2019)
2. Clayden, J., Greeves, N. and Warren, S. Organic Chemistry, 2nd Ed., Oxford University Press (2014)
3. Soni, P.L. and Chawla, H.M. Text Book of Organic Chemistry, Sultan and Sons (2010)

Reference Books

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Ed., Dorling Kindersley (India)Pvt. Ltd., Pearson Education (2018)
2. Pine, S. H. Organic Chemistry, 5th Ed., McGraw Hill (2006)
3. Carey, F. A. Organic Chemistry, Eighth Edition, Tata McGraw Hill (2017)
4. Carey, F. A. and Sundberg, R. J. Advanced Organic Chemistry, Part A: Structure and Mechanism, Kluwer Academic Publisher (2000)

Course Outcomes

Knowledge gain on

1. Basics of organic molecules, structure, bonding, reactivity and reaction mechanisms
2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature
3. Mechanism of organic reactions
4. Conformational Analysis of cycloalkanes
5. Aromatic compounds and aromaticity, mechanism of aromatic reactions

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M	M	M			M			H	M	M
CO 2	H	M	M	M			M				H	M	
CO 3	H	M	M	M							H	M	
CO 4	H	M	M	M	M			M			H	M	
CO 5	H	M	M	M			M				H	M	

Organic Chemistry Practical –I

Semester I
23BCHC02P

Hours of Instruction/Week: 4
No. of Credits: 2

Objectives

1. To identify functional groups of organic compounds by qualitative analysis
2. To learn to prepare simple organic compounds
3. To get acquainted with chromatographic techniques

Unit I Laboratory Glassware

Cleansing agents- test for cleanliness-cleaning and maintenance of burette-calibration of pipette-calibration of burette-calibration of volumetric flask, standardization-experimental requirements for volumetric analysis – concentration units- types of titration-indicators for acid-base titration- self indicators- external indicators, Calibration of the thermometer — 12h

Unit II

Purification of organic compounds by crystallization using the following solvents — 12h
a. Water b. Alcohol c. Alcohol-Water

Unit III

Determination of the melting point of organic compounds and unknown organic compounds(using Kjeldahl method and electrical melting point apparatus) — 12h

Unit IV

Effect of impurities on the melting point, mixed melting point of two unknown organic compounds — 12h

Unit V

Determination of boiling point of liquid compounds by distillation and capillary Method, **distillation process in the context of traditional knowledge- Yasodhara Bhatta –process of distillation** — 12h

Total hours: 60

Reference Books (Practical)

1. Mann, F.G. and Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. and Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

Course Outcomes

Knowledge gain on

1. Laboratory glassware and cleaning of glassware
2. Purification of organic compounds
3. Determination of melting points of unknown compounds
4. Effect of impurities on melting point
5. Determination of boiling points of unknown compounds

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M	M	H	H		M			H	M	M
CO 2	H	M	M	M	H	H					H	M	
CO 3	H	M	M	M	H	H					H	M	
CO 4	H	M	M	M	H	H		M			H	M	
CO 5	H	M	M	M	H	H					H	M	

Physical Chemistry– I

Semester II **Hours of Instruction/Week: 4**
23BCHC03 **No. of Credits: 4**

Objectives

1. To familiarize with states of matter and the laws related to describe the states.
2. To understand the Chemistry of Ionic equilibria
3. To enable students to gain knowledge on principles and processes of metallurgy and theory of metallic bonds and crystal structure

THEORY

Unit I Gaseous State

Real gas behavior: Gas Constant - Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases, deviation from ideal behavior –causes, van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature, Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states 12h

Unit II Kinetic Molecular Model of Gases

Postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities 12h

Unit III Liquid State

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents, structure of water 10h

Unit IV Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases,pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids

Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts, Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product 14h

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids,Hard and Soft Acids and Bases (HSAB) Application of HSAB principle

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations, Multistage equilibria in polyelectrolytes

Unit V Solid State

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals, Glasses and liquid crystals 12h

Total hours: 60

Textbooks

1. Puri, B.R., Sharma, L.R. and Madhan S. Pathania Principles of Physical Chemistry, Vishal Publishing Co. (2020)
2. Atkins, P. W. and Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press (2018)
3. Soni, P.L. and Mohan Katyal, Text Book of Inorganic Chemistry, S. Chand and Co Ltd. (2006)
4. Bahl, B.S., Tuli, G.D. and Arun Bahl, Essentials of Physical Chemistry, Sulthan Chand and Sons (2020)

Reference Books

1. Ball, D. W. Physical Chemistry, Thomson Press, India (2007)
2. Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004)
3. Mortimer, R. G. Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009)
4. Barrow, G. M. Physical Chemistry, 5th Ed., Tata McGraw Hill (2007)

Course Outcomes

On completion of this course, the students will be able to understand

1. Behavior of real gases and its deviation from ideal behavior
2. Kinetic model of gas and its properties
3. Properties of liquid as solvent for various household and commercial use
4. Electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria
5. Metallic bonding and crystal structure

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M	M	M		M	M			H	M	M
CO 2	H	M	M	M							H	M	
CO 3	H	M	M	M					M		H	M	
CO 4	H	M	M					M			H	M	
CO 5	H	M	M	H	M		M	M			H	M	

Physical Chemistry Practical – I

Semester II **Hours of Instruction/Week: 4**

23BCHC03P **No. of Credits: 2**

Objectives

1. To gain practical skill in carrying out experiments related to surface tension measurements
2. To gain practical skill in carrying out experiments related to viscosity measurements
3. To gain hands on experiments in the use of pH meter

Unit I Surface Tension Measurements

1. Determine the surface tension by (i) drop number (ii) drop weight method
2. Study the variation of surface tension of detergent solutions with concentration — 12h

Unit II Viscosity Measurements using Ostwald's Viscometer

1. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature — 16h
2. Viscosity of sucrose solution with the concentration of solute

Unit III pH Metry

1. Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their Mixtures — 12h
2. Preparation of buffer solutions of different pH i) Sodium acetate-acetic acid ii) Ammonium chloride-ammonium hydroxide

Unit IV pH Metry Titration I

1. pH metric titration of (i) strong acid vs strong base (ii) weak acid vs. strong base — 12h

Unit V pH Metry Titration II

1. Determination of dissociation constant of a weak acid — 8h

Total hours: 60

Reference Books

1. Khosla, B. D., Garg, V. C. and Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011)
2. Garland, C. W., Nibler, J. W. and Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed., McGraw-Hill, New York (2003)
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry, 3rd Ed., W.H. Freeman & Co., New York (2003)
4. Athawale V. D. and Mathur P. Experimental Physical Chemistry, New Age Intenational (2001)

Course Outcomes

On completion of this course, the students will be able to gain skill in

1. Measuring surface tension
2. Determination of viscosity of polymers and solutions.
3. Prepare buffer solutions
4. Carryout acid base titration by pH metry
5. Determination of dissociation constant

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M	M	H	H		M			H	M	M
CO 2	H	M	M	M	H	H					H	M	
CO 3	H	M	M	M	H	H			M		H	M	
CO 4	H	M	M		H	H		M			H	M	
CO 5	H	M	M	H	H	H		M			H	M	

Organic Chemistry – II

Semester II **Hours of Instruction/Week: 4**
23BCHC04 **No. of Credits: 4**

Objectives

1. To familiarize with different classes of organic compounds and their methods of preparation
2. To learn about organometallic compounds and their uses
3. To understand the chemistry of oxygenated functional derivatives of organic compounds

Unit I Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation - Nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereo chemical aspects, factors affecting nucleophilic substitution versus elimination; aryl halides: preparation, including preparation from diazonium salts, nucleophilic aromatic substitution; S_NAr, Benzyne mechanism 12h

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions; Organometallic compounds of Mg and Li and their use in synthesis.

Unit II Alcohols, Phenols, Ethers and Epoxides

Alcohols: Preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols- oxidation by periodic acid and lead tetra acetate, Pinacol- Pinacolone rearrangement

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism 12h

Ethers and Epoxides: Preparation and reactions with acids, Reactions of epoxides with alcohols, ammonia derivatives and lithium aluminium hydride $LiAlH_4$

Unit III Carbonyl Compounds I

Structure, reactivity and preparation; Nucleophilic additions reaction –mechanism, Nucleophilic addition-elimination reactions with ammonia derivatives - mechanism; Mechanism of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements 12h

Unit IV Carbonyl Compounds II

Mechanism of haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reduction reactions (Oppenauer oxidation, Meervin Pondorff Verley reduction, Clemmensen reduction, Wolff- Kishner reduction, hydride reductions- $LiAlH_4$, $NaBH_4$ reductions, PDC and PGC) - Addition reactions of unsaturated carbonyl compounds: Michael addition 12h

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate (use of active methylene groups in organic mechanism and preparation of new organic compound- **Self Study)**

Unit V Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids -Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement 12h

Total hours: 60

Textbooks

1. Bahl, B.S. and Arun Bahl, A Text Book of Organic Chemistry, S. Chand and Co. Ltd. (2019)
2. Clayden, J., Greeves, N. and Warren, S. Organic Chemistry, 2nd Ed., Oxford University Press (2014)
3. Soni, P.L. and Chawla, H.M. Text Book of Organic Chemistry, Sultan and Sons (2010)

Reference Books

1. Solomons, T.W. G., Fryhle, B. Craig, Organic Chemistry, John Wiley & Sons, Inc (2009)
2. McMurry, J.E. Fundamentals of Organic Chemistry, Seventh edition, Cengage Learning, (2013)
3. Sykes, P. A Guide Book to Mechanism in Organic Chemistry, 6th Ed., Orient Longman, New Delhi (2003)
4. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Sixth Edition Prentice Hall India (2018)

Course Outcomes

After completion of the course, the learner shall be able to understand:

1. Chemistry of halogenated hydrocarbon
2. Chemical structure and reactivity of alcohols and ethers
3. Reactivity of organic carbonyl compounds
4. Synthetic uses of active methylene compounds
5. Structure and reactivity of carboxylic acids

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M				L				H	M	
CO 2	H	M	M		M						H	M	
CO 3	H	M	M	M	M	L					H	M	M
CO 4	H	M	M	M							H	M	M
CO 5	H	M	M			L					H	M	

Semester II **Organic Chemistry Practical – II**

23BCHC04P **Hours of Instruction/Week: 4**

No. of Credits: 2

Objectives

1. To know preparation methods for simple organic compounds
2. To prepare simple organic compounds using reduction
3. To prepare condensation products

Unit I

Acetylation of aniline and salicylic acid - conventional method and microwave assisted method 12h

Unit II

Benzoylation of aniline and *p*-cresol by Schotten-Baumann reaction

Unit III 12h

Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline

Nitration of methyl salicylate

Unit IV 12h

Oxidation of benzaldehyde

Preparation of cinnamic acid from cinnamaldehyde

Preparation of benzoic acid from toluene 12h

Unit V

Aldol condensation – conventional method and green method (microwave assisted synthesis)

Preparation of semicarbazone of acetone, ethyl methyl ketone and benzaldehye 12h

Reference Books **Total hours: 60**

1. Mann, F.G. and Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. and Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
3. Ahluwalia, V.K. and Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2004)
4. Ahluwalia, V.K. and Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000)

Course Outcomes

After completion of the course, the learner shall be able to prepare

1. Compounds using acetylation reactions
2. Compounds using benzoylation reaction
3. Compounds using reduction reaction
4. *S*-benzyl iso thiouronium derivatives of acids
5. Compounds using aldol condensation

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M		H	H					H	M	
CO 2	H	M	M		H	H					H	M	
CO 3	H	M	M	M	H	H					H	M	M
CO 4	H	M	M	M	H	H					H	M	M
CO 5	H	M	M		H	H					H	M	

Physical Chemistry – II

Semester III **Hours of Instruction/Week: 4**
23BCHC05 **No. of Credits: 4**

Objectives

1. To enable students to understand concepts in thermodynamics and laws of thermodynamics
2. To apply the second law of thermodynamics to cyclic processes-Carnot cycle
3. To learn about colligative properties

Unit I Introduction to thermodynamics

Definition of thermodynamic terms- types of systems, surroundings, macroscopic properties, state variables and thermodynamic equilibrium, intensive and extensive properties- isothermal, adiabatic, isobaric, isochoric, reversible and irreversible processes, state function and path function, exact and inexact differentials, concept of heat and work, work of expansion at constant pressure and free expansion . First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. 12h

Unit II Thermochemistry

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions, Use of thermochemical equations for calculation of energy and related terms 12h

Unit III Laws of Thermodynamics

Second Law: Limitation of first law, need for second law, spontaneous processes, cyclic processes, Carnot cycle, second law of thermodynamics, efficiency of a heat engine, Carnot's Theorem, change in reversible and irreversible processes, Clausius inequality, ideal gas and effect of change in pressure, volume and temperature, concept of entropy - entropy change accompanying change of phase, entropy of mixing, entropy change in a chemical reaction, standard entropies, physical significance of entropy 12h

Third law: Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules. Use of thermodynamics in explaining chemical behavior of solute/solvent and reactions

Unit IV Free Energy, Work Function

Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state. 12h

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Unit V Chemical Kinetics-I

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions, temperature dependence of reaction rates; Arrhenius 12h

equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Total hours: 60

Textbooks

1. Puri, B.R., Sharma L.R. and Madhan S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co. (2020)
2. Bahl, B.S., Tuli, G.D. and Arun Bahl, Essential of Physical Chemistry, Sulthan Chand & Sons (2020)

Reference Books

1. Gurdeep Raj, Advanced Physical Chemistry, Goel Publishing House (2016)
2. Keith J. Laidler, Physical Chemistry, John H. Miser, CBS Publishers (2002)
3. Atkins P. and De Paula, J. Physical Chemistry, 11th Ed., OUP (2018)
4. Castellan, G. W. Physical Chemistry 4th Ed., Narosa, (2004)
5. Engel, T. and Reid, P. Physical Chemistry, 3rd Ed., Prentice Hall, (2012)
6. McQuarrie, D. A. and Simon, J. D. Molecular Thermodynamics, Viva Books (2004)
7. Levine, I .N. Physical Chemistry, 6th Ed., Tata Mc Graw Hill (2010)

Course Outcomes

After the completion of the course, the student will be able to

1. Analyse various thermodynamic processes
2. Understand the concept and appreciations of heat of reactions
3. Calculate and compare the efficiency of heat engine
4. Skills in problem solving, critical thinking
5. Predict the molar masses of different solutes in solution

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	M	M			M			H	M	M
CO 2	H	M	M	M			M				H	M	
CO 3	H	H	M	M	M			M			H	M	
CO 4	H	M	M	M	M			M			H	M	
CO 5	H	M	M	M			M				H	M	M

Physical Chemistry Practical – II

Semester III **Hours of Instruction/Week: 4**
23BCHC05P **No. of Credits: 2**

Objectives

1. To gain practical skill in carrying out experiments related to transition state and molecular weight and thermo chemistry
2. To gain practical skill in carrying out experiments related to kinetics and adsorption
3. To gain hands on experiments in the use of Colorimetry

Unit I Determination of Physical Constants

Determination of transition temperature of hydrated salts-sodium thiosulphate, sodium acetate, strontium chloride and manganous chloride — 24h

Determination of eutectic temperature of naphthalene – biphenyl system

Molecular weight determination – Rast's method

Unit II Thermochemistry

Determination of heat of neutralization-strong acid Vs strong base **(Class work only)** — 4h

Unit III Study the kinetics of the following reactions

Acid hydrolysis of methyl acetate with hydrochloric acid — 8h

Saponification of ethyl acetate

Unit IV Adsorption — 12h

Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal (Use of calorimeter for calculation of heat of reactions may be demonstrated)

Unit V Colorimetry — 12h

Estimation of copper sulphate, potassium permanganate and potassium dichromate

Total hours: 60

Reference Books

1. Khosla, B. D., Garg, V. C. and Gulati, A. Senior Practical Physical Chemistry, R. Chand, NewDelhi (2011)
2. Garland, C. W., Nibler, J. W. and Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed., McGraw-Hill (2003)
3. Halpern, A. M. and McBane, G. C. Experimental Physical Chemistry, 3rd Ed., W, H.Freeman (2003)

Course Outcomes

After the completion of the course, the student will be able to gain skill on

1. Determination of transition temperature & molecular weight
2. Experiments related to electrochemistry
3. Kinetics of Chemical reactions
4. Interpretation of experimental data using adsorption isotherm models.
5. Working of Colorimeter

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	M	M			M			H	M	M
CO 2	H	M	M	M			M				H	M	
CO 3	H	H	M	M	M			M			H	M	
CO 4	H	M	M	M	M			M			H	M	
CO 5	H	M	M	M			M				H	M	M

Organic Chemistry – III

Semester III
23BCHC06

Hours of Instruction /Week: 4
No. of Credits: 4

Objectives

1. To study the reactions of nitrogen containing functional groups
2. To familiarize with the reactions of polynuclear hydrocarbons
3. To understand the structure and reactions of heterocyclic compounds
4. To know about alkaloids and terpenes

Unit I Nitrogen Containing Functional Groups

Amines: Effect of substituent and solvent on basicity; Preparation- Gabriel phthalimide synthesis, Properties-Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium salts - Preparation and synthetic applications, preparation and important reactions of nitro compounds, nitriles and isonitriles — 12h

Unit II Polynuclear Hydrocarbons

Preparation, reactions and structure elucidation of naphthalene, phenanthrene and anthracene, important derivatives of naphthalene and anthracene — 10h

Unit III Heterocyclic Compounds

Classification and nomenclature, structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; synthesis, reactions and mechanism of substitution reactions of furan, pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine(Hantzsch synthesis), pyrimidine, structure elucidation of indole, Fischer indole synthesis and Madelung synthesis, structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction, derivatives of furan: furfural and furoic acid — 18h

Unit IV Alkaloids

Natural occurrence, general structural features, isolation and their physiological action-Hoffmann's exhaustive methylation, Emde's modification, structure elucidation and synthesis of hygrine and nicotine, medicinal importance of nicotine, hygrine, quinine, morphine, cocaine and reserpine — 10h

Unit V Terpenes

Occurrence, classification, isoprene rule, elucidation of structure and synthesis of citral, neral and α-terpineol — 10h

Total hours: 60

Textbooks

1. Morrison, R.T., Boyd, R. N. and Bhatterjee, S.K. Organic Chemistry, 7th Ed., Pearson
2. Acheson, R.M. Introduction to the Chemistry of Heterocyclic Compounds, John Welly & amp Sons (1976)
3. Solomons, T.W. and Fryhle Craig, Organic Chemistry, John Wiley & amp Sons (2009)
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed., Cengage Learning India Edition (2013)
5. Kalsi, P. S. Organic Reactions and their Mechanisms, New Age Science (2010)

Reference Books

1. Clayden, J., Greeves, N., Warren, S. and Wothers, P. Organic Chemistry, Oxford University Press Inc., New York (2001)
2. Singh, J., Ali, S.M. and Singh, J. Natural Product Chemistry, Prajati Parakashan (2010)
3. Bansal R. K. Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms, New Age, 3rd Ed. (1999)

Course Outcomes

After the completion of the course, the student will be able to

1. Distinguish between 1^0, 2^0 and 3^0 amines and understand their reactivity
2. Acquire knowledge on polynuclear hydrocarbon derivatives and their structure
3. Gain idea of reactivity and synthesis of heterocyclic compounds
4. Appreciate the significance of alkaloids and their medicinal importance
5. Gain insight on terpenes and their structure

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO2	PSO 3
CO 1	H	M		M		M	M	L			H	H	M
CO 2	H	L		M		L	M	L			H	H	M
CO 3	H	L		M		H	M	L		M	H	H	M
CO 4	H	L		H		M	M	L		H	H	H	M
CO 5	H	L		H		M	M	L		H	H	H	M

Semester III **Organic Chemistry Practical – III**

23BCHC06P **Hours of Instruction /Week: 4**

Objectives **No. of Credits: 2**

1. To obtain skills in identification of unknown organic compounds
2. To identify functional groups in organic compounds by IR
3. To interpret NMR spectrum of simple organic compounds

Unit I Qualitative Analysis

Qualitative analysis of unknown organic compounds containing mono functional groups (aromatic acids, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups for e.g. salicylic acid, cinnamic acid, nitrophenols 28h

Unit II Identification of Functional Groups

Identification of functional groups of simple organic compounds - ethanol, aniline, phenol, acetic acid, aldehydes, ketones and carboxylic acid by IR spectroscopy and NMR spectroscopy (IR and NMR of simple organic compounds may be recorded wherever facilities are available, otherwise sample spectra of simple organic compounds may be provided for identification of functional groups, References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill) 16h

Unit III

Preparation of methyl orange 4h

Unit IV

Extraction of caffeine from tea leaves 4h

Unit V

Analysis of carbohydrates- aldoses and ketoses, reducing and non-reducing sugars using simple lab procedures 8h

Reference Books **Total hours : 60**

1. Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012)
2. Mann, F.G. and Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. and Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
4. Ahluwalia, V.K. and Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000)
5. Ahluwalia, V.K. and Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000)

Course Outcomes

After the completion of the course, the student will acquire skills to

1. Identify the unknown organic compounds by simple lab procedures
2. Predict the functional groups by IR spectroscopy and interpret NMR spectrum of simple organic molecules
3. Synthesize dye molecules
4. Extract caffeine from coffee and tea leaves
5. Distinguish between reducing and non reducing sugars

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO2	PSO3
CO 1	H	M	M	M		M	M		M	M	M	M	M
CO 2	H	M	M	M		M	M		M	M	M	M	M
CO 3	H	M	M	M		M	M		M	M	M	M	M
CO 4	H	M	M	M		M	M		M	M	M	M	M
CO 5	H	M	M	M		M	M		M	M	M	M	M

Inorganic Chemistry – II

Semester IV **Hours of Instruction/ Week: 4**
23BCHC07 **No. of Credits: 4**

Objectives

1. To gain knowledge on metallurgy and sensitize students on metallurgy based on Indian knowledge system
2. To learn Chemistry of s and p-block elements
3. To learn Chemistry of noble gases
4. To understand chemistry and application of Inorganic polymers

Unit I Oxidation-Reduction and General Principle of Metallurgy

Redox equations, standard electrode potential - application to inorganic reactions, occurrence of metals based on standard electrode potential, Ellingham diagrams for reduction ofmetal oxides using carbon or carbon monoxide as reducing agent, electrolytic reduction, hydrometallurgy, methods of purification of metals: electrolytic Kroll process, parting process, Van Arkel - de boer process and mond's process, zone refining, **metal extraction based on Indian Knowledge Systems (IKS) – Gold extraction process, zinc production, copper mining, extraction of iron from Biotite by Ayurvedic method (incorporation of IKS)** 15h

Unit II Chemistry of s and p Block Elements I

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group, allotropy and catenation, complex formation tendency of *s* and *p* block elements, hydrides and their classification- ionic, covalent and interstitial, basic beryllium acetate and nitrate 10h

Unit III Chemistry of s and p Block Elements II

Structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, oxides and oxoacids of nitrogen, phosphorus and chlorine, per-oxo acids of sulphur inter-halogen compounds, poly-halide ions, pseudo-halogens, properties of halogens 10h

Unit IV Noble Gases

Occurrence, rationalization of inertness of Noble gases, clathrates- preparation and properties of XeF_2, XeF_4 and XeF_6. Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory), Uses of noble gas compounds 15 h

Unit V Inorganic Polymers

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects - Applications of silicones and siloxanes, borazines, silicates, phosphazenes and polysulphates 10 h

Total hours: 60

Textbooks

1. B.R.Puri, L.R.Sharma and K.C.Kalia,(2003) Principles of Inorganic Chemistry,Vallabh publications
2. B.R.Puri, L.R.Sharma and Madhan S. Pathania, (2003), Principles of Physical Chemistry, Vishal publishing Co.
3. B.S.Bahl and Arun Bahl, (2014) A Text book of Organic Chemistry, S. Chand and Co Ltd
4. R.D.Madan, Sathyaprakash's,(2003) Modern Inorganic Chemistry, S.Chand and Co Ltd.
5. P.L.Soni and Mohan Katyal (2007) Text book of Inorganic Chemistry, S.Chand and Co Ltd.

Reference Books

1. Lee, J.D. Concise Inorganic Chemistry, ELBS (1991)
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic

Chemistry, 3rd Ed., John Wiley Sons, N.Y. (1994)
3. Greenwood, N.N. and Earnshaw, Chemistry of the Elements, Butterworth- Heinemann (1997)
4. Cotton, F.A. and Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH (1999)
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition (2002)
6. Miessler, G. L. and Donald, A. Tarr, Inorganic Chemistry, 4th Ed., Pearson (2010)
7. Atkins, P. W. and Shriver D. N. Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010)

Course Outcomes

Knowledge gain on

1. Oxidation-Reduction reactions and their use in metallurgy
2. s and p block elements
3. Formation of various compounds of s and p block elements
4. Preparation and properties of compounds of Noble gases
5. Correlation between Inorganic and Organic polymers

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO 1	H	H										H	M	
CO 2	H	M										H	L	
CO 3	H	H	L			L			L	L		H	L	
CO 4	H	L							L			H	L	
CO 5	H	H	L	M		L						H	L	

Inorganic Chemistry Practical – II

Semester IV **Hours of Instruction/Week: 4**
23BCHC07P **No. of Credits: 2**

Objectives

1. To familiarize with the principles and procedure of Quantitative estimation
2. To learn about the types of volumetric estimation
3. To familiarize with the Inorganic preparations
4. To gain skills on synthetic methods

Unit I Iodimetric Titrations

Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution 8h

Unit II Gravimetric Estimation I

Estimation of barium as barium sulphate
Estimation of sulphate as barium sulphate 20h

Unit III Gravimetric Estimation II 16h

Estimation of copper as copper sulphate
Estimation of nickel as nickel dimethyl glyoxime complex

Unit IV Inorganic Preparations I

Preparation of Cuprous Chloride, Cu_2Cl_2 8h
Ferrous ammonium sulphate
Potassium trioxalatochromate (III)
Tetra ammine copper(II) sulphate

Unit V Inorganic Preparations II

Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum 8h

Total hours: 60

Course Outcomes

After the completion of the course, the students will be able to gain:

1. Knowledge on quantitative estimation
2. Knowledge on types of volumetric analysis
3. Experience on Volumetric estimation
4. Hands on training in preparations
5. Skills in Inorganic preparations

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	H					H						H	H	
CO2	H					M			L			M	H	
CO3	H	L				H						H	M	
CO4	H			M		M						H	M	
CO5	H			M		M						H	M	

Reference Books

1. Mendham, J. and Sivasankar, B. Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson (2009)
2. Svehala, G. and Sivasankar, B. Vogel's Qualitative Inorganic Analysis, Pearson, India (2012)

Physical Chemistry – III

Semester IV
23BCHC08

Hours of Instruction/Week: 4
No. of Credits: 4

Objectives

1. To gain knowledge on theories of chemical kinetics
2. To understand one component and two component systems
3. To gain knowledge on Surface Chemistry

Unit I Phase Rule-I

Definition of terms-phase, component, degree of freedom, derivation of phase rule, one-component system-water system, sulphur system, two component system-solid-liquid equilibria, reduced phase rule, simple eutectic system (Pb-Ag system),compound formation with congruent melting point (Mg-Zn system), peritectic change-$FeCl_3$-H_2O system, KI-H_2O system 12h

Unit II Phase Rule II

Binary liquid systems- Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal) Raoult's law, vapor pressure-composition curves and boiling point, azeotropic mixtures, lever rule, distillation of immiscible liquids, theory of steam distillation, partially miscible liquid system-phenol-water system, aniline-hexane system, triethanolamine -water system, nicotine-system, Three component systems, water-chloroform- acetic acid system, triangular plots, steam distillation. Nernst distribution law: its derivation and applications. Application of phase diagram (Self Study) 12h

Unit III Dilute Solutions

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation ofn boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. Study of calorimeter principle and its use (Self Study) 12h

Unit IV Electrochemistry

Conductors – metallic and electrolytic conductors, Faraday's law of electrolysis, Conductance – specific ,equivalent and molar conductance – relation between them, measurement of conductance and cell constant, variation of conductance with dilution, migration of ions.
Arrhenius theory of electrolytic dissociation, Ostwald's dilution law – determination of dissociation constants. Electrode potential expression for electrode potential-Nernst equation, standard electrode potential, electrochemical series, electrochemical cell – representation of a galvanic cell , EMF of a electrochemical cell and cell reaction , measurement of EMF of cell. 12h
Applications of EMF measurements, potentiometric titration.

Unit V Surface Chemistry and Catalysis

Adsorption-adsorbent, adsorbate, adsorption, absorption, sorption, occlusion, adsorption of gases by solids, heat of adsorption, factors influencing adsorption, adsorption isotherm, isobars and isosters, physisorption and chemisorption, Freundlich adsorption isotherm, Langmuir adsorption isotherm-derivation, types of adsorption isotherm, Test of Langmuirs equilibrium, desorption isotherm, Brunauer–Emmett–Teller (BET) adsorption isotherm (derivation not required), application of adsorption including adsorption indicators, catalysis-types of catalysis, characteristics of catalytic reactions theories of catalysis, enzyme catalysis- Michelis-Menton equation. Heterogeneous catalysis used in industry and its mechanism of action (Self Study) 12h

Total hours: 60

Textbooks

1. Puri, B.R., Sharma, L.R. and Madhan S. Pathania Principles of Physical Chemistry, Vishal Publishing Co. (2020)
2. Bahl, B.S., Tuli, G.D. and Arun Bahl, Essential of Physical Chemistry, Sulthan Chand & Sons (2019)

Reference Books

1. Atkins, P. W. and De Paula J., Physical Chemistry, 10th Ed., Oxford University Press (2014)
2. Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004)
3. McQuarrie, D. A. and Simon, J. D. Molecular Thermodynamics, Viva Books (2004)
4. Engel, T. and Reid, P. Physical Chemistry, 3rd Ed., Prentice-Hall (2012)
5. Mortimer, R. G. Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009)
6. Levine, I. N. Physical Chemistry, 6th Ed., Tata McGraw-Hill

Course Outcomes

After the completion of the course, the student will be able to

1. Gain knowledge on Phase diagrams and applications
2. Construct phase diagram of different systems, the application of phase diagram
3. Comprehend on Chemical kinetics: type of reactions
4. Grasp the theories of reaction rate, steadystate approximation
5. Understand about adsorption isotherms and mechanism of acid base catalysis, enzyme catalysis

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M		H	H					H	M	
CO 2	H	M	M		H	H					H	M	
CO 3	H	M	M	M	H	H					H	M	M
CO 4	H	M	M	M	H	H					H	M	M
CO 5	H	M	M		H	H					H	M	

Physical Chemistry Practical – III

Semester IV **Hours of Instruction/Week: 4**
23BCHC08P **No. of Credits: 2**

Objectives

1. To gain practical skill in carrying out experiments related to Phase rule
2. To gain practical skill in carrying out experiments related to Conductometry
3. To gain hands on experiments in the use of Potentiometer

Unit I Phase rule I

Determination of critical solution temperature and composition of the phenol-water system 6h

Unit II Phase rule II

Study of effect of impurity on CST of phenol-water system and determination of concentration of sodium chloride 6h

Unit III Conductometry I

Determination of cell constant

Conductometric titrations of: (i) strong acid vs strong base (ii) weak acid vs strong bas (iii)weak acid vs strong base (iv) strong acid vs weak base 20h

Unit IV Conductometry II

Equivalent conductance, degree of dissociation and dissociation constant of a weak acid 8h

Unit V Potentiometry

Potentiometric titrations of (i) strong acid and strong base (ii) weak acid and strong base (iii) dibasic acid and strong base (iv) potassium dichromate and Mohr's salt 20h

Total hours: 60

Reference Books

1. Khosla, B. D., Garg, V. C. and Gulati, A. Senior Practical Physical Chemistry, R. Chand New Delhi (2011)
2. Garland, C. W., Nibler, J. W. and Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed., McGraw-Hill, New York (2003)
3. Halpern, A. M. and McBane, G. C. Experimental Physical Chemistry 3rd Ed., W.H. Freeman & Co., New York (2003)

Course Outcomes

After the completion of the course, the student will be able to gain knowledge on

1. Determination of CST
2. Impact of impurity on CST
3. Understand the practical applications of EMF
4. Conductometry experiments
5. Experiments related to potentiometer

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M		H	H					H	M	
CO 2	H	M	M		H	H					H	M	
CO 3	H	M	M	M	H	H					H	M	M
CO 4	H	M	M	M	H	H					H	M	M
CO 5	H	M	M		H	H					H	M	

Introduction to Quantum Chemistry

Semester V **Hours of Instruction/Week: 4**
23BCHC09 **No. of Credits: 4**

Objectives

1. To widen the knowledge in kinetics and mechanism of chemical reactions
2. To understand the chemistry and kinetics of fast reactions
3. To get acquainted with quantum mechanical approach of atoms and molecules

Unit I Introduction to Quantum Mechanics

Introduction to black-body radiation and distribution of energy, photo-electric effect, concept of quantization, wave particle duality(de-Broglie's hypothesis), The uncertainty principle, Concept of operators- Sums and products of operators-commutator-linear and non-linear operators-Hermitian and Hamiltonian operators-deriving operators for energy and angular momentum from known operators-Eigen values and eigen functions-postulates of quantum mechanics-physical interpretation of wave function-orthogonality and normalization theorem 15h

Unit II Applications of Schrodinger Equation I

Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates, radial and angular parts of the hydrogenic orbitals, degeneracies, spherical harmonics 10h

Unit III Applications of Schrodinger Equation II

Quantitative treatment of simple harmonic oscillator model, setting up of Schrödinger equation and discussion of solution of wave functions, Rigid rotator model and discussion of application of Schrodinger equation. Idea about transformation to spherical polar coordinate, discussion on solution 10h

Unit IV Qualitative Treatment of Hydrogen Atom and Hydrogen-Like Ions

Setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression), Average and most probable distances of electron from nucleus. 10h

Unit V Valence bond and molecular orbital approaches

LCAO-MO treatment of H_2, H^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. 15h

Total hours: 60

Textbooks

1. Puri, L. B., Sharma, I. R., and Pathania, M. S., Principles of Physical Chemistry, Vishal (2017)
2. Bahl, B. S., Bahl, A., and Tuli, G. D., Essentials of Physical Chemistry, S. Chand (2014)

Reference Books

1. Laideler K.J. and Meiser J.M., Physical Chemistry, 3rd Edition (International)(2002)
2. Levine I.N., Physical Chemistry, Fourth Edition),McGraw-Hill (International) (1995)
3. McQuarrie D. A. and Simon J. D., Physical Chemistry-A Molecular Approach, University Science Books (1998)
4. Chandra,A.K., Introductory Quantum Chemistry, Tata McGraw-Hill (2001)
5. House, J. E., Fundamentals of Quantum Chemistry, 2nd Ed. Elsevier, USA (2004)

Course Outcomes

After the completion of the course, the student will be able to

1. Understand the basics of quantum mechanics
2. Identify the steps involved in studying a system quantum mechanically
3. Apply Schrödinger wave equation to Simple harmonic oscillator and Rigid rotor models
4. Apply Schrödinger wave equation to hydrogen and hydrogen like ions
5. Generalize the VB and MO treatment of H_2 species

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M				M					H	H	M
CO 2	H		M	M					M		H	M	
CO 3	H	M			M						H	M	M
CO 4	H			M	M	M					H	M	
CO 5	H	M	M					M	M	M	H	H	M

Introduction to Quantum Chemistry Practical

Semester V **Hours of Instruction/Week: 4**

23BCHC09P **No. of Credits: 2**

Unit I

Building a molecular model- leveling of atoms, editing individual atoms, changing bond order, centering, rotation of atoms 10h

Unit II

Selection of calculation method (*e.g.*, force field calculation, *ab-initio* setup), displaying calculated properties, to perform geometry optimizations (energy minimizations) to determine the lowest energy conformations of molecules 10h

Unit III

Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene 15h

Unit IV 15h

Perform a conformational analysis of butane.

Determine the enthalpy of isomerization of *cis* and *trans* 2-butene

Unit V

Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO 10h

Software to get acquainted for the above learning: Chem Sketch, Argus Lab, TINKER 6.2, Web Lab Viewer, Hyperchem, Guassian or any similar software.

Total hours: 60

Reference Books

1. Cramer, C. J., Essentials of Computational Chemistry: Theories and Models, John Wiley & Sons (2013)
2. Sindhu, P. S., Practicals in Physical Chemistry, Macmillan (2005)
3. Leach, A. R., Molecular Modelling: Principles and Applications, Pearson education (2001)
4. Haile, J. M., Molecular Dynamics Simulation: Elementary Methods, John Wiley & Sons, Inc. (1997)
5. Gupta, S.P., QSAR and Molecular Modeling, Springer-Anamaya Publishers (2008)

Course Outcomes

After the completion of the course, the student will be able to

1. Identify the steps involved in studying a system quantum mechanically
2. Perform geometry optimisation
3. Visualize molecular orbital of compounds
4. Execute molecular properties of simple compounds
5. Compute the electron density and electrostatic potential maps

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	H	M	H	H			M		H	M	
CO 2	H		H	M	H	H		M	M		H		
CO 3	H	M	H	M	H	H		M	M		H		
CO 4	H		H	M	H	H			M	M	H		
CO 5	H		M	M	H	H		M	M	M	H	M	M

Inorganic Chemistry – III

Semester V **Hours of Instruction/Week: 4**
23BCHC10 **No. of Credits: 4**

Objectives

1. To understand the nature of coordination compounds
2. To gain knowledge on various theories of metal complexes
3. To understand the chemistry of Transition Elements, Lanthanides and Actinides
4. To learn bioinorganic chemistry of metals in biological systems

Unit I Coordination Chemistry

Ligands, chelates, co-ordination number, classification of ligands, nomenclature of coordination compounds, Isomerism - Structural isomerism- Ionization isomerism, Hydrate isomerism, Linkage isomerism, Coordination isomerism, Coordinate position isomerism, Polymerization isomerism and geometric isomerism in 4 and 6 coordination compounds, optical isomerism and conditions for optical isomerism, optical isomerism in 4 and 6 coordinate compounds, piano-stool compounds. 10h

Unit II Theories of Metal Complexes

Theories of metal – ligand bonding in complexes, Werner's coordination theory, Sidgwick's electronic interpretation of coordination compounds and the concept of effective atomic number (EAN), valence bond theory (VBT), formation of inner and outer orbital octahedral complexes, square planar and tetrahedral complexes, limitations of VBT, crystal field theory (CFT) – crystal field splitting in tetrahedral, square planar and octahedral complexes, strong and weak ligands, spectrochemical series – high – spin and low – spin complexes, magnetic properties of octahedral and tetrahedral complexes, crystal field stabilization energy (CFSE) and its uses, limitations of CFT, comparison between VBT and CFT 15h

Unit III Transition Elements and Molecular Symmetry

Transition elements - position in the periodic table-general characteristics of d-block elements (electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes). Stability of various oxidation states with reference to Latimer and Bsworth diagrams. Chemistry of titanium, titanium dioxide, titanium tetrachloride, vanadium, vanadium penta oxide, ammonium metavanadate, chromium, chromous chloride, chromic oxide, potassium chromate, manganese, manganeous oxide, potassium permanganate, iron, potassium ferri cyanide, potassium ferro cyanide, cobalt, cobaltous nitrate, hexamine cobalt(III) chloride, in various oxidation states (excluding their metallurgy) Group theory: Introduction – symmetry – symmetry elements and symmetry operations of NH_3 and H_2O 15h

Unit IV Lanthanoids and Actinides

Position in the periodic table, general characteristic of lanthanoides and actinides (electronic configuration, oxidation states, color, spectra and magnetic behavior), lanthanoide contraction and its consequences, separation of lanthanoides (ion-exchange method only). Actinides- occurrence and extraction, chemistry of thorium and uranium, comparison of lanthanides and actinides 10h

Unit V Bio-Inorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action

in biological system, geochemical effect on distribution of metals sodium / potassium-pump, carbonic anhydrase and carboxypeptidase, excess and deficiency of some trace metals, toxicity of metal ions (Hg, Pb, Cd and As), chelating agents in medicine. Iron and its application in bio- systems – hemoglobin, storage and transfer of iron 10h

Total hours: 60

Textbooks

1. R.D.Madan and S.SatyaPrakash, Modern Inorganic Chemistry, Chand & Co. (2011)
2. B.R.Puri, L.R.Sharma and K.C.Katia, Principle of Inorganic Chemistry, Vallabh Publications (2003)
3. P.L. Soni and Mohan Katyal, Text Book of Inorganic Chemistry, S.Chand and Co Ltd. (2002)
4. U. Malik G.D Tuli and R.D.Madan, Selected Topics in Inorganic Chemistry, Wahid, S.Chand and Co Ltd. (2006)
5. Rajbir Singh, Co-Ordination Chemistry, Mittal Publication (2002)
6. R.K Gupta and R.K. Amit, Inorganic Chemistry, Arihant Publication (2000)

Reference Books

1. Purcell, K.F and Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co. (1977)
2. Huheey, J.E., Inorganic Chemistry, Prentice Hall (1993)
3. Lippard, S.J. and Berg, J.M., Principles of Bioinorganic Chemistry Panima Publishing Company (1994)
4. Cotton, F.A. and Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH (1999)
5. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, (1967)
6. Greenwood, N.N. and Earnshaw A., Chemistry of the Elements, Butterworth- Heinemann (1997)

Course Outcomes

1. Ability to recognize the types of isomers in coordination compounds
2. Ability to apply theories of coordination chemistry to the structure of complexes
3. Chemistry of transition elements and molecular symmetry
4. Ability to understand the importance of lanthanides and actinides
5. Understanding the significance of bioinorganic systems

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	M	M	H	L	M				H	H	
CO 2	H	M	M	M		M	M				H	M	
CO 3	H	M	M	M	M	L	M				H	M	M
CO 4	H	M	M	M		L	M				H	M	M
CO 5	H	M	M	M		M	M	M			H	M	M

Inorganic Chemistry Practical - III

Semester V
23BCHC10P

Hours of Instruction/Week: 4
No. of Credits: 2

Objectives

1. To learn principles and procedure involved in inorganic qualitative analysis
2. To develop experimental skills
3. To develop data presentation and record writing skills

Unit I Qualitative Inorganic Analysis

Analysis of mixture containing two cations and two anions including one interfering ion (Semi micro methods using the conventional scheme may be adopted)

Anions to be given for analysis – carbonate, sulphate, nitrate fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, Cations for analysis - lead, bismuth, copper, cadmium, iron, aluminium, zinc, manganese, nickel, cobalt, barium, strontium, calcium, magnesium and ammonium — 36h

Unit II Controlled synthesis of two copper oxalate hydrate complexes: understanding kinetic *versus* thermodynamic factors — 8h

Unit III Preparation of acetylacetanato complexes of Cu^{2+} and Fe^{3+}, Finding λmax of the prepared complex using UV-Visible Spectrometer — 8h

Unit IV Synthesis of ammine complexes of Ni(II) — 4h

Unit V Exchange of ligands (e.g. bidentate ligands like acetylacetone, DMG, glycine) with prepared ammine complex (substitution method) — 4h

Total hours: 60

Textbooks

1. P. K. Mani and A.O. Thomas, Textbook for Practical Chemistry for B.Sc. Main Students, Xavier Press, Cannanore (2006)
2. S. Giri, Practical Chemistry, S. Chand & Sons (2015)
3. V.Venkateswaran, R.Veeraswamy and A.R.Kulandaivelu, Basic Principles of Practical Chemistry, Sultan Chand & Sons, New Delhi (1995)
4. Revised by G. Svehla, Vogel's Qualitative Inorganic Analysis, Pearson Education (2002)
5. Marr and Rockett, Practical Inorganic Chemistry, John Wiley & Sons (1972)

Course Outcomes

1. Skills in identifying inorganic elements by qualitative analysis
2. Experimental skills in controlled synthesis
3. Ability to prepare bidendate complexes of copper and iron and identify their λmax in UV Visible spectra
4. Ability to prepare Ammine complexes of nickel
5. Understanding ligand exchange reactions

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	M	L	M		M	M	M	H	M	H	H	M
CO 2	H	M		M		H	M	M	H		H	H	M
CO 3	H	M		M		M	M	M	H	M	H	H	M
CO 4	H	M		M		H	M	M	H	M	H	H	M
CO5	M	M	L	M		H	M	M	H		H		

Molecular Spectroscopy and Photochemistry

Semester VI **Hours of Instruction/Week: 4**
23BCHC11 **No. of Credits: 4**

Objectives

1. To understand the theory of rotational and vibrational spectroscopy
2. To comprehend the theoretical aspects of Raman spectroscopy and electronic spectroscopy
3. To gain knowledge on the basics of photophysics and photochemistry

Unit I Basics of Electromagnetic Radiation and Rotation Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra, Born- Oppenheimer approximation 10h

Rotation Spectroscopy: Rigid rotor model, rotational energy levels, selection rules, rotational spectra, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution

Unit II Vibrational Spectroscopy

Classical equation of vibration, linear harmonic oscillator, energy levels and frequency of vibrations, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibrations of polyatomic molecules, concept of group frequencies, vibration-rotation spectroscopy, diatomic vibrating rotator, P, Q, R branches 20h

Unit III Raman Spectroscopy

Qualitative treatment of Raman effect; Effect of nuclear spin, vibrational Raman spectra, Raleigh and Raman scattering, Stokes and anti-Stokes lines- intensity difference, rule of mutualexclusion 10h

Unit IV Electronic Spectroscopy

Electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre dissociation-photoelectron spectroscopy-Instrumentation and photoelectron spectra 10h

Unit V Photophysical and Photochemical Processes

Laws of photochemistry, quantum yield, Jablonski diagrams: Franck-Condon principle, Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency, kinetics of photochemical reactions ($H_2 + Br_2 = HBr$, $2HI = H_2 + I_2$), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, discussion of electronic spectra 10h

Total hours: 60

Textbooks

1. Laideler K. J., and Meiser J. M., Physical Chemistry Third Edition (International) (2002)
2. Levine I. N., Physical Chemistry, Sixth Edition McGraw-Hill (International), (2009)
3. McQuarrie D. A. and Simon J. D., Physical Chemistry- A Molecular Approach, University Science Books (1998)

Reference Books

1 Rohatgi-Mukherjee K. K., Fundamentals of Photochemistry, New age (revised 2nd edition), (2017)

2 Banwell C. N. and McCash E. M., Fundamentals of Molecular Spectroscopy, 4th Ed. TataMcGraw-Hill: New Delhi (2006)

Course Outcomes

After the completion of the course, the student will be able to

1. Understand the significance of rotational spectroscopy
2. Comprehend vibrational behavior of diatomic and polyatomic molecules
3. Understand the significance of Raman lines of molecules
4. Familiarity with the basic aspects of UV-Visible spectroscopy
5. Gain knowledge on photophysics and photochemistry

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	M	M			M			H	M	M
CO 2	H	M	M	M			M				H	M	
CO 3	H	H	M	M	M			M			H	M	
CO 4	H	M	M	M	M			M			H	M	
CO 5	H	M	M	M			M				H	M	M

Molecular Spectroscopy and Photochemistry Practical

Semester VI **Hours of Instruction/Week: 4**
23BCHC11P **No. of Credits: 2**

Objectives

1. To gain problem solving skills in rotational and vibrational spectra
2. To gain hands on experience in using UV-Visible spectroscopy
3. To learn the estimation of concentration of solutions using colorimeter

Unit I 10h

Problem solving exercises based on rotational spectra of diatomic and triatomic molecules-determination of bond length

Unit II 12h

Problem solving exercises in vibrational spectroscopy-calculation of force constant, amplitude, degrees of freedom for modes of vibrational spectra of polyatomic molecules- CO_2, H_2O, NH_3, CH_4, CCl_4, CH_3X, benzene and toluene

Unit III 14h

Problem solving exercises in Raman Spectroscopy - interpretation of Raman Spectrum, identifying intensity of Stokes line and Antistokes line Field visit to lab to see Demo of Raman spectrometer

Unit IV 12h

Working out problems based on principles of electronic spectroscopy, Demo on working of UV-Visible spectrometer – recording UV Visible spectra of few carbonyl compounds

Unit V 12h

Verification of Beer-Lambert Law – Determination of concentration of metal solution and dye sample and determination of indicator constant by colorimetry ($CuSO_4$, $KMnO_4$, $K_2Cr_2O_7$)

Total hours: 60

Reference Books

1. Sindhu P.S., Practicals in Physical Chemistry – a Modern Approach, Macmillan Publishers
2. Wilson J.M., Newcomb R.J., Denaro A.R., Experiments in Physical Chemistry, 2nd Ed., Elsevier

Course Outcomes

After the completion of the course, the student will be able to

1. Determine bond length by rotational spectroscopy
2. Compute force constants, degrees of freedom and amplitude of molecules
3. Gain skills in interpretation of Raman spectra
4. Gain skills in recording UV Visible spectra
5. Understand the significance of Beer-Lambert law

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	H	M	M			M			H	M	M
CO 2	H	M	M	M			M				H	M	
CO 3	H	H	M	M	M			M			H	M	
CO 4	H	M	M	M	M			M			H	M	
CO 5	H	M	M	M			M				H	M	M

Analytical Chemistry

Semester VI **Hours of Instruction /Week: 4**
23BCHC12 **No. of Credits: 4**

Learning objective:
1. To learn fundamentals of analytical chemistry
2. To gain knowledge on thermal and electrochemical techniques
3. To learn principle of separation techniques and their applications

Unit I Qualitative and Quantitative Aspects of Spectral Analysis
Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals 12h
Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules

Unit II Spectrophotometry
Dual characteristics of light, Newton's Corpuscular theory and its derivation. Wave theory-wave characteristics-wavelength, frequency, wave number, absorbance, transmittance, relationship between absorbance and transmittance, basic principles of spectro-photometry, electromagnetic spectrum, various regions of electromagnetic spectrum. Instrumentation of spectrophotometry, principles of quantitative analysis, estimation of metal ions from aqueous solution, determination of composition of metal complexes using Job's method of continuous variation and mole ratio method 12h

Unit III Thermal and Electroanalytical Methods of Analysis
Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture, theory and applications of Differential Scanning Calorimetry (DSC)
Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations, techniques used for the determination of equivalence points-determination of pKa values 12h

Unit IV Separation Techniques I-Solvent Extraction
Classification, principle and efficiency of the technique, mechanism of extraction: extraction by solvation and chelation, technique of extraction: batch, continuous and counter current extractions, qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media – refluxing and soxhlet extraction, concentration of extracts-simple distillation, rotary evaporation, freeze drying 12h

Unit V Separation Techniques II- Chromatography
Classification, principle and efficiency of the technique, mechanism of separation: adsorption, partition and ion exchange, development of chromatograms: frontal, elution and displacement methods, qualitative and quantitative aspects of chromatographic methods of analysis - LC, GLC and HPLC 12h

Total hours: 60

Textbooks

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis, 7th Ed., Pearson, (2012)
2. Willard H.H. et al., Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing California, USA, (1988)
3. Christian G.D, Analytical Chemistry, 7th Ed., John Wiley & Sons, New York (2013)

Reference Books

1. Harris D.C., Exploring Chemical Analysis, 9th Ed., New York, W.H. Freeman (2016)
2. Skoog D.A., Holler F.J. and Nieman, T.A., Principles of Instrumental Analysis, Saunder College Publications, (1998)
3. Mikes O., Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood John Wiley (1979)
4. Ditts R.V., Analytical Chemistry: Methods of Separation, van Nostrand (1974)
5. Khopkar S. M., Basic Concepts of Analytical Chemistry, New Age (3rd edition) (2008)
6. Skoog D.A., Holler F.J. and Nieman T.A., Principles of Instrumental Analysis, 5th Edn., Brooks & Cole (1997)

Course Outcomes

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

1. Analyze experimental data and present it systematically
2. Understand the principle and applications of spectrophotometry
3. Comprehend the quantitative measurement in electro analytical, thermal techniques
4. Understand the concept of solvent extraction
5. Gain knowledge on chromatographic techniques.

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	L	M	M					H	M	
CO 2	H	M	M	L	L	L					H		
CO 3	H	M	L	L		L					H		
CO 4	H	H	L			L					H		
CO 5	H	H	M	L		H					H		

Analytical Chemistry Practical

Semester VI **Hours of Instruction /Week : 4**
23BCHC12 P **No. of Credits: 2**

Unit I Thin Layer Chromatography

(i) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values
(ii) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC — 12 h

Unit II Paper Chromatography

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}
(ii) Separation and identification of the monosaccharide present in the given mixture (glucose and fructose) by paper chromatography. Reporting R_f values — 12 h

Unit III Solvent Extractions

(i) To separate a mixture of Ni^{2+} and Fe^{2+} by complexation with DMG and extracting the Ni^{2+}- DMG complex in chloroform and determine its concentration by spectrophotometry
(ii) Determination of the pH of the given aerated drinks, fruit juices, shampoos and soaps — 12 h

Unit IV Ion Exchange

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins
(ii) Separation of metal ions from their binary mixture
(iii) Separation of amino acids from organic acids by ion exchange chromatography — 12 h

Unit V Spectrophotometric Estimations

(i) Determination of pKa values of indicators
(ii) Determination of dissolved oxygen in water
(iii) Determination of chemical oxygen demand (COD)
(iv) Determination of biological oxygen demand (BOD) — 12 h
(v) Determine the composition of the Ferric-salicylate/ Ferric-thiocyanate complex by Job's method

Total hours: 60

Reference Books

1. Mendham, J., A. I., Vogel's Quantitative Chemical Analysis, 7th Ed., Pearson (2012)
2. Mikes O. and Chalmes, R.A., Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd., London
3. Ditts, R.V., Analytical Chemistry: Methods of Separation, Van Nostr and, New York, (1974)

Course Outcomes

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

1. Analyze and gain skills in thin layer Chromatography.
2. Understand and analyze paper Chromatography.
3. Gain skills in solvent extraction
4. Understand the concept of ion exchange chromatography
5. Correlate the physical constants BOD, COD

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3
CO 1	H	H	M	M		H			H		H	H	
CO 2	H	H	M	M		H			H		H	H	
CO 3	H	H	H	M		H			M		H	H	
CO 4	M	L	L	L		M			M		M	L	
CO 5	M	M	L	M		M			M		H	M	