MIZORAM UNIVERSITY

Undergraduate Syllabus for Chemistry Subject

Under NEP -2020 Guidelines

Table: Course Structure and Paper Distribution for UG/Bachelor's Degree Program with Multiple Entry and Exit Options for Chemistry Subject

Semester	Course No.	Paper Name	Components	Credits	Total credits	Marks		Total Marks
						Continuous Assessment	End Semester	
1st	CHEM100	Organic chemistry-I	T	4	4	25	75	100
	CHEM101*	Inorganic chemistry-I	T	4	4	25	75	100
	MN 101	*From other subjects*	T	4	4	25	75	100
	MDC 110	Chemistry in Everyday Life	T	3	3	25	75	100
	AEC 150	Ability Enhancement Course/Language Skill and Communication		3	3	25	75	100
	VAC 100	Value Added Course		2	2	25	75	100
					20			**600**
2nd	CHEM 160	Inorganic Chemistry-II	T	4	4	25	75	100
	CHEM161*	Physical Chemistry-I	T	4	4	25	75	100
	MN 161	*From other subjects*	T	4	4	25	75	100
	MDC 110	Chemistry in Everyday life	T	3	3	25	75	100
	SEC160	Skill Enhancement Course		3	3	25	75	100
	VAC120	Value Added Course		2	2	25	75	100
					20			**600**
3rd								
	CHEM 200	Physical Chemistry-II	T	3	4	25	75	100
	CHEM(P) 200	Lab work (Physical chemistry-IP)	P	1		25	75	100
	CHEM 201*	Organic Chemistry-II	T	4	4	25	75	100
	MN 201	*From other subjects*	T	4	4	25	75	100
	MDC 110	Chemistry in Everyday Life	T	3	3	25	75	100
	SEC 270	Skill Enhancement Course		3	3	25	75	100
	VAC 230	Value Added Course		2	2	25	75	100
					20			**700**
4th	CHEM 260	Organic Chemistry-III	T	3	4	25	75	100
	CHEM(P)260	Lab work (Organic Chemistry-IP)	P	1		25	75	100
	CHEM 261*	Analytical Chemistry	T	4	4	25	75	100
	MN 261	*From other subjects*	T	4	4	25	75	100
	AEC 250	Ability Enhancement Course/Language Skill and Communication		3	3	25	75	100
	SEC 280	Skill Enhancement Course		3	3	25	75	100
	VAC 240/241/242	Sports and fitness/Health and Wellness/Yoga education		2	2	25	75	100
					20			**700**
5th	CHEM 300	Inorganic Chemistry-III	T	3	4	25	75	100
	CHEM(P) 300	Lab work (Inorganic Chemistry-IP)	P	1		25	75	100
	CHEM 301	Physical Chemistry-III	T	3	4	25	75	100
	CHEM(P) 301	Lab work (Physical Chemistry-IIP)	P	1		25	75	100
	CHEM 302*	Environmental Chemistry	T	4	4	25	75	100
	MN 302	*From other subjects*		4	4	25	75	100
	AEC 350	Ability Enhancement Course/Language Skill and Communication		2	2	25	75	100
	IAF 300	Internship	T	2	2	25	75	100
					20			**800**

6th	CHEM 360	Inorganic Chemistry-IV	T	3	4	25	75	100
	CHEM(P) 360	Lab work (Inorganic Chemistry-IIP)	P	1		25	75	100
	CHEM 361	Organic Chemistry-IV	T	3	4	25	75	100
	CHEM(P) 361	Lab work (Organic Chemistry-IIP)	P	1		25	75	100
	CHEM 362	Physical Chemistry-IV	T	4	4	25	75	100
	CHEM 363*	Industrial Chemistry	T	4	4	25	75	100
	MN 363	*From other subjects*	T	4	4	25	75	100
					20			**700**
			Total		**120**			**4100**
7th	CHEM/7/MJ/124	Organic Chemistry-V	T	4	4	25	75	100
	CHEM/7/MJ/125*	Inorganic Chemistry-V	T	4	4	25	75	100
	CHEM/7/MJ/126*	Physical Chemistry –V	T	4	4	25	75	100
	CHEM/7/MN	*From other subjects*	T	4	4	25	75	100
	CHEM/7/MN	*From other subjects*	T	4	4	25	75	100
					20			**500**
	Bachelor's Degree (Honours with Research)							
8th	CHEM/8/MJ/127(a)	Medicinal Chemistry and Natural products	T	4	4	25	75	100
	CHEM/8/MJ/127(b)	Organometallics	T	4	4	25	75	100
	CHEM/8/RP/128	Research Project	T	12	12	25	75	100
					20			**300**
			Total		**160**			**4900**
	Bachelor's Degree (Honours without Research)							
8th	CHEM/8/MJ/127(a)	Medicinal Chemistry and Natural products	T	4	4	25	75	100
	CHEM/8/MJ/127(b)	Organometallics	T	4	4	25	75	100
	CHEM/8/MJ/127(c)	Material Chemistry	T	4	4	25	75	100
	CHEM/8/MJ/127(d)	Bio-organic Chemistry	T	4	4	25	75	100
	CHEM/8/MJ/127(e)	Green Chemistry	T	4	4	25	75	100
					20			**500**
			Total		**160**			**5100**

** means Minor Courses offered for other subjects*

1st Semester

Organic Chemistry-I

CHEM 100

Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To impart the knowledge of basic reaction mechanisms, stereochemistry of organic compounds, concept of aromaticity.*

UNIT I. Mechanism of Organic Reactions

Inductive-effect; Electromeric-effect; Mesomeric-effect or Resonance; hyperconjugation; homolytic and heterolytic bond-breaking; curved arrow notation; Types of reagents – electrophiles & nucleophiles; Energy profiles; Reactive intermediates-Formation and stability of carbocations, free-radicals, carbanions, carbenes and Arynes; General mechanism of substitution, addition, elimination, rearrangement reactions; Methods used to determine reaction mechanism.

UNIT II. Stereochemistry of Organic Compounds

Concept of Isomerism, types of Isomerism.

(a) Geometrical Isomerism: E & Z system of nomenclature; geometrical isomerism in oximes and alicyclic compounds.

(b) Optical Isomerism: Elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centres; diastereo isomers; meso compounds. Sequence rules, D & L and R & S system of nomenclature. Relative and absolute configuration; Inversion and retention of configuration; Resolution of enantiomers; Racemization.

(c) Conformational Isomerism: Conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono-substituted and disubstituted cyclohexane, Newman projection and Sawhorse formulae, Fischer and flying wedge formulae. Difference between configuration and conformation.

Unit III.

(a) **Nucleophilic Substitution Reactions**: Nucleophile, ambident nucleophile, SN_1, SN_2, SN_i, factors affecting substitution reactions (structure of substrate, nature of nucleophile, solvent, role of leaving group), mechanism and stereochemistry of substitution reactions, difference between Nucleophile and bases.

(b) **Elimination Reactions: (E_1, E_2):** Orientation in elimination reactions (Saytzeff's and Hofmann's rule). Substitution vs. Elimination.

Unit IV.

Arenes and *Aromaticity*

Structure of benzene, molecular orbital picture of benzene, stability of benzene ring, resonance –energy; Aromaticity: the Huckel rule & its application; Antiaromaticity and non-aromaticity; Electrophilic Aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism; Directing effects of groups on electrophilic Aromatic Substitution.

Recommended Books:

1. P.Y. Bruice, Organic Chemistry, Pearson Education, ISBN 81 – 7808-581-X
2. M.K. Jain, S.C. Sharma, Modern Organic Chemistry, Vishal Publishing Co. ISBN 9788193293492

Additional Books:
1. G.M. Loudon, Organic Chemistry, Oxford University Press, ISBN 0-19-511999-1
2. R.T. Morrison and R.N. Boyd, Organic Chemistry, Prentice Hall India, ISBN 81-203-0765-8
3. L.G. Wade, Jr., Organic Chemistry, Pearson Education, ISBN 81-297-0248-7
4. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, ISBN 0-19-580346-6.

Course Outcomes: *At the end of the course, the student will be able to:*

1. Know fundamental effects that governs the mechanisms of organic reactions, learn energy profiles and Reactive intermediates and general mechanism of substitution, addition, elimination, rearrangement reactions

2. Acquainted with geometrical, optical and conformational isomerism of organic compounds

3. Know arenes and aromaticity with special reference to benzene and its properties.

4. Know different types of nucleophilic substitution reactions and elimination reactions.

Inorganic Chemistry-I
CHEM 101
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To convey the knowledge of atomic structure, chemical bonding and periodic properties of elements*

UNIT I. Atomic Structure:

Review of Bohr's theory and its limitations; de-Broglie's concept of dual character of matter; Heisenberg's Uncertainty Principle; Schrodinger wave equation (derivation not required); quantum numbers and their significance; radial and angular wave functions (derivations not required) and probability distribution curves; atomic-orbitals; shapes of *s*, *p* and *d*-orbitals.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations. Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

UNIT II.

Periodic Properties:

General features of long form of periodic table. Effective Nuclear Charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in the periodic table. Detailed discussions (definition, factors affecting it, periodic trends including irregularities in periodic trends) of the following properties of the elements, with reference to *s* & *p*- block: (a) Atomic radii and Ionic radii (b) Ionization Energy (c) Electron Affinity (d) Electronegativity.

UNIT III.

Chemical Bonding - I:

Basic idea of ionic bond, covalent bond and coordinate bond.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization.

Ionic character in covalent compounds: Bond moment and dipole moment, ionic character from dipole moment and electronegativities.

Concept of hybridization, types, orientation of hybrid orbitals; Resonance and resonance energy, Valence shell electron pair repulsion (VSEPR) theory, shapes of simple molecules and ions containing lone pairs and bond pairs of electrons taking the following examples: BeF_2, BF_3, $SnCl_2$, NH_3, H_2O, H_3O^+, H_2S, PCl_3, PCl_5, SF_4, SF_6, ClF_3, ICl_2^-.

Unit IV.

Nuclear Chemistry and Radioactivity

Units of radioactivity; group displacement law; theory of radioactive disintegration; half-life and average-life period; radioactive equilibrium; artificial radioactivity. Nuclear stability; N/P ratio;Neutron-proton ratio in a nucleus and its implications; packing fraction; mass defect; Nuclear binding energy; magic number concept.

Elementary ideas of fission, fusion, controlled fission reactions and nuclear reactors (fast breeder reactor and thermal reactors).

Recommended Books

1. R.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry,* Milestone Publishers & Distributors.
2. J.D. Lee, *Concise Inorganic Chemistry*, Oxford University Press.
3. R. Gopalan, *Inorganic Chemistry* for undergraduates, University Press
4. S. Prakash, G.D. Tuli, S.K. Basu & R.D. Madan. *Advanced Inorganic Chemistry*, Vol. I & II, S. Chand & Co.
5. R.D. Madan, Modern Inorganic Chemistry, S. Chand & Co.
6. W.U. Malik G.D Tuli and R.D Madan, Selected Topics in Inorganic Chemistry, S. Chand & Co.

Course Outcomes: *At the end of the course, the student will be able to:*

1. understand the structure of atoms and its stability
2. learn the general periodic properties of an element
3. learn the concept of chemical bonding
4. learn elementary ideas regarding nuclear reactions and radioactivity

1st Semester
Chemistry in Everyday Life
MDC 110
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To deliver the knowledge of synthesis, structures and applications of polymers, dyes, oils, fats and vitamins*

UNIT I. Plastics and Papers

Plastics: Classification of polymers, polymerization reactions, uses of plastics (polyethylene, LDPE, HDPE, polypropylene, PVC, polystyrene), biodegradability of polymers, environmental hazards of polymers, recycling and recycling codes/symbols (Resin Identification Code).
Applications of polymers as plastics in electronics, automobiles, and in medical field.
Paper: Brief idea of paper manufacturing process; thickness, weight and size of paper; types of paper, paper stability, environmental impact of paper.

UNIT II. Dyes and Cosmetics

Dyes: Requirements of a dye, Natural dyes (Indigo and Tyrian purple) and Synthetic organic dyes, Classes of dyes based on the method of application (direct dyes, azoic dyes, mordant dyes, vat dyes) and chemical compositions (azo dyes, triphenylamine dyes, phthalein dyes, indigoid dyes, anthraquinoid dyes).
Cosmetics: Introduction, toothpaste, shampoos, hair dyes, creams and lotions, lipstick, perfumes, aftershave lotions, perfumes and colognes, deodorants and antiperspirants, shaving cream, talcum powder, toxicology of cosmetics.

UNIT III. Oils, Fats and Vitamins

Oils and Fats: Difference between fats and oils, saturated and unsaturated fatty acids; iodine number, saponification number; randicity, factors affecting randicity, types of randicity, prevention of randicity. Determination of iodine number.

Vitamins And Minerals: Water-soluble vitamins, fat-soluble vitamins. Occurrence, deficiency of vitamins and minerals: Vitamin A_1, B_1, B_2, B_6, B_{12}, C, D, E and K_1.

Recommended Books

1. Suryawanshi and Mahesha, Chemistry in Daily Life, Sunstar Publisher.
2. G.D. Gem Mathew, Chemistry in Everyday Life, Vishal Publishing Co.
3. S. Kislaya, Chemistry in Everyday Life, Discovery Publishing House Pvt. Ltd., New Delhi.

Course Outcomes: *At the end of the course, the student will be able to:*

1. Learn synthesis and applications of various types of synthetic polymers and papers
2. Learn different types of dyes and cosmetics and their applications
3. Differentiate oils and fats and their identification
4. Learn water soluble vitamins and their deficiencies

2nd Semester
Inorganic Chemistry-II
CHEM 160
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To impart the knowledge of coordination compounds, properties of s and p-block elements and fundamentals of nuclear & radioactivity.*

Unit I.

Coordination Chemistry: Definition and terminology; Ligands and their classification; Werner's Theory; IUPAC nomenclature of coordination compounds; effective atomic number (EAN) rule; Chelate effect; Factors affecting the stability of metal complexes. Isomerism in coordination compounds. Stereochemistry of complexes with coordination number 4 and 6.

Valence bond theory (inner and outer orbital complexes). Drawbacks of VBT.

Unit II.

Chemistry of s and p Block Elements:

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of the 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.

Oxides and oxoacids of nitrogen and Chlorine. Peroxo acids of Sulphur. Inter-halogen compounds, poly-halide ions, pseudo-halogens, properties of halogens.

Unit III.

Oxidation-Reduction and general principle of metallurgy:

Oxidation and reduction; Oxidation number, calculation of oxidation number; Calculation of Equivalent Weights of Oxidants and Reductants. Balancing of redox reactions by ion-electron methods (simple redox reactions). Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, van Arkel - de Boer process and Mond's process, Zone refining.

Unit IV

Volumetric Analysis

Terms commonly used in volumetric titrimetry (analyte, titrant, titration, equivalence point, end point, indicator), primary standard and secondary standard, expressing concentrations of standard solutions (normality, molarity, ppm), acid base titrations, redox titrations, iodimetric and iodometric titrations, theory of acid-base indicators.

Gravimetric Methods

Principles of gravimetric analysis: Theory of precipitation and purification of precipitates, co-precipitation, post-precipitation, fractional-precipitation, washing of precipitate, drying and ignition.

Chemistry of separation and estimation of ions (iron-calcium, calcium-barium and iron-copper).

Recommended Books

1. R.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry,* Milestone Publishers & Distributors.
2. J.D. Lee, *Concise Inorganic Chemistry*, Oxford University Press.
3. R. Gopalan, *Inorganic Chemistry* for undergraduates, University Press
4. S. Prakash, G.D. Tuli, S.K. Basu & R.D. Madan. *Advanced Inorganic Chemistry*, Vol. I & II, S. Chand & Co.
5. R.D. Madan, Modern Inorganic Chemistry, S. Chand & Co.
6. W.U. Malik G.D Tuli and R.D Madan, Selected Topics in Inorganic Chemistry, S. Chand & Co.
7. H.J. Arnikar, Essentials of Nuclear chemistry.

Course Outcomes: *At the end of the course, the student will be able to:*

1. Learn the concept, nomenclature and isomerism in coordination chemistry

2. Learn the chemistry of s and p block elements

3. Learn elementary ideas regarding nuclear reactions and radioactivity

4. Learn principles and applications of volumetric and gravimetric methods of analysis.

2nd Semester
Physical Chemistry-I
CHEM 161
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To impart the concept of different states of matter, surface chemistry and kinetics of chemical reactions.*

UNIT I. Gaseous State-I

Kinetic Molecular model of a gas, Postulates and Derivation of Kinetic Gas Equation (KGE), Deviation from Ideal behavior (causes); Compressibility factor (Z) and its variation with pressure for different gases; Vander Waal's equation of state; Evaluation of Critical Constant from Vander

Waal's equation; critical compressibility factor (Zc), Law of Corresponding states & Boyle temperature.

UNIT II. Liquid State

Introduction, Vacancy theory of liquid, Free volume in liquid, Physical properties of liquids viz., surface tension, viscosity & refraction. Refraction Index, Specific refraction & Molar refraction (definitions only), Effect of temperature on surface tension & viscosity.

Liquid crystals – structure and types of liquid crystals (elementary discussion only).

UNIT III. Colloids and Surface Chemistry

Classification of colloids, preparation of colloids, Bredig's and condensation methods, Peptization, Optical properties of colloids-Tyndall effect. Origin of charge on colloidal particles, protective colloids, gold number.

Physisorption & chemisorptions; molar enthalpy of adsorption, Langmuir, Freundlich & Gibbs adsorption isotherms.

UNIT IV. Chemical Kinetics & Catalysis

Concepts of Rate, Order and Molecularity of reaction, Concentration dependence of rates, mathematical characteristics of simple chemical reactions- zero, first order, second order, pseudo order, half-life and mean life. Methods for determination of rate law; Effect of Temperature on Reaction Rate; Temperature Coefficient of a reaction, Arrhenius Equation; Concept of Activation energy, Collision Theory & Absolute Reaction Rate Theory. Types and characteristics of Catalysis, Enzyme catalysis; Michaelis–Menten equation; Turn over number (definition only).

Recommended Books:

1. Puri, Sharma, & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, Jallandhar.
2. A.S. Negi, S.C. Anand, A Text book of Physical Chemistry, New Age International Publishers, N. Delhi
3. N. B. Singh, S. S. Das, & Ram Ji Singh, Physical Chemistry, New Age International Publishers, N. Delhi.
4. Arun Bhal, B.S. Bhal & G.D. Tuli, Essential of Physical Chemistry, S. Chand & Co.

Course Outcomes: *At the end of the course, the student will be able to:*

1. Learn the difference between real and ideal gases and Laws governing deviations from ideal behaviour

2. Learn types of liquid crystals and their important physical properties

3. Learn types and chemistry of colloids and their properties and surface chemistry

4. Learn concept of chemical kinetics and enzyme chemistry

2nd Semester
Chemistry in Everyday Life
CHEM 110
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To deliver the knowledge of synthesis, structures and applications of polymers, dyes, oils, fats and vitamins*

UNIT I. Plastics and Papers

Plastics: Classification of polymers, polymerization reactions, uses of plastics (polyethylene, LDPE, HDPE, polypropylene, PVC, polystyrene), biodegradability of polymers, environmental hazards of polymers, recycling and recycling codes/symbols (Resin Identification Code).
Applications of polymers as plastics in electronics, automobiles, and in medical field.
Paper: Brief idea of paper manufacturing process; thickness, weight and size of paper; types of paper, paper stability, environmental impact of paper.

UNIT II. Dyes and Cosmetics

Dyes: Requirements of a dye, Natural dyes (Indigo and Tyrian purple) and Synthetic organic dyes, Classes of dyes based on the method of application (direct dyes, azoic dyes, mordant dyes, vat dyes) and chemical compositions (azo dyes, triphenylamine dyes, phthalein dyes, indigoid dyes, anthraquinoid dyes).
Cosmetics: Introduction, toothpaste, shampoos, hair dyes, creams and lotions, lipstick, perfumes, aftershave lotions, perfumes and colognes, deodorants and antiperspirants, shaving cream, talcum powder, toxicology of cosmetics.

UNIT III. Oils, Fats and Vitamins

Oils and Fats: Difference between fats and oils, saturated and unsaturated fatty acids; iodine number, saponification number; randicity, factors affecting randicity, types of randicity, prevention of randicity. Determination of iodine number.
Vitamins And Minerals: Water-soluble vitamins, fat-soluble vitamins. Occurrence, deficiency of vitamins and minerals: Vitamin A_1, B_1, B_2, B_6, B_{12}, C, D, E and K_1.

Recommended Books

1. Suryawanshi and Mahesha, Chemistry in Daily Life, Sunstar Publisher.
2. G.D. Gem Mathew, Chemistry in Everyday Life, Vishal Publishing Co.
3. S. Kislaya, Chemistry in Everyday Life, Discovery Publishing House Pvt. Ltd., New Delhi.

Course Outcomes: *At the end of the course, the student will be able to:*
1. Learn synthesis and applications of various types of synthetic polymers and papers
2. Learn different types of dyes and cosmetics and their applications
3. Differentiate oils and fats and their identification
4. Learn water soluble vitamins and their deficiencies

3rd Semester
Physical Chemistry-II
CHEM 200
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To understand gaseous and solid states of matter; laws of thermodynamics.*

UNIT I. Gaseous state II
Kinetic Molecular theory of gases, Gas Laws, Maxwell's Distribution Law of Molecular Velocities (Derivation), Types of molecular velocities, Evaluation of average, root mean square (rms) & Most Probable Velocities, and Average Kinetic Energy (KE) from Maxwell's law, KE as a function of Temperature; Degrees of freedom; Law of Equipartition of Energy.

UNIT II. Solid State Space lattice and Unit cell (Definitions); Laws of Crystallography; Laws of Constancy of Interfacial angles and Rational indices; Miller indices; Law of Symmetry: Symmetry Elements in Crystals. Bravais lattices; X-ray Diffraction by Crystals; Derivation of Bragg's equation. Experimental methods of crystal analysis; Bragg's X-ray spectrometer; The Debye-Scherrer equation and its application.

UNIT III. Thermodynamics I
Limitations of the First Law and Need of the second law, Statements of the 2nd law; Carnot's cycle; Efficiency of Carnot's engine; Concept of Entropy; Entropy change for Reversible and Irreversible processes, Entropy change for an Ideal gas with (i) T & V (ii) T & P, Relationship between entropy (S) and probability (W).

UNIT IV. Thermodynamics - II
Third Law Statement; Nernst Heat Theorem; Calculation of absolute Entropy from Heat Capacity Data (up to Debye T^3 Law); Concept of Residual Entropy, Gibb's (G) and Helmholtz (A) Energy; Gibb's – Helmholtz Equation; Variation of free energy change with T & P
Thermodynamics of Open System
Concepts of Partial Molar properties and Partial Molar Energy (Chemical potential), Gibbs – Duhem equation, Variation of Chemical potential with T & P.

Books Recommended:
1. Puri, Sharma, & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, Jallandhar.
2. A.S. Negi, S.C. Anand, A Text book of Physical Chemistry, New Age International Publishers, N. Delhi
3. N. B. Singh, S. S. Das, & Ram Ji Singh, Physical Chemistry, New Age International Publishers, N. Delhi.
4. Arun Bahl, B.S. Bahl & G.D. Tuli, Essential of Physical Chemistry, S. Chand & Co.

Course Outcomes: *At the end of the course, the student will be able to:*

1. Understand laws of gases, and types of molecular velocities
2. Acquainted with the concept of space lattice and unit cell and the laws of crystallography
3. Know the laws of thermodynamics, concept and variation of entropy, Gibbs energy and chemical potential with physical variables.

3rd Semester
Lab work (Physical Chemistry-IP)
CHEM(P) 200
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -1

Objectives: *To experience experimental techniques in the determination of surface tension, viscosity, pH of buffer solution.*

1. Determination of Surface tension of a field liquid by Drop number method.
2. Determination of coefficient of viscosity by Oswald's viscometer of ethanol – water system.
3. Determination of water equivalent of a calorimeter.
4. Determination of heat of neutralization of a strong acid with strong base.
5. Study of Heat of dilution of H_2SO_4 and then determination of the strength of the unknown acid.

6. Determination of indicator constant - colorimetry.
7. Beer's Law - Determination of concentration of solution by colorimetry.
8. Determination of pH of a given solution using glass electrode.
9. Dissociation constants of weak acid, base.
10. Determination of pH of a given buffer.
11. To titrate HCl solution against NaOH solution potentiometrically and to determine the concentration of HCl in a solution.
12. To titrate a solution of Fe^{2+} salt against $Cr_2O_7^{2-}$ and to determine the formal redox potential of Fe^{2+} reversible to Fe^{3+} system.

NOTE: Experiments may be added/deleted subject to the availability of facilities

Recommended Books

1. B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books Private Ltd. New Delhi.
2. S. Chawla, Essentials of Experimental Engineering Chemistry, Dhanpat Rai & Co. New Delhi.
3. J.B. Yadav, Advance Practical Physical Chemistry, Goel Publishing House, Meerut.
4. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, Longman.

Course Outcomes: *At the end of the course, the student will be able to:*
1. Determine surface tension, coefficient of viscosity, water equivalent, heat of neutralization and heat of dilution
2. Determine indicator constant, concentration of solution, pH and dissociation constant.

3rd Semester
Organic Chemistry-II
CHEM 201
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To impart the knowledge of different organic functional groups and their chemical reactions*

UNIT I. Alkanes
IUPAC nomenclature of branched and unbranched alkanes; Classification of carbon atoms in alkane; isomerism; sources; methods of formation with special reference to Wurtz, Kolbe, Corey-House reactions and decarboxylation of carboxylic acids. Physical properties and chemicals reactions of alkanes.

UNIT II. Alcohols
Classification and Nomenclature.
Monohydric alcohols – nomenclature; methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters. Acidic nature. Reactions of alcohols.
Dihydric alcohols – nomenclature; methods of formation; chemical reactions of vicinal glycols.
Trihydric alcohols – nomenclature; methods of formation; chemical reactions of glycerols.

UNIT III. Ethers and epoxides
Nomenclature of ethers and methods of their formation. Chemical reactions – cleavage and autoxidation, Ziesel's method.
Synthesis of epoxides. Acids and base catalyzed ring opening of epoxides. Reactions of Grignard and organolithium reagents with epoxides.

UNIT IV. Aldehydes and Ketones
Nomenclature and structure of the carbonyl group, chemical reactivity of carbonyl group, Synthesis of aldehydes from acid chloride and ketones from nitriles and carboxylic acids. Nucleophilic additions and addition-elimination reactions with HCN, $NaSO_3H$, NH_2OH, $NH_2–NH_2$, $C_6H_5NHNH_2$, $NH_2CONH\text{-}NH_2$. Chemical test to identify aldehydes and ketones.

Recommended Books
1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Jain, M.K. & Sharma, S.C. Modern organic Chemistry, Vishal publishing Co. ISBN 9788193293492

Course Outcomes: *At the end of the course, the student will be able to:*
1. Learn the IUPAC nomenclature of Organic compounds
2. Understand the methods of laboratory preparations of different functional groups
3. Learn the physical properties and general chemical reactions of important organic functional groups.

3rd Semester
Chemistry in Everyday Life
CHEM 110
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To deliver the knowledge of synthesis, structures and applications of polymers, dyes, oils, fats and vitamins*

UNIT I. Plastics and Papers

Plastics: Classification of polymers, polymerization reactions, uses of plastics (polyethylene, LDPE, HDPE, polypropylene, PVC, polystyrene), biodegradability of polymers, environmental hazards of polymers, recycling and recycling codes/symbols (Resin Identification Code).
Applications of polymers as plastics in electronics, automobiles, and in medical field.
Paper: Brief idea of paper manufacturing process; thickness, weight and size of paper; types of paper, paper stability, environmental impact of paper.

UNIT II. Dyes and Cosmetics

Dyes: Requirements of a dye, Natural dyes (Indigo and Tyrian purple) and Synthetic organic dyes, Classes of dyes based on the method of application (direct dyes, azoic dyes, mordant dyes, vat dyes) and chemical compositions (azo dyes, triphenylamine dyes, phthalein dyes, indigoid dyes, anthraquinoid dyes).
Cosmetics: Introduction, toothpaste, shampoos, hair dyes, creams and lotions, lipstick, perfumes, aftershave lotions, perfumes and colognes, deodorants and antiperspirants, shaving cream, talcum powder, toxicology of cosmetics.

UNIT III. Oils, Fats and Vitamins

Oils and Fats: Difference between fats and oils, saturated and unsaturated fatty acids; iodine number, saponification number; randicity, factors affecting randicity, types of randicity, prevention of randicity. Determination of iodine number.
Vitamins And Minerals: Water-soluble vitamins, fat-soluble vitamins. Occurrence, deficiency of vitamins and minerals: Vitamin A_1, B_1, B_2, B_6, B_{12}, C, D, E and K_1.

Recommended Books

1. Suryawanshi and Mahesha, Chemistry in Daily Life, Sunstar Publisher.
2. G.D. Gem Mathew, Chemistry in Everyday Life, Vishal Publishing Co.
3. S. Kislaya, Chemistry in Everyday Life, Discovery Publishing House Pvt. Ltd., New Delhi.

Course Outcomes: *At the end of the course, the student will be able to:*
1. Learn synthesis and applications of various types of synthetic polymers and papers
2. Learn different types of dyes and cosmetics and their applications
3. Differentiate oils and fats and their identification
4. Learn water soluble vitamins and their deficiencies

4th Semester
Organic Chemistry-III
CHEM 260
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To impart the knowledge of different organic name reaction; applications of inorganic reagents in organic synthesis and green chemistry.*

UNIT I.

(a) **Introduction to Organic Synthesis:(Name Reactions):** Formation of carbon-carbon bond, electrophilic and nucleophilic carbon species; Henry, Knoevenagel, Michael, Dieckmann, Darzen, Robinson annulation, Wittig reaction, Reformatsky reaction, Claisen-Schmidt reaction, Mannich reaction, benzoin, cannizzaro's, Baeyer-Villiger reaction.

(b) **Molecular Rearrangements:** Carbocation/carbanion rearrangement - pinacol-pinacolone, Wagner-Meerwein, dienone-phenol, Beckmann, Wolff, Hofmann, Curtius, Schmidt, Benzil-Benzilic acid, Fries, Claisen, Favorskii rearrangements.

UNIT II. Reagents in Organic Synthesis:

Synthetic applications of the following reagents- $LiAlH_4$, $NaBH_4$, $Na/NH_3(l)$, PCC, Jone's reagent, $Pb(OAc)_4$, LDA, $Al(OPr^i)_3$, OsO_4, SeO_2, NBS, Periodic acid (H_5IO_6), Raney Nickel, DCC.

UNIT III. Heterocycles

(a) **Heterocycles-I**: Introduction, preparation and electrophilic substitution reactions of pyrrole, furan and thiophene, Structure, synthesis and reactions of pyridine; comparative basicity of pyrrole/pyridine, pyrrole/pyrrolidine and pyridine/piperidine.

(b) **Heterocycles-II**: Introduction to condensed five and six membered heterocycles, preparation of indole, quinoline and isoquinoline with special reference to Fischer Indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Electrophilic substitution; Nucleophilic substitution; oxidation and reduction reactions of Indole, quinoline and isoquinoline.

UNIT IV. **Green Chemistry**

Principles of Green Chemistry

Green Reactions with mechanism: Aldol Condensation, Baeyer – Villager Oxidation with Migratory Aptitude, Michael Addition, Diels-Alder Reaction, Wittig Reaction.

Microwave Assisted Organic Reactions in water: Mannich Reaction, Hofmann Elimination.

Green Preparation (Sonication Reaction): Butyraldehyde, 2-Chloro-N-aryl anthranilic acid.

Organic Synthesis using Biocatalysts: Biochemical (Microbial) Oxidation and Reduction.

Recommended Books:

1. Gautam Brahmachari, Organic Name Reactions (A unified Approach), Narosa Publishing House, ISBN 9788173197192
2. P.S. Kalsi, Organic Reactions and their Mechanisms, New Age International Publishers, ISBN 978-81-224-2596-3
3. R.R. Gupta. M. Kumar, V. Gupta, Heterocyclic Chemistry I & II, Springer, ISBN 81-81-28-221-3
4. Green Chemistry (Environmentally Benign Reactions), Ane Books India.

5. V.K. Ahluwalia, Green Solvents for Organic Synthesis, Narosa.

Additional Books:

1. R.P. Narain, Mechanisms in Organic Chemistry, Pearson, ISBN (10): 81-224-2135-0
2. R. Bruckner, Advance Organic Chemistry; Reactions Mechanism, Academic Press an Imprint of Elsevier, ISBN 81-8147-713-8
3. TL Gilchrist, Heterocyclic Chemistry, Longman Scientific & Technical, ISBN 0-582-01421-2.

Course Outcomes: *At the end of the course, the student will be able to:*

1. Know important organic named reactions currently employed in organic synthesis
2. Learn the importance and application of different types organic reagents used in synthesis.
3. Know introduction, preparation and electrophilic substitution reactions of heterocycles
4. Learn principle of green chemistry and green reactions.

4th Semester
Lab work (Organic Chemistry-IP)
CHEM(P) 260
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -1

Objectives: *To experience laboratory techniques of qualitative identification of organic compounds and preparations of their derivatives.*

1. **Qualitative Analysis**: Systematic qualitative analysis of organic compounds containing one or two functional group(s).
(a) Detection of elements (N, Cl, Br, I,S)
(b) Detection of the following functional groups (with systematic reporting): COOH, NH_2, NO_2, OH (phenolic) & CO (Carbonyl group) and amide
(c) Preparation of derivatives
2. **Organic separation**:
    1. Separation of Binary organic mixtures based on acid-base concept
    2. Determination of melting points.

Recommended Books

1. O.P.Pandey, D.N. Bajpai, S. Giri, Practical Chemistry, S.Chand & Co., New Delhi
2. J.N. Gurtu & R. Kapoor, Advance Experimental Chemistry, Vol. II, S Chand & Co., New Delhi

Course Outcomes: *At the end of the course, the student will be able to:*

1. Systematically analyze organic compounds for presence of elements and functional group.
2. Learn how to prepare derivatives of organic compounds
3. Separate binary organic mixtures based on acid-base concept and determine of melting points of organic compounds

4th Semester
Analytical Chemistry
CHEM 261
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To impart the knowledge of laboratory safety and hygiene techniques, classical and chromatographic method for sample separation.*

Unit I
Safety and hygiene in the Chemistry Lab
Storage and handling of chemicals, incompatible chemicals, personal protective equipments, handling of acids, ethers, toxic and poisonous chemicals, odour threshold and first aid procedure.
Heating methods, stirring methods and filtration techniques.
Qualitative Analysis
Common ion effect, solubility product principle, application of solubility product and common ion effect in analytical chemistry; Interfering anions and their removal; chemistry of group separation.
Unit II
Classical separation methods:
Theories of distillation, fractional distillation, steam distillation, sublimation and zone refining.
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.
Electroanalytical methods:
Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations.
UNIT III. Chromatography
Principle of adsorption and partition chromatography, Classification of chromatography methods.
Paper Chromatography: Principles, Rf values, experimental procedures, choice of paper and solvent systems, developments of chromatogram - ascending, descending and radial.
Thin Layer Chromatography (TLC): Advantages, principles, factors affecting Rf values, experimental procedures, adsorbents and solvents, preparation of plates, development of the
Chromatogram, detection of the spots and applications.
Column chromatography: Adsorbents, classification of adsorbents, solvents, preparation of column, adsorption and applications.
Unit IV
Evaluation of experimental Data
Significant figures, rounding off of numerical expressions, types of errors: correction/minimization of errors, propagation of determinate errors, accuracy and precision, methods of their expression, difference between accuracy and precision, rejection of data, Statistical treatment of analytical data, uncertainties involve in addition, subtraction, multiplication and division, confidence limits and intervals, test of significance (the F-test and t-test).

Recommended Books

1. D.A. Skoog, D.M. West anf F.J. Holler, Fundamentals of Analytical Chemistry, Saundes College publishing.
2. G.D. Christian,Analytical Chemistry, New York – John Willy
3. S.M. Khopkar, Basic Concepts of Analytical Chemistry, New Age International Publisher
4. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, Longman

Additional Books

5. J.J. Lingane, Electroanalytical Chemistry, Interscience

6. H.W. Willard, L.L. Merrit, J.A. Dean and F.A. Settle, Instrumental Methods of Analysis, CBS Publishers & Distributors, Delhi
7. R.A. Dau and A.L. Thomas and R.P. Bauman, Advance Analytical Chemistry, McGraw Hill

Course Outcomes: *At the end of the course, the student will be able to:*

1. Follow SOP regarding the safety and hygiene in the Chemistry Lab
2. Learn different types of separation methods
3. Learn and apply chromatographic techniques such as paper, TLC and Column chromatography.
4. Minimize error, test significance of their analytical data and correctly express their experimental data

5th Semester
Inorganic Chemistry-III
CHEM 300

Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To impart the knowledge of molecular orbitals and their structures, properties transition elements, reactions of organometallic compounds and defects in ionic crystal*

Unit I.
Chemical Bonding II:
Crystal field theory, d-orbital splitting, weak and strong fields, pairing energies, factors affecting the magnitude of (Δ_o). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar complexes, CFSE, Variation of lattice energies. Qualitative aspect of Ligand field theory.
Molecular orbital theory: Conditions for the combination of atomic orbital to form molecular orbital; pictorial representation of combination of atomic orbital to form various molecular orbital; Molecular orbital diagrams of simple homonuclear (H_2, He_2, O_2 and N_2), heteronuclear diatomic molecules (CO and NO) and their ions (idea of s-p mixing and orbital interaction to be given).

Unit II.
Transition Elements: General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states of 3d series. Difference between the first, second and third transition series.
Lanthanides and Actinides: Electronic configuration, oxidation states, color, spectra and magnetic behavior. Lanthanide contraction, Separation of lanthanides (ion-exchange method only). Comparison of Lanthanides and actinides.

Unit III.
Organometallic compounds-I: Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Preparations, properties and applications of alkyls and aryls of Magnesium and Boron. Zeise's salt, a brief account of bonding in π-metal-ethylene complexes.
Metal carbonyls: 18 electron rule, General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. pi-

acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Unit IV.

Ionic Solids:

General characteristics; Packing of ions in crystals; types of interstitial sites, limiting radius ratio values for different interstitial sites; radius ratio rule and the shape of ionic crystals; lattice energy; factors affecting the magnitude of lattice energy, Born-Haber cycle and its application, Solvation energy and solubility of ionic solids. Defects in crystals and the consequences, semiconductors (n-type and p-type).

Recommended Books

1. R.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry,* Milestone Publishers & Distributors.
2. J.D. Lee, *Concise Inorganic Chemistry*, Oxford University Press.
3. R. Gopalan, *Inorganic Chemistry* for undergraduates, University Press
4. S. Prakash, G.D. Tuli, S.K. Basu & R.D. Madan. *Advanced Inorganic Chemistry*, Vol. I & II, S. Chand & Co.
5. R.D. Madan, Modern Inorganic Chemistry, S. Chand & Co.
6. W.U. Malik G.D Tuli and R.D Madan, Selected Topics in Inorganic Chemistry, S. Chand & Co.

Course Outcomes: *At the end of the course, the student will be able to:*

1. understand atomic and molecular orbital structures of inorganic molecules.

2. have knowledge on general properties of transition elements including lanthanides and actinides.

3. learn chemical and physical properties of organometallic compounds and metal carbonyls

4. have knowledge on structures and defects in ionic crystals and their applications.

5th Semester

Lab work (Inorganic Chemistry-IP)

CHEM(P) 300

Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -1

Objectives: *To convey the knowledge of estimation of metal element content using redox, argentometric and iodimetric titrations*

(A) **Oxidation-Reduction Titrimetry**

(i) Estimation of Fe(II) using standardized $KMnO_4$ solution.

(ii) Estimation of oxalic acid using standardized $KMnO_4$ solution.

(iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iv) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) indicator.

(v) Estimation of Fe(II) with $K_2Cr_2O_7$ using external (potassium ferricyanide) indicator.

(B) **Argentometry**

Estimation of Cl^- (i) By Mohr's method (ii) By Vohlard's method.

(C) Iodo / Iodimetric Titrations

(i) Estimation of the strength of I_2 solution by using sodium thiosulphate solution (Iodimetry).
(ii) Estimation of Cu(II) using sodium thiosulphate (Iodometrically).
(iii) Estimation of $K_2Cr_2O_7$ using sodium thiosulphate (Iodometrically).
(iv) Estimation of the percentage of available chlorine in bleaching powder iodometrically.

NOTE: Experiments may be added/deleted subject to the availability of facilities

Recommended Books

1. O.P. Pandey, D.N. Bajpaj and Giri, S. Practical Chemistry, S. Chand & Co.
2. Gurtu, J.N. & Kapoor, R. *Advanced Experimental Chemistry*, Vol. II, S. Chand & Co.
3. J. Basset, R.C Danney, G.H. Jeffery and j. Mendham, Vogel's Text Book of Quantitative Inorganic Analysis, 4th ed., ELBS
4. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, ELBS

Course Outcomes: *At the end of the course, the student will be able to:*
1. Design estimation of metal element content using redox, argentometry and iodimetric titrations.

5th Semester
Physical Chemistry-III
CHEM 301
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To provide the knowledge of quantum treatment of atoms and molecules, molecular symmetry elements and operations, electric and magnetic properties, theories of spectroscopy methods.*

Unit I: Quantum Chemistry

Black body radiation; Planck's radiation law; Photoelectric effect; heat capacity of solids; Postulates of quantum mechanics; Schrodinger wave-equation and its applications to i) free particles ii) particle in a one dimensional (1D) box, quantization of energy levels, zero point energy, Schrodinger wave-equation for H-atom.

UNIT II. Molecular Symmetry and Group Theory

Symmetry elements and symmetry operations, Group postulates, Types of groups, Point groups, Representations of molecular point groups, Point groups and geometry of some common molecules, Application of group theory, Crystallographic symmetry, Crystal systems, Molecular Symmetry and crystallographic symmetry.

UNIT III. Electric and Magnetic properties

Clausius-Mosotti equation, Debye equation, Dependence of polarizability on frequency, Molar refractivity, Dipole moments and molecular structure, Magnetic permeability, Magnetic susceptibility, Diamagnetism, Paramagnetism, Measurement of magnetic susceptibility.

UNIT IV. Molecular spectroscopy

Interaction of Electromagnetic Radiation with molecules; Various types of Spectra, Born – Oppenheimer approximation

(a) Rotational spectroscopy: Rotational energy levels of diatomic molecules (rigid rotor); selection rule; relative intensity of rotational spectral lines; determination of bond-length. (b)Vibrational Spectroscopy: Vibrational energy levels of diatomic molecules (one dimensional harmonic oscillator); selection-rules; evaluation of force constant from fundamental frequencies; anharmonicity and Morse potential. Dissociation energy, overtones, and hot bands. (c) Raman Spectroscopy: classical theory of Raman effect; Selection rules; Effect of nuclear spins, stokes and anti-stokes lines, Mutual exclusion rule.

Books Recommended:

1. Puri, Sharma, & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, Jallandhar.
2. A.S. Negi, S.C. Anand, A Text book of Physical Chemistry, New Age International Publishers, N. Delhi
3. N. B. Singh, S. S. Das, & Ram Ji Singh, Physical Chemistry, New Age International Publishers, N. Delhi.
4. Arun Bshl, B.S. Bahl & G.D. Tuli, Essential of Physical Chemistry, S. Chand & Co.

Course Outcomes: *At the end of the course, the student will be able to:*

1. understand the quantum theory and its application
2. Predict the symmetric properties of the given molecules with their point groups
3. understand the electric and magnetic properties of molecules.
4. understand theories of spectroscopy and their applications in identification of molecules.

5th Semester
Lab work (Physical Chemistry-IIP)
CHEM(P) 301
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -1

Objectives: *To impart the knowledge of experimental methods of conductometric titrations and calorimetric methods for determination of unknown concentrations.*

1. Determination the solubility of a given salt ($BaCl_2$) at two temperatures (60°C and 40°C) and to determine the heat of solution
2. Determination of the solubility of benzoic acid (an organic acid) at two temperatures (50°C and room temperature); and then to determine the heat of solution of that solute.
3. Determination of the strength of the given ferrous sulphate solution potentiometrically.
4. Determination of velocity constant of the hydrolysis of methyl acetate, catalysed by an acid.
5. Determination of the strength of hydrochloric acid solution (approx. N/10) by titration against standard sodium hydroxide solution conductometrically (use oxalic acid for the standardization of sodium hydroxide conductometrically).
6. Acid-Alkali titration using potentiometer.
7. Determination of the strength of a halide solution potentiometrically using silver nitrate.
8. Conductometric titration of a weak acid and a strong base.
9. Conductometric titration of a strong acid and a weak base.

10. Determination of the partition coefficient of Iodine between CCl_4 and water.
11. Determination of the partition coefficient of Iodine between Kerosene and water.
12. Determination of the partition coefficient of benzoic acid between benzene and water.
13. Verification of Beer-Lambert's law using copper sulphate or $K_2Cr_2O_7$ solution Colorimetrically or Spectrometrically and determination of the concentration of the above solution.
14. To study the adsorption of oxalic acid on activated charcoal and to verify Freundlich's adsorption isotherm.
15. Preparation of colloidal sols of Arsenious sulphide, $Fe(OH)_3$, and Prussian blue sols.

NOTE: Experiments may be added/deleted subject to the availability of facilities

Recommended Books

1. B. Viswanathan and P.S. Raghavan, Practical Physical Chemistry, Viva Books Private Ltd. New Delhi
2. S. Chawla, Essentials of Experimental Engineering Chemistry, Dhanpat Rai & Co. New Delhi
3. J.B. Yadav, Advance Practical Physical Chemistry, Goel Publishing House, Meerut
4. A.I. Vogel, A Textbook of Quantitative Inorganic Analysis, Longman

Course Outcomes: *At the end of the course, the student will be able to:*

1. Experimentally determine the solubility of a given salt and velocity constant of hydrolysis.
2.Demonstrate potentiometric and conductometric determination of the given unknown concentration.
3. Differentiate oils and fats and their identification
4. Determine partition coefficient of two immiscible liquids

5th Semester
Environmental Chemistry-I
CHEM 302
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To give the basic knowledge of environmental chemistry, different pollutants and their management*

UNIT-I.

I**ntroduction**: Concept and Scope of Environmental Chemistry. Segments of environment.

Atmosphere and Air Pollution: Primary air pollutants and their sources, Chemical and photochemical Reactions in the Atmosphere: Oxygen and Ozone Chemistry, Sulphur Dioxide, Nitrogen Oxides. Greenhouse Effect and Global Warming, Greenhouse gases, Ozone hole. Chemical Processes for Formation of Organic Particulate Matter, sources and their effects on human and environment. Hydrocarbons and Photochemical smog, Acid rain.

UNIT-II.

Soil pollution: Soil pollution and its causes.

Water pollution: Major water pollutants and their classifications. Water quality and criteria for finding of water quality, Dissolved oxygen, BOD and COD. Eutrophication. Hardness of water, softening of water.

UNIT-III.

Waste Management and Recycling: Brief discussion of Solid Waste Disposal, Solid Waste Management: Municipal Solid Waste, composition, collection and disposal, sanitary landfill, composting and incineration.

Wastewater treatment: Domestic wastewater treatment, aerobic treatment process, anaerobic treatment process, industrial wastewater treatment, Reverse Osmosis, Sludge treatment, water reuse and recycling.

UNIT-IV.

Noise pollution: Noise and its measurement, classification, noise pollution hazards.

Chemical Toxicology: Toxic chemicals in the environment, toxicity of and biochemical effects of lead, mercury, arsenic and cadmium, CO, NOx and SO_2. Cyanide and its toxic effects, Pesticides and its biochemical effects.

Recommended Books

1. A.K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
2. A Text book of Environmental Chemistry by W. Moore and F.A. Moore
3. S.E. Manahan, Environmental Chemistry, CRC Press (2005).

Course Outcomes: *At the end of the course, the student will be able to:*

1. have knowledge on concept and scope of environmental chemistry.
2. understand different types of Pollutants
3. learn importance of waste management and their recycling

6th Semester
Inorganic Chemistry-IV
CHEM 360
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To give the basic idea of acid-base concept, noble gas chemistry, metallic bonding and bio-inorganic chemistry.*

UNIT I.
Acid Base Concept: Arrhenius concept, Bronsted – Lowry concept, levelling effects of solvents, Lewis concept and solvent system concept of acids and bases. HSAB principle and applications.
Non-Aqueous Solvents: Classification of solvents; importance of non-aqueous solvents. Reactions in liquid ammonia and sulphur dioxide – (i) Neutralisation reactions, (ii) precipitation reactions, (iii) complex formation reactions, (iv) redox reactions and (v) solvolysis reactions. Action of liquid ammonia on alkali metals and alkaline-earth metals.

UNIT II.
Noble Gases:
Occurrence and uses, rationalization of inertness of noble gases, Isolation and separation of noble gases by fractionation of liquid air, Clathrates. Preparations, properties, structures and bonding of XeF_2, XeF_4 and XeF_6.
Inorganic Polymers:
Types of inorganic polymers, comparison with organic polymers. Glass transition temperature. Synthesis, structural aspects and applications of silicones, phosphazines, boranes (only diborane) and silicates (only structural aspects).

UNIT III.
Magneto-Chemistry: Explanation of the terms - magnetic induction, permeability, intensity of magnetisation, magnetic susceptibility, diamagnetism, paramagnetism, ferromagnetism and antiferromagnetism. Origin of magnetic moment, Curie's law, Curie-Weiss law, Variation of magnetic susceptibility with temperature for paramagnetic, ferromagnetic and antiferromagnetic substances. Bohr Magneton. Explanation of the magnetic behaviour of simple inorganic complexes.
Molecular symmetry: Symmetry operations, symmetry elements and symmetry point groups of SOX_2, R_2NH, $BeCl_2$, H_2O, BF_3, H_2O, BF_3, H_2O_2 and NH_3.

UNIT IV.
Metallic bonding and Weak chemical forces:
Metallic Bond: Qualitative idea of free electron model and band model.
Weak Chemical Forces: van der Waals forces: ion-dipole, dipole-dipole, dipole-induced dipole, instantaneous dipole-induced dipole interactions.
Hydrogen bond, types, nature and conditions for its formation. Effects of hydrogen bonding on solubility, melting and boiling points.
Bioinorganic Chemistry:
Role of metal ions present in biological systems, classification of elements according to their action in biological system. Sodium potassium pump, calcium and magnesium in living systems, carbonic anhydrase and carboxypeptidase. Effects of excess and deficiency of some trace metals and toxicity of metal ions (Hg, Pb, Cd and As). Iron and its application in biosystems, Haemoglobin and myoglobin, cooperativity effect.

Recommended Books

1. R.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry,* Milestone Publishers & Distributors.
2. J.D. Lee, *Concise Inorganic Chemistry*, Oxford University Press.
3. R. Gopalan, *Inorganic Chemistry* for undergraduates, University Press
4. S. Prakash, G.D. Tuli, S.K. Basu & R.D. Madan. *Advanced Inorganic Chemistry*, Vol. I & II, S. Chand & Co.
5. R.D. Madan, Modern Inorganic Chemistry, S. Chand & Co.
6. W.U. Malik G.D Tuli and R.D Madan, Selected Topics in Inorganic Chemistry, S. Chand & Co.

Course Outcomes: *At the end of the course, the student will be able to:*

1. understand the acid-base concept of different approach and the properties of non-aqueous solvent.
2. Learn different symmetry operations and properties of inorganic molecules.
3. know the properties of noble gases, preparations and properties of polymers.
4. impart knowledge on magnetic properties, weak chemical forces and bio-inorganic molecules.

6th Semester
Lab work (Inorganic Chemistry-IIP)
CHEM(P) 360
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -1

Objectives: *To have experimental qualitative and quantitative analysis and preparations of important inorganic compounds*

(A) **Inorganic preparations:**

(i) Cuprous Chloride, Cu_2Cl_2
(ii)Aluminium Potassium sulphate $K_2SO_4.Al_2(SO_4)_3.24H_2O$ (Potash alum) or
$K_2SO_4.Cr_2(SO_4)_3.24H_2O$ (Chrome alum).
(iii) Tetraammine copper (II) sulphate, $[Cu(NH_3)_4]SO_4 .H_2O$
(iv) Potassium trisoxalatochromate (III), $K_3[Cr(C_2O_4)_3]$
(v) Microcosmic salt, $Na(NH_4)HPO_4.4H_2O$
(vi) Potassium chlorochromate (III), $CrO_2Cl(OK)$
(vii) Sodium cobaltinitrite $Na_3[Co(NO_2)_6]$

(B) Quantitative (Gravimetric) Analysis:

(i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.
(ii) Estimation of sulphate as Barium sulphate / Barium as Barium sulphate.
(iii) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

(C) Complexometric Titrations:

(i) Complexometric estimation of (i) Mg^{2+} (ii) Ca^{2+} using EDTA
(ii) Estimation of temporary, permanent and total hardness of water sample(s).

(D) Qualitative semi-micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given on understanding of the chemistry of different reactions. Following radicals may be analyzed: Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-} , NO_2^- and NO_3^- ,Cl^- and Br^- , Cl^- and I^- , Br^- and I^- , NO_3^- and Br^- , NO_3^- and I^- . Spot analysis/tests should be done whenever possible.

NOTE: Experiments may be added/deleted subject to the availability of facilities

Recommended Books

1. O.P. Pandey, D.N. Bajpaj and Giri, S. Practical Chemistry, S. Chand & Co.
2. Gurtu, J.N. & Kapoor, R. *Advanced Experimental Chemistry*, Vol. II, S. Chand & Co.
3. J. Basset, R.C Danney, G.H. Jeffery and j. Mendham, Vogel's Text Book of Quantitative Inorganic Analysis, 4th ed., ELBS
4. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, ELBS

Course Outcomes: *At the end of the course, the student will be able to:*

1. Experienced laboratory preparation of several inorganic compounds.
2. know quantitative analysis using gravimetric and complexometric titrations.
3. analyse different anions and cations present in the chemical samples qualitatively.

6th Semester
Organic Chemistry-IV
CHEM 361
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -3

Objectives: *To impart the knowledge of photochemical reactions, pericyclic reactions and applications of spectroscopic techniques in the identification of organic compounds.*

UNIT I. Organic Photochemistry: Molecular energy and photochemical energy, excitation of molecules, Franck-Condon Principle, dissipation of energy and Jablonski-diagram, depicting various processes occurring in the excited state, singlet-triplet states, photosensitization, quenching and quantum yield. Qualitative description of fluorescence, phosphorescence, non-radiative processes (Internal conversion & inter system crossing). Introduction to the photochemical reactions of carbonyl compounds, Photoreduction, Paterno-Buchi reaction, Norrish type-I and Norrish type-II cleavages.

UNIT II.

(a) Pericyclic Reactions: Definition of Pericyclic reaction.

(i) **Electrocyclic reactions**: stereochemistry of electrocyclic reaction, conrotatory – disrotatory ring closure and ring opening (with simple examples like 1,4 – disubstituted 1,3-butadiene, 1,6, -disubstituted,1,3,5, hexatriene, 1,8, disubstituted, 1,3,5,7 – octatetraene). Woodward-Hofmann's rule for electrocyclic reactions, Frontier molecular orbital theory (correlation diagram not required).
(ii) **Cycloaddition reactions**: Definition of dienes and dienophiles, supra-supra, antara-antara modes of cycloadditions (π^4_s +- π^2_s, π^4_s + π^2_a, π^2_s +π^2_s, π^2_s + π^2_a) by taking examples of simple dienes and dienophiles.

UNIT III. Organic Spectroscopy-I
General principles: Introduction to absorption and emission spectroscopy.
(a) **UV Spectroscopy**: Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts; Application of Woodward Rules for calculation of λmax for the following systems: alicyclic dienes and polyenes, enones and dienones.
(b) **IR Spectroscopy**: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; application in functional group analysis.

UNIT IV. Organic Spectroscopy-II
(c) **NMR Spectroscopy**: Basic principle, chemical shifts, shielding and deshielding of protons, chemically and magnetically equivalent protons, NMR peak area and proton coupling, chemical shifts and coupling constants for ethyl bromide, ethanol, acetaldehyde, 1,1,2 – tribromo ethane, ethyl acetate, toluene and acetophenone.
(d) **Mass-Spectrometry**: Basic principle, types of ion produced in mass spectrometer, molecular ion-peak, base-peak and metastable ion, determination of molecular weight of organic compounds.

Recommended Books
1. J.S. Jagdamba Singh, Photochemistry and Pericyclic reactions. New Age International Publishers.
2. S.C. Ameta, S, Meta and S. Sharma, Organic Photochemistry- An Introduction. Sadguru PubIications.
3. R.R. Gupta, M. Kumar, V. Gupta, Heterocyclic Chemistry I & II, Springer.
4. Green Chemistry (Environmentally Benign Reactions), Ane Books India.
5. V.K. Ahluwalia, Green Solvents for Organic Synthesis, Narosa.
6. P.S. Kalsi, Spectroscopy of Organic Compounds, New Age International Publishers.
7. Y.R. Sharma. Elementary Organic Spectroscopy. Principles and applications, S. Chand & Co.
8. Jag Mohan, Organic spectroscopy, principles and applications, Narosa Publishing House.

Course Outcomes: *At the end of the course, the student will:*
1. understand the photochemical reactions of organic compounds.
2. have knowledge on pericyclic reactions viz. electrocyclic and cycloaddition reactions.
3. Learn concept of spectroscopy and their applications in identification of organic compounds.

6th Semester
Lab work (Organic Chemistry-IIP)
CHEM(P) 361
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -1

Objectives: *To impart experimental techniques of preparations, extractions of essential oils, operating uv-vis spectrophotometer for qualitative and quantitative analysis.*

1. **Organic Preparations**:
Preparation of the following organic compounds

1. Phthalimide
2. m-Dinitro benzene
3. Picric acid
4. Aspirin from methyl salicylate
6. Preparation of quinoline from aniline (skraup synthesis)
7. Preparation of 2-Phenyl indole from hydrazine (Fischer Indole synthesis)

2. **UV/Vis Spectroscopy**:
(i). Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
(ii). Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
(iii). Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
(iv). Determine the concentration of the given organic compound using UV-Vis spectrophotometer.

3. **Synthesis of heterocyclic compounds** and monitoring the progress of the reaction using Thin Layer chromatography
(i) Biginelli condensation: Synthesis of 3, 4-dihydropyrimidin-2-ones using acid catalysts.
(ii) Hantzsch ester synthesis: synthesis of 1, 4-dihydropyridine.

4. **Extraction of organic compounds**:
(i). Extraction of essential oils from plants (eucalyptus, Ageratina adenophora, etc.) using Clevenger apparatus.
(ii). Extraction and isolation of casein and lactose from milk.
(iii). Extraction of caffeine from tea leaves.

NOTE: Experiments may be added/deleted subject to the availability of facilities

Recommended Books

1. Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).

3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

Course Outcomes: *At the end of the course, the student will be able to:*
1. Prepared organic compounds in a laboratory.
2. Use spectrophotometer for qualitative and quantitative analysis.
3. Perform extraction of essential oils from different sources.

6th Semester
Physical Chemistry-IV
CHEM 362
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To inculcate the knowledge of theory of photochemical reactions, electrochemical reactions and equilibrium reactions.*

UNIT I. Photochemistry
Difference between Thermal and Photochemical reactions; Grotthus-Draper law; Beer-Lambert's Law; Stark-Einstein law of photochemical equivalence and quantum yield, Photochemical reactions involving dissociation of HI, CH_3CHO; Photo-sensitized reaction involving photosensitizes; Quenching & Chemiluminescence.

UNIT II. Electrochemistry I
Electrolytic Conductance; Specific, Equivalent and Molar Conductivity; Variation of Conductance with Dilution for weak and strong electrolytes; Kohlrausch's Law of independent migration of ions.
Arrhenius theory of Electrolytic dissociation; Ostwald's dilution law, Ionic strength, Debye – Huckel – Onsager equation for strong electrolytes (derivation not required), Asymmetry effect; Electrophoretic effect. Drift Velocity, Ionic mobility and Transport number; Determination of transports number by Hittorf's and Moving boundary Method.

UNIT III. Electrochemistry II:
Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass electrodes.
Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Quantitative discussion of potentiometric titrations (acid-base, redox titrations).

UNIT IV. Dissociation Equilibria

Dissociation equilibria of weak electrolytes, dissociation constant of weak acids (Ka), ionic product of water (Kw), hydrogen ion concentration and pH scale, buffer solutions and buffer activity, hydrolysis constant (Kh), derivation of hydrolysis between Ka, Kw and Kh, derivation of hydrolysis constant for salts of (i) strong acid and weak base, (ii) weak acid and strong base and (iii) weak acid and weak base, pH, buffer solutions and buffer activity & Henderson- Hasselbach equations for acidic & basic buffers.

Books Recommended:

1. Puri, Sharma, & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, Jallandhar.
2. A.S. Negi, S.C. Anand, A Text book of Physical Chemistry, New Age International Publishers, N. Delhi
3. N. B. Singh, S. S. Das, & Ram Ji Singh, Physical Chemistry, New Age International Publishers, N. Delhi.
4. Arun Bahl, B.S. Bahl & G.D. Tuli, Essential of Physical Chemistry, S. Chand & Co.

Course Outcomes: *At the end of the course, the student will be able to:*

1. Learn the theory of photochemical reactions
2. Understand theory of electrochemistry and its applications in electrochemical cells.
3. Know equilibrium reactions and buffer activity under acidic and basic conditions.

6th Semester
Industrial Chemistry-IV
CHEM 363
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To inseminate the idea of fermentation techniques, origin and processing of coal and petrochemical products, knowledge of synthetic polymers and their applications*

UNIT I.

(a) **Fermentation Technology**

Introduction, application of fermentation-microbial biomass, microbial enzyme, transformation process, recombinant products, fermentation process, mode of operation fermentation process, the genetic improvement of product formation-mutation.

(b) **Food Technology**

Introduction, food safety assurance, food chemistry-carbohydrates, proteins, lipids, minor components of foods, water in foods, food processing-fundamental of fluid flow, food preservation, food process and flowcharts, refrigerated transport of fruits and vegetables.

UNIT II.

(a) **Leather Industry**

Curing, preservation and tanning of hides and skins, process of dehairing and dyeing, treatment of tannery effluents.

(b) **Chemical Explosives**

Origin of explosive, preparation and chemistry of lead azide, nitroglycerine, nitrocellulose, TNT, Dynamite, cordite, picric acid, gunpowder, introduction to rocket propellants.

UNIT III.

(a) **Coal**: Origin and economics importance of coal, types, analysis and composition, coal gasification, carbonization, coal-tar based chemicals manufacture, coal mines in India.

(b) **Petroleum**: Origin, refining, cracking, reforming, knocking and octane number, synthetic gas, synthetic petrol. Fuel gases: Large scale production, storage, hazards and uses of coal gas, water gas, producer gas and oil gas.

UNIT IV. Polymer Chemistry:

Plastic, elastomers and fibres; Thermosetting and thermoplastics. Important industrial polymers, preparation and applications of – polyethylene, polystyrene, polyamides, PVC, polyethylmethacrylate, polyesters, polyurethanes, phenol-formaldehyde, Urea-formaldehyde, melamine-fromaldehyde, epoxy resins.

Reference

1. B.N. Chakraborty, Industrial Chemistry, Oxford and IBH Publishing Co., New Delhi (1981).
2. B.K. Sharma, Industrial Chemistry, Geol Publishing House, Meerut.
3. M.P. Stevens, Polymer Chemistry –An Introduction, Oxford (1990).
4. Geofferey Cambell-Plat, Food Science and Technology, John Wiley and Sons (2009) [ISBN-978-0-632-06421-2]
5. P.F. Stanbury, Stephen J. Hall and A. Whitaker, Principles of Fermentation Technology, Butterworth-Heinemann, 2nd edition (1999) [ISBN-10: 0750645016].

Course Outcomes: *At the end of the course, the student will be able to:*

1. Learn food compositions and fermentation processes.
2. understand leather preparation and composition of chemical explosives.
3. know the composition, origin, storage and hazards of coal and petrochemicals.
4. impart knowledge on preparation of synthetic polymers and their applications.

7th Semester
Inorganic Chemistry-V
CHEM/7/MJ/124

Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To impart the knowledge of coordination chemistry of transition elements, structures and their spectra.*

UNIT I. Molecular Structures: Ionic bond, Covalent bond, Coordinate bond, Metallic bond, Hydrogen bond, Structures of solids- Types of crystals, Packing, Radius ratio -Goldschmidt radius ratio, Crystal structures, Lattice energy, Lattice defects, F-centre; Basic ideas of powder XRD, Single crystal diffraction (Bragg's law). Solid state 3D network, pyroxene, amphibole, talc, mica, clay, zeolite.
Acid-Base: Acid and base concept, Hard and soft acid and bases (HSAB), Non-aqueous solvents.

UNIT II. Fundamentals of Coordination Chemistry: Metal ion, Ligand, Complex ion,
Coordination number; IUPAC nomenclature, Isomerism, Chelate effect; Werner's theory of coordination compounds. VBT-Inner and Outer Orbital complex; CFT- splitting of d orbitals in ligand fields and different symmetries; CFSE, Factors affecting the magnitude of Dq, Spin only magnetic moment, Anomalous and subnormal magnetic moments, Basic idea of magnetism in inorganic materials.
Spectrochemical series and Nephelauxetic series, Irving William series. Racah parameter.

UNIT III.
Metal-Ligand Bonding in Transition Metal Complexes: Tetragonal distortion from octahedral symmetry, Jahn-Teller distortions, Thermodynamic and structural effects, Spin and orbital moments, Basic idea of spin orbit coupling, Quenching of orbital momenta, Site selection in spinels; Experimental evidence for metal-ligand orbital overlap, and Nephelauxetic effect, Ligand field theory, Molecular orbital theory of octahedral complexes.

UNIT IV.
(a) **Electronic Spectra of Transition Metal Complexes**: Atomic term symbols & spectroscopic ground states, orgel energy level and Tanabe-Sunago diagrams for transition metal complexes, charge transfer spectra, electronic spectra of octahedral and tetrahedral Co(II) and Ni(II) complexes and calculation of ligand-field parameters.
(b) **Lanthanides & Actinides**: Introduction, principles and energetics, binary compounds, coordination compounds, electronic and magnetic properties.

Recommended Books:

1. Shriver and Atkin‟s Inorganic Chemistry, 5th Ed. Oxford (2010).
2. B. Douglas, D. Mc Daniel & J. Alexander, *Concepts and models of inorganic chemistry*, 3rd Ed. J. Wiley (2007).
3. F. A. Cotton, G.Wilkinson, *Advanced Inorganic Chemistry*, 6th Ed., Wiley & Sons, New York (2006).
4. A.R. West. *Solid State Chemistry and Its Applications*, John Wiley and Sons, Singapore (2006).

Additional Books:

1. B. R. Puri, L.R. Sharma and K.C. Kalia, Principles of Inorganic Chemistry, 32nd Ed. Milestone publishers, India (2015).
2. D. E. Fenton, *Biocoordination Chemistry*, (1997) Oxford Chemistry Primers, Oxford University Press.
3. L.V. Azaroff, *Introduction to Solids*, Tata McGraw-Hill, New Delhi (1990).

Course Outcomes: *At the end of the course, the student will be able to:*
1. Understand the chemical bonding in inorganic molecules and structural feature of solids including their analysis.
2. Understand the basic principles of HSAB.
2. Explain the structure and properties of coordination compounds.
3. Understand the structure and properties of transition metal complexes.
4. Explore the principles of electronic spectra of transition metal complexes.

7th Semester
Organic Chemistry-V
CHEM/7/MJ/125
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To impart the knowledge of systematic organic synthesis; stereoselective synthesis and advanced organic synthesis name reactions.*

UNIT I: **Retrosynthesis**- Synthons and synthetic equivalents, disconnection approach, functional group inter-conversion, importance of order of events in organic synthesis, one group and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclization reaction, one group C-C disconnections- alcohols and carbonyl compounds, regioselectivity. Two group C-C disconnections- Diels-alder reaction, difunctionalised compounds. Retrosynthesis and total synthesis of quercetin, pinene and prostaglandins.

UNIT II: **Stereoselective reactions**- classification (enantioselective and diastereoselective reactions), modes of asymmetric induction- chiral pool synthesis, chiral auxiliaries and asymmetric synthesis, Asymmetric oxidation- Sharpless asymmetric epoxidation, asymmetric dihydroxylation, Shi epoxidation. Asymmetric reduction- Corey and Noyori asymmetric hydrogenation. Organocatalysis- classification, L-proline catalysed asymmetric aldol and Michael addition reactions.

UNIT III: Named Reactions- Prins reaction, Vilsmeier-Hack reaction, Pictet-Sprengler reaction, Heck reaction, Biginelli reaction, Hantzsch reaction, Passerini reaction, Ugi reaction, McMurry olefination, Ring closing metathesis (RCM) - Grubb's reaction, Mitsonobu reaction, Nef reaction, 1,3-dithiane reactivity: Umpolung effect, Peterson's synthesis.

UNIT IV: Modern synthetic method: (a) Baylis-Hillman reaction, Kulinkovich reaction, Ritter reaction, Sakurai reaction, Brook rearrangement, Tebbe olefination.

(b) Metal mediated C-C and C-X coupling reactions: Heck, Stille, Suzuki, Negishi and Sonogashira, Nozaki-Hiyama, Buchwald-Hartwig, Ullmann coupling reactions.
(c) Construction of ring system- i) Different approaches towards the synthesis of three, four, five, and six-membered rings; ii) Pauson-Khand reaction, Bergman cyclization; Nazarov cyclization.

Recommended Books

1. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, 2001.
2. F. A. Cary and R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edition, Springer, 2009. 3. M. B. Smith, Organic Synthesis, 2nd Edition, 2005
4. S. Warren, Organic Synthesis, The disconnection Approach, John Wiley & Sons, 2004.
5. J. March, Advanced Organic Chemistry: Reactions, Mechanism and Structure (4th edition), John Wiley & Sons (2005)

Course Outcome*: At the end of the course, the learners should be able to:*
1. Understand the use various reagents and organic reactions in organic synthesis
2. Explore the retrosynthetic method for the logical dissection of complex organic molecules and devise synthetic methods
3. Apply asymmetric transformations in a logical manner for the synthesis of chiral molecules.
4. Explore and understand some named reactions for organic synthesis.

7th Semester
Physical Chemistry-V
CHEM/7/MJ/126
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To familiarize the causes and prevention of the corrosion, chemical and mathematical equations of kinetics of reaction, surface catalysis and thermodynamics of phase transition.*

UNIT I. **Electrochemistry and Corrosion**: Metal/Electrolyte interface: OHP and IHP, potential profile across double layer region, potential difference across electrified interface; Structure of the double layer: Helmholtz-Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, Exchange current density,Tafel plot. Polarizable and non-polarizable interfaces. Ion association: Bjerrum equation, fraction of ions associated, ion association constant.
Causes and types of corrosion, electrochemical theories of corrosion. Kinetics of corrosion (corrosion current and corrosion potential).Corrosion measurements (weight loss and polarization methods), units of corrosion rate, passivity and its breakdown, corrosion prevention (electrochemical, inhibitor, and coating methods).

UNIT II. (a) Chemical Kinetics: Composite Reactions: Types & rate equations of composite mechanisms, steady state treatment, rate-determining steps, microscopic reversibility and detailed

balance; simultaneous and consecutive reactions, dynamic chain: H2-Br2 reaction; and oscillatory reactions, branching chain: H_2-O_2 reaction.
(b) **Solid state:** Identification of lattice planes; Bragg's law and applications; concept of particle-hole in conduction process, band structure of solids (conductors, semiconductors and insulators).

UNIT III. Catalysis: Catalytic activity at surfaces (volcano curve), surface area determination (BET equation), transition state theory of surface reactions, rates of chemisorption and desorption, unimolecular and bimolecular surface reactions, comparison of homogeneous and heterogeneous reaction rates, surface heterogeneity, lateral interaction.

UNIT IV. Thermodynamics: Description of phase transitions; phase equilibria and phase rule. Properties of ideal solutions; Non-ideal systems-deviations (negative and positive) from ideal behavior. Fugacity: Concept and determination. Excess functions for non-ideal solutions, calculations of partial molar quantities, determination of partial molar volume and enthalpy.

Recommended Books:

1. J.O.M. Bockris and A.K.N. Reddy, *Modern Electrochemistry*, Vol.2A& 2B, Second Ed., Plenum Press, New York (2006).
2. Mars G. Fontana, *Corrosion Engineering*, Third Edition, McGraw-Hill Book Company, New York (2007).
3. K.J. Laidler, *Chemical Kinetics*, 3rdEd., Harper & Row, New York (2001).
4. P.W. Atkins & J. de Paula, *Physical Chemistry*, 8th Ed., Oxford University Press, New York(2009).

Additional Recommended Books:

1. I.N. Levine, *Physical Chemistry*, 5th Ed., Tata-McGraw Hill Pub. Co. Ltd., New Delhi(2009).
2. D.A.McQuarrie& D. Simon, *Physical chemistry,* Viva Books (2007).
3. *P. Atkins, J. de Paula & R. Friedman,* Quanta, Matter, and Change*, Oxford University Press(2009).*

Course Outcomes*: At the end of the course, the student will be able to:*

1. Fulfill the causes, types and mechanism of corrosion and their electrochemical and kinetic theories.
2. Acquire the knowledge about the corrosion measurements and preventions.
3. Establish the mathematical relations for different type kinetic reactions.
4. Understand the surface phenomenon.
5. Understand the concepts, behaviour and significance of thermodynamics.

8th Semester
Medicinal Chemistry and Natural products
CHEM/8/MJ/127(a)

Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To introduce the concept of drug design using Structure-activity relationship (SAR) and the factors affecting bioactivity of drugs; classification and biosynthesis of natural product terpenes, alkaloids and steroids.*

UNIT I: Introduction to Medicinal Chemistry
Concept of drug, lead compound and lead modification, prodrugs and soft drugs; Structure-activity relationship (SAR), quantitative structure-activity relationship (QSAR); Factors affecting bioactivity – resonance, inductive effect, isosterism, bio-isosterism, spatial considerations; Theories of drug activity – occupancy theory, rate theory, induced fit theory, Concept of drug receptors – elementary treatment of drug-receptor interactions; Physico-chemical parameters – lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials; Factors affecting modes of drug administration, absorption, metabolism and elimination; Significance of drug metabolism in medicinal chemistry.

UNIT II: Antibiotics Cell wall biosynthesis, inhibitors of β-lactam rings, antibiotics inhibiting protein synthesis; Isolation, structure elucidation, synthesis, SAR and mode of action of penicillins; Synthesis of penicillin G, penicillin V, ampicillin, amoxicillin and cephalosporin. Isolation, structure elucidation, synthesis, SAR and mode of action of following antibiotics: streptomycin, tetracyclines and chloroamphanicol.

UNIT III: (a) **Terpenes**- Definition, isoprene rule, classification, biosynthesis, some representatives of monoterpenes, sesquiterpenes, diterpenes, sesterterpenes, triterpenes, tetraterpenes.
(b) **Alkaloids**- Definition, isolation, detection, some representatives of benzylisoquinoline alkaloids, quinoline alkaloids, indole alkaloids, ergot alkaloids, diterpene alkaloids, pyridine alkaloids, tropane alkaloids, pseudoalkaloids, purines bases; Hoffmann, Emde and von Braun degradation, biosynthesis of morphine and benylisoquinoline alkaloids.

UNIT IV: (a) **Steroids**- Introduction, nomenclature, biosynthesis of steroids; sterols, estrogens and saponins; isolation, biogenesis and chemical properties of cholesterol, testosterone and estrone.
(b) **Reactions and rearrangements**: Rearrangement reaction of Morphine, The Wesley – Moser rearrangement, Molecular Yoga: Reactions of papaverine, Reactions of Linalool, The Nametkin rearrangement.

Recommended books:
1. Chemistry of Natural Products: A unified approach by NR Krishnaswamy, Second Edition
2. Chemistry of Natural Products by SV Bhat, BA Nagasampagi and M. Sivakumar
3. Organic Chemistry by Paula Y. Bruice, Seventh Edition
4. Organic Chemistry by G. Marc Loudon, Fourth Edition

5. Lehninger Principles of Biochemistry by D. L Nelson & M. M. Cox, 5 th Edition (2008) W. H. Freeman and CBS Publishers, New Delhi
6. Medical Chemistry by Ashutosh Kar, New Age International Publishers.

Course Outcomes: *At the end of the course, the student will be able to:*
1. Understand the process of drug design by using different methods and theories of drug activity. Importance of physico-chemical parameters in drug activity.
2. Understand the structure and properties of antibiotic drugs and their biological activities.
3. Explore the isolation, classification and properties of natural product terpenes, alkaloids and steroids.
4. Understand the importance of molecular rearrangement for the synthesis of natural product derivatives.

8th Semester
Organometallics
CHEM/8/MJ/127(b)
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To inculcate the knowledge of organometallic compounds: their synthesis, structure and properties with reaction mechanisms.*

Unit I. Basic Organometallic Chemistry:
Complexes with pi-acceptor and sigma-donor ligands – 16 electron and 18 electron rules – Stability and Reactivity. Ligands in organometallic chemistry; Synthesis, bonding and reactivity of Metal-alkyl, -alkene, -alkyne, -allyl, -carbene, -carbyne and -carbide complexes, Agostic interaction.

Unit II. Main group organometallics:
Synthesis and reactions of organolithium and organomagnesium compounds; Organometallics of zinc and mercury: preparation, structure, bonding and reactions of aluminum organyls.

Unit III.
Metal carbonyls, clusters and Metal-metal multiple bond Synthesis, structure and reactivity of metal carbonyls; Metal cluster: Low nuclearity and high nuclearity carbonyl clusters; Boron clusters: Structure and bonding of boranes and Lipscomb's topology, styx system of numbering, nomenclature; Synthesis and structure of carboranes, metalloboranes, metallocarboranes; Skeletal electron counting, Wade's rule. Metal-metal multiple bond, quadruple bond, structures and bonding (MO).

Unit IV.
Reaction Mechanism of Transition Metal Complexes; Energy profile of reactions, discussion on general reactivity of metal complexes, Labile and inert complexes; mechanisms of ligand-replacement reactions; ligand displacement reactions in square planar and octahedral complexes; trans effect; electron transfer reactions: outer sphere and inner sphere, atom transfer.

Recommended Books

1. B. D. Gupta, A. J. Elias, "Basic Organometallic Chemistry", University Press, 2010.
2. C. Elschenbroich, Organometallics (3rd edn.), Wiley-VCH Publication (2006).
2. R. C. Mehrotra & A. Singh, Organometallic Chemistry: A Unified Approach (2nd edn.), New Age International (2000).
3. J. E. Huheey, E. A. Keiter, R. L. Keiter & O. K. Medhi, Principles, Structure and Reactivity (1st impression), Pearson Education (2006).
4. F. A. Cotton, G. Wilkinson, C.A. Murillo & M. Bochmann, Advanced Inorganic Chemistry (6th edn.), John Wiley (1999).
5. N. N. Greenwood & A. Earnshaw. Chemistry of the Elements, Pergamon Press (1984).
6. J. D. Lee, Concise Inorganic Chemistry (5th edn.) John Wiley & Sons (1996).

Course Outcomes: *At the end of the course, the student will be able to:*

1. Understand the structure, bonding, reactivity including safe handling of various organometallic compounds.

2. Understand and apply the various organometallics for catalytic applications.

3. Understand structure – activity relationship of metal carbonyls and reaction mechanisms of TM complexes.

4. Explain the reaction mechanism of the transition metal complexes.

8th Semester
Material Chemistry
CHEM/8/MJ/127(c)
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To make students learn about the properties of solid substance including their structure and defects, thermal, electrical, magnetic and optical properties.*

UNIT I. Solid State Structure:

Order - spatial, orientational; Types of solids; Symmetry in crystals - primitive lattice vector – Wigner-Seitz cell - crystal systems - Bravais lattices - crystallographic point groups and space groups; X-ray diffraction - reciprocal lattice - Ewald construction - structure factor - crystal structure solution and refinement - common crystal structure motifs.

Defects and Nonstoichiometery: Point, line and plane defects; Intrinsic and extrinsic defects - vacancies, Schottky and Frenkel defects - charge compensation; Nonstoichiometry and defects - thermodynamic and structural aspects; Color centres.

UNIT II.

Thermal Properties: Lattice vibrations - phonon spectrum; Lattice heat capacity; Thermal expansion; Thermal conductivity.

Electrical Properties: Free electron theory - electrical conductivity and Ohm's law - Hall effect; Band theory - band gap - metals and semiconductors - intrinsic and extrinsic semiconductors; Hopping

semiconductors; Semiconductor/metal transition; p-n junctions; Superconductors - Meissner effect - type I and II superconductors - isotope effect - basic concepts of BCS theory - manifestations of the energy gap - Josephson devices.

UNIT III. Magnetochemistry

Magnetic Properties: Classification of magnetic materials; Langevin diamagnetism; Quantum theory of paramagnetism; Cooperative phenomena - ferro, antiferro and ferrimagnetism - magnetic domains and hysteresis; Superparamagnetism.

Optical Properties: Optical reflectance - plasmon frequency; Raman scattering in crystals; Photoconduction; Photo and electroluminescence; Lasers; Photovoltaic and photoelectrochemical effects. (3 h)

UNIT IV.

General Concepts in Materials Synthesis: Phase diagrams; Preparation of pure materials; Nucleation and crystal growth; Crystal growth techniques; Zone refining.

Brief Introduction to Different Classes of Materials: High TC superconductors, Ionic conductors, Polymers, Liquid crystals, Molecular materials, Nanomaterials.

Recommended Books:

1. H. V. Keer, Principles of the Solid State (541.0421 K25P)
2. L. E. Smart and E. A. Moore, Solid State Chemistry: an Introduction (541.0421 Sm295)
3. M. T. Weller, Inorganic Materials Chemistry (546 W45I)
4. K. J. Klabunde, Nanoscale Materials in Chemistry (660 K66N)
5. W. D. Callister, Materials Science and Engineering, An Introduction (620.11 C13M)
6. C. Kittel, Introduction to Solid State Physics (530.41 K65I)
7. Journals like Chemistry of Materials, Journal of Materials Chemistry, Advanced Materials etc..

Course Outcomes: *At the end of the course, the student will be able to:*

1. Understand the different crystal systems and their properties.
2. Explain the defects and nonstoichiometry of crystals with their properties.
3. Understand the thermal, electrical, magnetic and optical properties of the substance.
4. Understand the concept of material synthesis using different techniques.

8th Semester

Bio-organic Chemistry

CHEM/8/MJ/127(d)

Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To make the students learn about the importance of biomolecules and enzymes in the biological reactions including carbohydrates, nucleic acid, lipids, amino acids, peptides and proteins.*

UNIT I.

(a) **Introduction of biomolecules**: Examples of biomolecules and building blocks of biopolymers. Types of reactions occurring in cells, structure of ice and liquid water, hydrogen bonding and hydrophobic interactions, buffers and the Henderson-Hasselbalch equation.

(b) **Carbohydrates chemistry**: Classification, D and L system of nomenclature, configuration of aldoses and ketoses; reactions of monosaccharides- base catalyzed isomerization, reduction, oxidation, Kiliani-Fischer synthesis, Wohl degradation, glycosides formation; reducing and non-reducing sugars, carbohydrates of glycolipids and glycoproteins, disaccharides and polysaccharides.

UNIT II.

(a) **Nuclei acids**- Nucleosides and nucleotides, structures of DNA and RNA, double helical structure of DNA, Base pairing, Methods used in nucleic acid separation and characterization, nucleic acid sequencing. Messenger RNA, RNA polymerase and protein synthesis.

UNIT III. Amino acids, Peptides and Proteins

(a) **Amino acids**- Definition, nomenclature, configuration, acid-base properties, synthesis (HVZ reaction, Strecker synthesis, reductive amination).

(b) **Peptides**- Definition, nomenclature, peptide bonds, synthesis of di- and tri-peptides.

(c) **Proteins**- structures of protein (primary, secondary, tertiary and quaternary), protein denaturation. Oligomeric proteins.

UNIT IV. Enzymes and catalysis: Substrate specificity of enzymes, requirement of coenzymes, regulation of enzyme activity and allosteric effect, enzyme nomenclature, enzyme kinetics and the Michaelis-Menten equation, various types of enzyme inhibition. application of enzymes in chemical synthesis, enzyme models and their applications.

Recommended Books:

1. Biochemistry by D. Voet & J. G. Voet, 4th Edition (2010) John Wiley
2. Lehninger Principles of Biochemistry by D. L Nelson & M. M. Cox, 5 th Edition (2008) W. H. Freeman and CBS Publishers, New Delhi
3. Biochemistry by J. M. Berg, J. L. Tymoczko & L. Stryer, 5 th Edition (2002) W. H. Freeman
4. Organic Chemistry by Paula Y. Bruice, Seventh Edition
5. Organic Chemistry by G. Marc Loudon, Fourth Edition

Course Outcomes: *At the end of the course, the student will be able to:*

1. Understand the biomolecules and its importance, carbohydrates reactions.
2. Explain the role of nucleic acids, lipids and membranes.
3. Understanding the importance of amino acids, peptides and proteins.
4. Understand that enzyme activity and its catalytic properties.

8th Semester
Green Chemistry
CHEM/8/MJ/127(e)
Marks [Scaled]: 100 (Internal Exam: 25 + End Semester Exam: 75); Credit -4

Objectives: *To introduce the green reagent and solvent in the chemical reaction to minimized the environmental effect.*

UNIT I. Green Chemistry Definition; Need for Green chemistry, evolution of Green Chemistry, principles of Green Chemistry. Classification of organic reactions under Green chemistry principles: a) Atom economic and non-toxic byproduct reactions: rearrangements, addition reaction, condensations, cascade strategies under catalysis, b) atom uneconomic reactions: substitutions, eliminations, Wittig reactions, degradation reactions.

UNIT II.
(a) **Organic reactions in Supercritical water or in Near Critical water (NCW) Region**:
Introduction; Organic reaction in SC-H_2O; Organic reactions in Near Critical water (NCW) Region; Synthesis of Carvacrol from carvone; Decarboxylation and autocatalysis.
(b) Microwave assisted organic reactions in water: Introduction; synthesis of heterocycles; Aminocarbonylation; synthesis of ketones from amines; Williamsons ether synthesis; Nucleophilic aromatic substitution.

UNIT III. Organic synthesis using Biocatalyst: Introduction; biochemical (microbial) Oxidations; biochemical (microbial) Reductions; Enzymes catalyzed hydrolytic processes; Enantioselective hydrolysis of mesodiesters; hydrolysis of N-Acyl aminoacids; Miscellaneous applications of enzymes.
UNIT IV. Green Preparations:
(a) Aqueous phase reactions – hydrolysis of methylsalicylate with alkali; chalcones, iodoforms, Phenacetin, Tylenol; Vanillideneacetone;
(b) Solid state (solvenless) reactions – Diphenyl carbinol; Phenyl benzoate
(c) Microwave assisted reactions – preparations of derivatives of some organic compounds.
(d) Esterification – benzocaine; Isopentyl acetate; Methylsalicylate.

Recommended Books:
1. Green Chemistry (Environmentally Benign Reactions), V.K. Ahluwalia, Ane Books Pvt. India.
2. Green Solvents for Organic Synthesis, V.K. Ahluwalia, Narosa.
3. Strategies for Green Organic Synthesis, by V. K. Ahulwalia, Ane Books Pvt. Ltd. 1st Edition, 2012.
4. Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner, Oxford University Press, Oxford, 1998.

Course outcomes*: At the end of the course, the student will be able to:*
1. Understand the importance of Green Chemistry and its environmental impact.

2. Explore the used of water as a green solvent in the chemical reaction.
3. Understand the importance of designing chemical synthesis through the minimization of hazardous chemicals.
4. Understand the importance of green chemistry in synthesizing organic chemicals in a greener way.
5. Exploring the used of biocatalyst for the synthesis of organic molecules.

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