SANSKARAM UNIVERSITY
JHAJJAR

Scheme of Examination and Syllabus for

B.Sc. Chemistry Hons.

Under Multiple Entry-Exit, Internships and CBCS-LOCF in accordance to NEP 2020

w.e.f. 2024-25

Programme Structure, B.Sc. Chemistry Hons., 2024

Semester	Discipline Specific Core Courses (4) #	Discipline Specific Elective (DSE) (4)#	Generic Elective (GE) (4)#	Ability Enhancement Course (AEC) (2)#	Skill Enhancement Course (SEC) (2)#	Internship/Apprenticeship/ Project/Community Outreach (IAPC) (2)	Value Addition Course (VAC) (2)#	Total Credits
I	Atomic Structure & Chemical Bonding (Inorganic Chemistry -I) Basic Concepts and Aliphatic Hydrocarbons Organic Chemistry-I) Gaseous and Liquid State (Physical Chemistry-I)	NA	Choose one GE from the pool of GE Courses of sem I	Choose one AEC from pool of courses	Choose one SEC from a pool of SEC of sem I	NA	Choose one VAC from apool of courses	**22**
II	Chemistry of s and p-Block Elements (Inorganic Chemistry -II) Haloalkanes, Arenes, Haloarenes, Alcohols, Phenols, Ethers and Epoxides (Organic Chemistry-II)	NA	Choose one GE from the pool of GE Courses of sem II	Choose one AEC from pool of courses	Choose one SEC from a pool of SEC of seme II	NA	Choose one VAC from apool of courses	**22**

	Chemical Thermodynamics and its Applications (Physical Chemistry – II)							
Students on exit shall be awarded Undergraduate Certificate in Chemistry after securing the requisite 44 credits in Semesters I - II								
III	DSC- 7 DSC- 8 DSC- 9	Choose one DSE from the pool of DSE Courses of sem III Or Choose one GE from the pool of GE Courses of sem III		Choose one AEC from a pool of courses	Choose one SEC **OR** Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*		Choose one VAC from apool of courses	**22**
IV	DSC- 10 DSC- 11 DSC- 12	Choose one DSE from the pool of DSE Courses of sem IV Or Choose one GE from the pool of GE Courses of sem IV		Choose one AEC from a pool of courses	Choose one SEC from a pool of SECs given for sem IV **OR** Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*		Choose one VAC from apool of courses	**22**
Students on exit shall be awarded Undergraduate Diploma in Chemistry after securing the requisite 88 credits after completion of Semesters I - IV								
Semester	**Core DSC (4) #**	**Discipline SpecificElective (DSE) (4) #**	**Generic Elective (GE) (4) #**	**Ability Enhancement Course (AEC) (2) #**	**Skill Enhancement Course (SEC) (2) #**	**Internship/Apprenticeship/ Project/Community Outreach (IAPC) (2)**	**Value Addition Course (VAC) (2) #**	**Total Credits**
V	DSC- 13 DSC- 14 DSC- 15	Choose one DSE from the pool of DSE Courses of sem V	Choose one GE from the pool of GE Courses of sem V		Choose one SEC from a pool of SECs given for sem V **OR** Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*			**22**
VI	DSC- 16 DSC- 17 DSC- 18	Choose one DSE from the pool of DSE Courses of sem VI	Choose one GE from the pool of GE Courses of sem VI		Choose one SEC from a pool of SECs given for sem VI **OR** Internship/Apprenticeship/Project/Community Outreach (IAPC) (2)*			**22**
Students on exit shall be awarded Bachelor of Chemistry (Hons.) after securing the requisite 132 credits on completion of Semesters I - VI								

VII	DSC-19	Choose from a pool of DSE and GE courses given for semester VII in the combinations given below: • Choose three DSE courses (3*4) OR • Choose two DSE (2*4) and one GE courses(4) OR • Choose one DSE (4) and two GE courses (2*4) ***			Dissertation on Major (4+2) OR Dissertation on Minor (4+2) OR Academic project/ Entrepreneurship (4+2)		**22**
VIII	DSC-20	Choose from a pool of DSE and GE courses given for semester VIII in the combinations given below: Choose three DSE courses(3*4) OR • Choose two DSE(2*4) and one GE courses(4) OR • Choose one DSE (4) and two GE courses (2*4) ***			Dissertation on Major (4+2) OR Dissertation on Minor(4+2) OR Academic project/ Entrepreneurship (4+2)		**22**
After securing the requisite 176 credits on completion of Semester VIII, students on exit shall be awarded • ***Bachelor of Chemistry (Hons. with Research / Academic Projects / Entrepreneurship)*** ***Or*** • ***Bachelor of Chemistry (Hons.) with Research in Chemistry (Major) and Discipline-2 (Minor)***							

Value inside parenthesis signifies credit of that course.
* There shall be choice in Semester III and IV to either choose a DSE (from a pool of Chemistry DSE courses) or a GE (from a pool of GE courses other than Chemistry).
** 'Research Methodology' shall be offered as one of the DSE courses in VI and VII. If a student wishes to pursue four years Honours Degree with research, he/she shall compulsorily opt for a Research Methodology course in either VI Semester or VII Semester.
***The following choices will be available in VII and VIII semesters:

(i) to choose three DSEs of 4 credits each

OR

(ii) to choose two DSEs and one GE of 4 credits each

OR

(iii) to choose one DSE and two GEs of 4 credits each.

List of Discipline Specific Core (DSC) Courses

A student will study three Discipline Specific Core Courses each in Semesters I to VI and one core course each in semesters VII and VIII. The semester wise distribution of DSC courses over eight semesters as listed in Table.

Semester	Discipline Specific Core (DSC) Course	Course Code	Nomenclature	Credits		
				L	P	Total
I	DSC-1	020701001	Atomic Structure & Chemical Bonding (Inorganic Chemistry - I)	3	1	4
	DSC-2	020701002	Basic Concepts and Aliphatic Hydrocarbons Organic Chemistry-I)	3	1	4
	DSC-3	020701003	Gaseous and Liquid State (Physical Chemistry-I)	3	1	4
II	DSC-4	020702004	Chemistry of s and p-Block Elements (Inorganic Chemistry - II)	3	1	4
	DSC-5	020702005	Haloalkanes, Arenes, Haloarenes, Alcohols, Phenols, Ethers and Epoxides(Organic Chemistry-II)	3	1	4
	DSC-6	020702006	Chemical Thermodynamics and its Applications (Physical Chemistry – II)	3	1	4
III	DSC-7	020703007		3	1	4
	DSC-8	020703008		3	1	4
	DSC-9	020703009		3	1	4
IV	DSC-10	020704010	Coordination Chemistry and Reaction Mechanism (Inorganic Chemistry -IV)	3	1	4

	DSC-11	020704011	Carbohydrates, Lipids and Hetero cyclic Compounds (Organic Chemistry- IV)	3	1	4
	DSC-12	020704012	Electrochemical Cells, Chemical Kinetics and Catalysis (Physical Chemistry IV)	3	1	4
V	DSC-13	020705013	Basics of Organometallic Chemistry (Inorganic Chemistry-V)	3	1	4
	DSC-14	020705014	Nucleic Acids, Amino Acids, Proteins and Enzymes (Organic Chemistry- V)	3	1	4
	DSC-15	020705015	Quantum Chemistry and Covalent bonding (Physical Chemistry V)	3	1	4
VI	DSC-16	020706016	Principles in Qualitative Analysis and Bioinorganic Chemistry (Inorganic Chemistry -VI)	3	1	4
	DSC-17	020706017	Polynuclear Hydrocarbons, Photochemistry, Pericyclic Reactions, and Spectroscopy of Organic Compounds (Organic Chemistry-VI)	3	1	4
	DSC-18	020706018	Photochemistry and Spectroscopy (Physical Chemistry VI)	3	1	4
VII	DSC-19	020707019				
VIII	DSC-20	020708020				

List of Discipline Specific Elective (DSE) Courses

The Discipline Specific Electives (DSEs) are a pool of credit courses of Chemistry from which a student will choose to study based on his/ her interest. A student of B.Sc. Hons. Chemistry gets an option of choosing one DSE of Chemistry in each of the semesters III to VI, while the student has an option of choosing a maximum of three DSE courses of Chemistry in semesters VII and VIII. The semester wise distribution of DSE courses over six semesters is listed in Table. In addition to the proposed courses, students may select courses from the Swayam.org as MOOCs courses in semester VII & VIII up to the permissible limit.

Semester	Discipline Specific Elective (DSE) Course	Course Code	Nomenclature	Credits		
				L	P	Total
III	DSE 1		Nuclear and Environmental Chemistry	3	1	4
	DSE 2		Inorganic Materials of Industrial Importance	3	1	4
IV	DSE 3		Green Chemistry in Organic Synthesis	3	1	4

	DSE 4		Reactions, Reagents and Chemical Process	2	2	4
	DSE 5		Solutions, Colligative properties, Phase Equilibria and adsorption	4	0	4
V	DSE 6		Applications of computers in Chemistry	4	0	4
	DSE 7			2	2	4
	DSE 8			2	2	4
VI	DSE 9			4	0	4
	DSE 10			2	2	4
	DSE 11			4	0	4
VII	DSE 12			2	2	4
	DSE 13			4	0	4
	DSE 14			4	0	4
	DSE 15			4	0	4
	DSE 16			2	2	4
	DSE 17			4	0	4
	DSE 18			3	1	4
	DSE 19		Research Methodology	4	0	4
VIII	DSE 20			4	0	4
	DSE 21			2	2	4

	DSE 22			4	0	4
	DSE 23			4	0	4
	DSE 24			4	0	4
	DSE 25			4	0	4

List of Generic Elective (GE) Courses

Generic Elective courses provide multidisciplinary education to students. Various GE courses offered by the Chemistry Department are listed below in Table**.** In addition to the proposed courses, students may select courses from the Swayam.org as MOOCs courses semesters VII & VIII up to the permissible limit.

Semester	Generic Elective (GE) Course	Course Code	Nomenclature	Credits		
				T	P	Total
I	GE-1		Atomic Structure and Chemical Bonding (GE1)	3	1	4
	GE-2		Coordination and Organometallic Compounds	2	2	4
II	GE-3		Bioinorganic Chemistry (GE-3)	2	2	4
	GE-4		Basic Concepts of Organic Chemistry (GE-4)	3	1	4
III	GE-5		Chemistry of Oxygen containing Functional Groups and their Applications to Biology (GE-5)	2	2	4
	GE-6		Molecules of Life	2	2	4
IV	GE-7		States of Matter (GE-7)	3	1	4
	GE-8		Chemical Kinetics and Photochemistry	3	1	4
V	GE-9		Conductance and Electrochemistry (GE-9)	3	1	4
	GE-10		Basics of Polymer Chemistry	3	1	4
VI	GE-11		Chemistry of Food Nutrients (GE-11)	3	1	4
	GE-12		Chemistry: Statistical Methods and Data Analysis (GE-12)	3	1	4
VII	GE-13		Medicines in Daily Life (GE-13)	3	1	4
	GE-14			4	0	4
	GE-15		Chemistry and Society (GE-15)	3	1	4
	GE-16		Role of Metals in Medicines	4	0	4
VIII	GE-17		Energy and the Environment	4	0	4
	GE-18		Chemistry of Fragrances and Flavours: An Industry's Perspective	3	1	4
	GE-19		Radiochemistry in Energy, Medicine and Environment (GE-19)	3	1	4

	GE-20		Green Chemistry	3	1	4

List of Skill Enhancement (SEC) Courses

To enhance the skills required for advanced studies, research and employability of studentsvarious Skill Enhancement Courses will be offered to students as listed in Table. In addition to the above proposed courses, students may select courses from the Swayam.org as MOOCs courses upto the permissible limit.

Semester	Skill Enhancement Course (SEC)	Course Code	Nomenclature	Credits		
				T	P	Total
I	SEC 1		Chemistry of Cosmetics and Hygiene Products	0	2	2
	SEC 2		Food Adulterants in everyday life	0	2	2
II	SEC 3		Water Treatment	0	2	2
	SEC 4		Lab Testing and Quality Assurance	1	1	2
III	SEC 5					
	SEC 6					
IV	SEC 7					
	SEC 8					
V	SEC 9					
	SEC 10					
VI	SEC 11					
	SEC 12					

Detailed Syllabus

Course Code: DSC-1

Course Title: Atomic Structure & Chemical Bonding

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives: The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic and covalent bonding, and explains that chemical bonding is best regarded as a continuum between the two cases. It discusses the periodicity in properties with reference to the s and p block, which is necessary in understanding their group chemistry. The student will also learn about the fundamentals of acid-base and redox titrimetric analysis.

Course Learning Outcomes: Upon completion of this course, students will be able to,

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization enthalpy and electron affinity of elements.

● Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

● Understand the concept of lattice energy using Born-Landé and Kapustinskii equation.

● Calibrate the apparatus used in titrimetric analysis and prepare standard solutions for titration

● Understand the theory and application of various acid-base and redox titrations.

● Comprehend the theory of acid-base indicators

THEORY

(Credit: 03; 45 Hours)

UNIT – I (15 Hours)

Unit 1: Atomic Structure Recapitulation of concept of atom in ancient India, Bohr's theory & its limitations, atomic spectrum of hydrogen atom. de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Postulates of wave mechanics, Time independent Schrödinger's wave equation, well behaved wave function, significance of ψ and ψ^2 . Quantum mechanical treatment of H- atom, Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of s, p, and d orbitals, Relative energies of orbitals. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its

limitations.

UNIT – II (6 Hours)

Unit 2: Periodic properties of Elements & Periodic Trends Brief discussion of the following properties of the elements, with reference to s- & pblock and their trends: (a) Effective nuclear charge, shielding or screening effect and Slater's rules (b) Atomic and ionic radii (c) Ionization enthalpy (Successive ionization enthalpies) (d) Electron gain enthalpy (e) Electronegativity, Pauling's scale of electronegativity. Variation of electronegativity with bond order and hybridization.

UNIT – III (12 Hours)

Unit 3: Ionic bond General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Landé equation with derivation, Madelung constant, importance of Kapustinskii equation for lattice energy. Born-Haber cycle and its applications. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

UNIT – IV (12 Hours)

Unit 4: Covalent bond Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H2O, NH3, PCl3, PCl5, 98 SF6, ClF3, I3, BrF2+, PCl6- , ICl2- ICl4- , and SO42-. Application of VSEPR theory in predicting trends in bond lengths and bond angles. Valence Bond theory (Heitler-London approach). Hybridization, equivalent and nonequivalent hybrid orbitals, Bent's rule. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Molecular orbital diagrams of homo & hetero diatomic molecules [N2, O2, C2, B2, F2, CO, NO] and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

Practical component

Practicals: Inorganic Chemistry-I (30 Hours) (Laboratory periods: 15 classes of 2 hours each)

1. Titrimetric Analysis: (i) Calibration and use of apparatus (ii) Preparation of solutions of different Molarity/Normality.

2. Acid-Base Titrations: Principles of acid-base titrations to be discussed.

(i) Estimation of oxalic acid using standardized NaOH solution

(ii) Estimation of sodium carbonate using standardized HCl.

(iii)Estimation of carbonate and hydroxide present together in a mixture.

(iv)Estimation of carbonate and bicarbonate present together in a mixture.

3. Redox Titration: Principles of oxidation-reduction titrations to be discussed.

(i) Estimation of oxalic acid using standardized KMnO4 solution

(ii) Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.

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

readings

References:

Theory : 1. Lee, J.D. (2010), Concise Inorganic Chemistry, Wiley India.

2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.

3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.

4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.

5. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.

6. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson.

7. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.

8. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.

9. Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), Inorganic Chemistry, 6th Edition, Freeman & Company

10. Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

2. Harris, D. C.; Lucy,C. A.(2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company

Course Code: DSC-2

Course Title: Basic Concepts and Aliphatic Hydrocarbons

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives: The core course Organic Chemistry I is designed in a manner that it forms a cardinal part of the learning of organic chemistry for the subsequent semesters. The course is infused with the recapitulation of fundamental concepts of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, the functional groups-alkanes, alkenes, alkynes are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Course Learning Outcomes: After completing this course, student will be able to,

- Understand and explain the electronic displacements and reactive intermediates and their applications in basic concepts.
- Formulate the mechanistic route of organic reactions by recalling and correlating the fundamental concepts.
- Identify and comprehend mechanism for free radical substitution, electrophilic addition, nucleophilic substitution and elimination reactions.
- Understand the fundamental concepts of stereochemistry.
- Understand and suitably use the chemistry of hydrocarbons

THEORY (Credit: 03; 45 Hours)

UNIT – I (9 Hours)

Unit I: Basic Concepts of Organic Chemistry Electronic displacements and their applications: inductive, electromeric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity. Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions, carbenes and free radicals. Electrophiles & nucleophiles, and introduction to types of organic reactions: addition, elimination and substitution reactions.

UNIT – II (18 Hours)

Unit II: Stereochemistry Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newman, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration. Racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations (CIP rules). Geometrical isomerism: cis-trans, syn-anti and E/Z notations. Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagrams of Ethane, Propane and butane). Relative stability of cycloalkanes (Baeyer strain theory), Cyclohexane conformations with energy diagram. Conformations of monosubstituted cyclohexanes.

UNIT – III (9)

Unit III: Aliphatic Hydrocarbons Alkanes: Preparation, Halogenation of alkanes, Concept of relative reactivity v/s selectivity.

Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E1, E2, E1cb reactions, Saytzeff and Hoffmann eliminations. Electrophilic additions, mechanism with suitable examples, (Markownikoff/Anti-markownikoff addition), syn and anti-addition; addition of H2, X2, oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, hydroxylation, reaction with NBS,

UNIT – IV (9)

Reactions of alkynes; acidity, Alkylation of terminal alkynes, electrophilic addition: hydration to form carbonyl compounds, Relative reactivity of alkenes and alkynes, 1,2-and 1,4-addition reactions in conjugated dienes, Diels Alder reaction (excluding stereochemistry)

Practical component

Practical (30 Hours)

Credits: 01 (Laboratory periods: 15 classes of 2 hour each)

Note: Students should be provided with handouts prior to the practical class

1. Calibration of a thermometer and determination of the melting points of the organic compounds using any one of the following methods-Kjeldahl method, electrically heated melting point apparatus and BODMEL).

2. Concept of melting point and mixed melting point.

3. Concept of recrystallisation using alcohol/water/alcohol-water systems (Any two).

4. Determination of boiling point of liquid compounds (boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL method)

5. Separation of a mixture of two amino acids/sugars by radial/ascending paper chromatography.

6. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

7. Detection of extra elements

Essential/recommended readings References: Theory

1. Morrison, R.N., Boyd, R.N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

2. Finar, I.L. (2002), Organic C hemistry, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education. 3. Eliel, E.L., Wilen, S.H. (1994), Stereochemistry of Organic Compounds; Wiley: London.

Practicals

1. Mann, F.G., Saunders, B.C. (2009), Practical O rganic C hemistry, 4th Edition, Pearson Education.

2. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

3. Furniss, B.S., Hannaford, A.J., Smith, P.W.G.; Tatchell, A.R (2004), Vogel's Textbook of Practical Organic Chemistry, Pearson.

4. Leonard, J., Lygo, B., Procter, G. (2013) Advanced Practical Organic Chemistry, 3rd Edition, CRC Press.

5. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

Course Code: DSC- 3

Course Title: Gaseous and Liquid State

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives: The objective of this course is to develop basic and advance concepts regarding gases and liquids. It aims to study the similarity and differences between the two states of matter and reasons responsible for these. The objective of the practicals is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-I course.

Course Learning Outcomes: On successful completion of this course, the students will have the skill and knowledge to,

- Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
- Apply the concepts of gas equations and liquids while studying other chemistry courses and every-day life.
- Handle stalagmometer and Ostwald viscometer properly.
- Determine the density of aqueous solutions.
- Dilute the given solutions as per required concentrations.
- Data reduction using numerical and graphical methods.

THEORY (Credit: 03; 45 Hours)

UNIT – I (14 Hours)

Gaseous state

Kinetic theory of gases- postulates and derivation of kinetic gas equation, Maxwell distribution of molecular velocities and its use in evaluating average, root mean square and most probable velocities and average kinetic energy. Definition, expression, applications and temperature and pressure dependence of each one of the following properties of ideal gases: Collision frequency, Collision diameter, Mean free path. Coefficient of viscosity, definition, units and origin of viscosity of gases, relation between mean free path and coefficient of viscosity, temperature and pressure dependence of viscosity of a gas, calculation of molecular diameter from viscosity Barometric distribution law, its derivation and applications,

alternative forms of barometric distribution law in terms of density and number of molecules per unit volume, effect of height, temperature and molecular mass of the gas on barometric distribution

Behavior of real gases- Compressibility factor, Z, Variation of compressibility factor with pressure at constant temperature (plot of Z vs P) for different gases (H_2, CO_2, CH_4 and NH_3), Cause of deviations from ideal gas behaviour and explanation of the observed behaviour of real gases in the light of molecular interactions

UNIT – I (11 Hours)

van der Waals (vdW) equation of state, Limitations of ideal gas equation of state and its modifications

in the form of derivation of van der Waal equation, Physical significance of van der Waals constants, application of van der Waal equation to explain the observed behaviour of real gases.

Isotherms of real gases- Critical state, relation between critical constants and van der Waals constants,

correlation of critical temperature of gases with intermolecular forces of attraction, Continuity of states,

Limitations of van der Waals equation, Reduced equation of state and law of corresponding states (statement only). Virial equation of state-Physical significance of second and third virial coefficients,

van der Waals equation expressed in virial form, Relations between virial coefficients and van der Waals

constants

UNIT – III (10 Hours)

Liquid state Nature of liquid state, qualitative treatment of the structure of the liquid state Physical properties of liquids-vapour pressure, its origin and definition, Vapour pressure of liquids and intermolecular forces, and boiling point

Surface tension, its origin and definition, Capillary action in relation to cohesive and adhesive forces, determination of surface tension by (i) using stalagmometer (drop number and drop mass method both) and (ii) capillary rise method, Effects of addition of sodium chloride, ethanol and detergent on the surface tension of water and its interpretation in terms of molecular interactions, Role of surface tension in the cleansing action of detergents.

UNIT – IV (10 Hours)

Coefficient of viscosity and its origin in liquids, Interpretation of viscosity data of pure liquids (water, ethanol, ether and glycerol) in the light of molecular interactions, Effects of addition of sodium chloride, ethanol and polymer on the viscosity of water, relative viscosity, specific viscosity and reduced viscosity of a solution, comparison of the origin of viscosity of liquids and gases, effect of temperature on the

viscosity of a liquid and its comparison with that of a gas.

Practical component

Practicals 60 Hours

(Laboratory periods: 15 classes of 4 hours each)

1. Gases

a. To verify the Charles law using Charles law apparatus

b. To determine the value of universal gas constant R using the reaction $Mg(s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)$

2. **Surface tension measurements using stalagmometer**

a. Determine the surface tension of a liquid by drop number method.

b. Determine the surface tension of a liquid by drop weight method.

c. Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.

d. Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions: (i) sugar (ii) ethanol (iii) sodium chloride

e. Study the variation of surface tension with different concentration of sodium chloride solutions.

3. **Viscosity measurement using Ostwald's viscometer**

a. Determination of co-efficient of viscosity of two unknown aqueous solution.

b. Study the variation of viscosity with different concentration of sugar solutions.

c. Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature and explain the observations in terms of molecular interactions

d. Study the variation of viscosity of water with the amounts of a solute and calculate the intrinsic viscosity at room temperature.

e. Determine the viscosity average molecular mass of the polymer (PVA) using viscosity measurements.

Essential/recommended readings References:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.

2. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.

3. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.

4. Kapoor, K.L. (2015), A Text book of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.

Practical:

• Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.

• Kapoor, K.L. (2019), A Text book of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

• Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.

Suggestive readings Additional Resources:

1 Moore, W.J. (1972), Physical Chemistry, 5th Edition, Longmans Green & Co. Ltd. Glasstone, S. (1948), Textbook of Physical Chemistry , D. Van Nostrand company, New York.

Course Code: DSC-4

Course Title: Chemistry of s and p-Block Elements

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives:

- To develop the general principles of metallurgy and s-, p-block elements.
- To introduce the terms minerals, ores, concentration, benefaction, calcination, roasting, refining, etc. and explain the principles of oxidation and reduction as applied to the extraction procedures.
- To make students ware of different methods of purification of metals, such as electrolytic, oxidative refining, VanArkel-De Boer process and Mond's process are discussed and applications of thermodynamic concepts like that of Gibbs energy and entropy to the extraction of metals.
- To familiarize students with the patterns and trends exhibited by s- and p-block elements and their compounds with emphasis on synthesis, structure, bonding and uses.
- To impart information about the fundamentals of internal and external redox indicators, and iodometric/iodimetric titrations.

Course Learning Outcomes: After completing this course, student will be able to,

- Learn the fundamental principles of metallurgy and understand the importance of recovery of by-products during extraction.
- Applications of thermodynamic concepts like that of Gibbs energy and entropy to the principles of extraction of metals.
- Learn about the characteristics of s- and p- block elements as well as the synthesis, structure, bonding and uses of their compounds
- Understand the concept and use of internal and external redox indicators
- Comprehend the theory and application of iodometric and iodimetric titrimetric analysis

THEORY (Credit: 03; 45 Hours)

UNIT – I: General Principles of Metallurgy (6 Hours)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining. Brief discussion of metals and alloys used in ancient and medieval India.

UNIT – II: Chemistry of s- Block Elements (15 Hours)

General characteristics: melting point, flame colouration, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. Common features such as ease of formation, thermal stability, energetics of dissolution, and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates. Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties

UNIT – III: Chemistry of p-Block Elements (9 Hours)

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.

UNIT – IV: Compounds of p-Block Elements (15 Hours)

Acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction,
hydrolysis, action of heat on the following:

- Hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P,As, Sb, Bi), Group 16 and Group 17.
- Oxoacids of phosphorus, sulphur and chlorine
- Interhalogen and pseudohalogen compound
- Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF_2)

Practical component – 30 Hours

1**. Redox Titrations**

(i)Estimation of Fe(II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.

(ii) Estimation of Fe(II) with $K_2Cr_2O_7$ using N-phenyl anthranilic acid as internal indicator.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using external indicator.

2. Iodo/Iodimetric Titrations

(i) Estimation of Cu(II) using sodium thiosulphate solution (Iodometrically).

(ii) Estimation of K2Cr2O7 using sodium thiosulphate solution (Iodometrically).

(iii)Estimation of antimony in tartaremetic iodimetrically.

(iv) Estimation of Iodine content in iodized salt.

Essential/recommended readings

Theory:

1. Lee, J. D.; (2010), Concise Inorganic Chemistry, Wiley India.

2. Huheey, J. E.; Keiter, E. A.; Keiter; R.L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.

3. Atkins, P. W.; Overton, T. L.; Rourke, J. P.; Weller, M. T.; Armstrong, F. A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.

4. Miessler, G. L.; Fischer P. J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.

5. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5thEdition, Pearson.

6. Canham, G. R., Overton, T. (2014), Descriptive Inorganic Chemistry, 6th Edition, Freeman and Company.

7. Greenwood, N. N.; Earnsaw, A., (1997), Chemistry of Elements, 2nd Edition, Elsevier.

Practicals:

1. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denney, R. C. (1989), Vogel's Text book of Quantitative Chemical Analysis, John Wiley and Sons.

2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.

3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, 6th Edition, PHI Learning Private Limited.

Course Code: DSC-5

Course Title: Haloalkanes, Arenes, Haloarenes, Alcohols, Phenols, Ethers and Epoxides

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives:

- To impart understanding of the chemistry of organic functional groups, which include haloalkanes, aromatic hydrocarbons, haloarenes and some oxygen containing functional groups, along with their reactivity patterns.
- To develop understanding of detailed reactions and mechanistic pathways for each functional group to unravel the spectrum of organic chemistry and the extent of organic transformations.
- To aid in the paramount learning of the concepts and their applications.

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

- Understand reactions of arenes, haloarenes and some oxygen containing functional groups.
- Understand the concept of protection and deprotection
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Propose plausible mechanisms for the reactions under study.

THEORY (Credit: 03; 45 Hours)

Unit - 1: Haloalkanes (10 Hours)

Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution v/s elimination.

Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.

Unit - II: Aromatic Hydrocarbons (06 Hours)

Concept of Aromaticity and anti-aromaticity; Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/acylation with their mechanism. Directing effects of groups in electrophilic substitution.

Unit - III: Aryl halides (04 Hours)

Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Unit - IV: Alcohols, Phenols, Ethers & Epoxides (10 Hours)

Alcohols: Relative reactivity of 1°, 2°, 3° alcohols, reactions of alcohols with sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline KMnO4, acidic dichromate, conc. HNO3). Oppenauer oxidation; Diols: oxidation of diols by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation using Cumene hydroperoxide, Acidity and factors affecting it, Kolbe's–Schmidt reactions, Riemer-Tiemann reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Fries and Claisen rearrangements and their mechanism. Ethers and Epoxides: Acid and Base catalyzed cleavage reactions.

Practical - 60 Hours

1. Acetylation of any one of the following compounds: amines (aniline, o-, m-, ptoluidines and o-, m-, p-anisidine) and phenols (β-naphthol, salicylic acid) by any one method:

i. Using conventional method ii. Using green approach

2. Benzolyation of one of the following amines (aniline, o-, m-, p-toluidines and o, m-, p-anisidine) or one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.

3. Bromination of acetanilide/aniline/phenol by anyone of the following:

(a) Green method b) Conventional method

4. Nitration of nitrobenzene/chlorobenzene.

5. Haloform reaction of ethanol.

6. Oxidation of benzyl alcohol to benzoic acid

7. Estimation of the given sample of phenol/amine by: a) Acetylation b) Bromate-Bromide method

8. Functional group tests for alcohols, phenols, carboxylic acids, phenols, carbonyl compounds, esters.

Essential/recommended readings

Theory:

1. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

2. Finar, I.L. (2002), Organic Chemistry, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

3. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), Intermediate for Organic Synthesis, I.K. International.

4. Solomons, T.W.G., Fryhle, C.B., Snyder, S.A. (2017), Organic Chemistry, 12th Edition, Wiley.

Practical:

1. Mann, F.G., Saunders, B.C. (2009), Practical Organic Chemistry, 4th Edition, Pearson Education.

2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2005), Vogel's Textbook of Practical Organic Chemistry, Pearson.

3. Ahluwalia, V.K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press.

4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

5. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Suggestive readings

1. Carey, F.A., Sundberg, R. J. (2008), Advanced Organic Chemistry: Part B: Reaction and Synthesis, Springer.

2. Bruice, P.Y. (2020), Organic Chemistry, 3rd Edition, Pearson.

3. Patrick, G. (2012), BIOS Instant Notes in Organic Chemistry, Viva Books.

4. Parashar, R.K., Ahluwalia, V.K. (2018), Organic Reaction Mechanism, 4th Edition, Narosa Publishing House.

Course Code: DSC-6

Course Title: Chemical Thermodynamics and its Applications

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives: To make students understand thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics and their correlation with other branches of physical chemistry and make them able to apply thermodynamic concepts to the system of variable compositions, equilibrium and colligative properties.

Course Learning Outcomes: After completing this course, student will be able to,

- Understand the three laws of thermodynamics, concept of State and Path functions, extensive and intensive properties.
- Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for an ideal gas under different conditions.
- Explain the concept of partial molar properties.

THEORY (Credit: 03; 45 Hours)

UNIT – I: Basic Concepts of Chemical Thermodynamics (06 Hours)

Intensive and extensive variables; state and path functions; isolated, closed and open systems. Mathematical treatment - Exact and inexact differential, Partial derivatives, Euler's reciprocity rule, cyclic rule.

UNIT – II: First law and Thermochemistry (15 Hours)

Concept of heat, Q, work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, Joule Thompson Porous Plug experiment, Nature of Joule Thompson coefficient, calculations of Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of hydration, enthalpy of formation and enthalpy of combustion and its applications, bond dissociation energy and bond enthalpy; effect of temperature (Kirchhoff's equations) on enthalpy of reactions.

UNIT – III: Second Law (15 Hours)

Concept of entropy; statement of the second law of thermodynamics, Carnot cycle. Calculation of entropy change for reversible and irreversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity (for ideal gases). Relation between JouleThomson coefficient and other thermodynamic parameters;

inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

UNIT – IV Third Law (09 Hours)

Statement of third law, unattainability of absolute zero, calculation of absolute entropy of molecules, concept of residual entropy, calculation of absolute entropy of solid, liquid and gases.

Systems of Variable Composition

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

Practical – 30 Hours

Thermochemistry:

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization).

(b) Determination of heat capacity of a calorimeter for different volumes using heat gained equal to heat lost by cold water and hot water.

(c) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(d) Determination of the enthalpy of ionization of ethanoic acid.

(e) Determination of integral enthalpy solution of endothermic salts.

(f) Determination of integral enthalpy solution of exothermic salts.

(g) Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(h) Determination of enthalpy of hydration of salt.

(i) Study of the solubility of benzoic acid in water and determination of ΔH. Any other experiment carried out in the class.

Essential/recommended readings

Theory

1. Peter, A.; Paula, J. de. (2011), Physical Chemistry, 9th Edition, Oxford University Press.

2. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.

3. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 2, 6th Edition, McGraw Hill Education.

4. Kapoor, K.L., A Textbook of Physical Chemistry, Vol 3, 5th Edition, McGraw Hill Education.

5. McQuarrie, D. A.; Simon, J. D. (2004), Molecular Thermodynamics, Viva Books Pvt. Ltd.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi. 2. Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York. Suggestive readings 1. Levine, I.N. (2010), Physical Chemistry, Tata Mc Graw Hill. 2. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A.; Will, S. (2011), Commonly asked Questions in Thermodynamics. CRC Press.

GENERIC ELECTIVE (GE) COURSES

Course Code: GE 1

Course Title: Atomic Structure and Chemical Bonding

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives:

- To discuss the structure of atom as a necessary pre-requisite in understanding the nature of chemical bonding in compounds.
- To provide basic knowledge about ionic and covalent bonding.

Course Learning Outcomes: Upon completion of this course, students are expected to understand the following concepts.

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, and shapes of s, p, and d orbitals
- Understand the concept of lattice energy and solvation energy.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

THEORY (Credit: 03; 45 Hours)

Theory:

Unit – 1: Atomic Structure (14 Hours)

Review of: Bohr's theory and its limitations, Heisenberg uncertainty principle, Dual behaviour of matter and radiation, De-Broglie's relation, Hydrogen atom spectra, need of a new approach to atomic structure. Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and $\psi 2$, Schrödinger equation for hydrogen atom, radial and angular parts of the hydrogen wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation), radial and angular nodes and their significance, radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes, discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, 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 – 2: Chemical Bonding and Molecular Structure (12 Hours)

Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, statement of Born-Landé equation for calculation of lattice energy (no derivation), Born Haber cycle and its applications, covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules. Ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Unit – 3 (10 hours)

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR (H_2O, NH_3, PCl_5, SF_6, ClF_3, SF_4) and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

Unit – 4 (9 hours)

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for ss, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+

Practicals: (30 Hours) (Laboratory Periods: 30)

1. Acid-Base Titrations: Principles of acid-base titrations to be discussed.

(i) Estimation of sodium carbonate using standardized HCl.

(ii) Estimation of carbonate and hydroxide present together in a mixture.

(iii) Estimation of carbonate and bicarbonate present together in a mixture.

(iv) Estimation of free alkali present in different soaps/detergents

2. Redox Titrations: Principles of oxidation-reduction titrations (electrode potentials) to be discussed.

(i) Estimation of oxalic acid by titrating it with KMnO4.

(ii) Estimation of Mohr's salt by titrating it with KMnO4.

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

(iv) Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator (diphenylamine/ N-phenylanthranilic acid).

References: Theory:

1. Lee, J.D.; (2010), Concise Inorganic Chemistry, Wiley India.

2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry Principles of Structure and Reactivity, Pearson Education.

3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts a nd M dels of Inorganic Chemistry,

John Wiley & Sons. 4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.

Practicals

• Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Additional Resources:

1. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.

2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition

Course Code: GE 2

Course Title: Coordination and Organometallic Compounds

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives:

- To introduce students to some important d-block metals and their compounds which they are likely to come across.
- To make students learn about organometallic compounds, a frontier area of chemistry providing an interface between organic and inorganic chemistry.
- To familiarize students with coordination compounds which find manifold applications in diverse fields.

Course Learning Outcomes: At the end of this course, the students will be able to,

- Familiarize with different types of organometallic compounds, their structures and bonding involved.
- Understand the nature of Zeise's salt and compare its synergic effect with that of carbonyls.
- Identify important structural features of tetrameric methyl lithium and understand the concept of multicenter bonding in these compounds
- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species
- Use IR data to explain the extent of back bonding in carbonyl complexes
- Understand the terms, ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes
- Understand the properties of coordination compounds and VBT and CFT for bonding in coordination compounds
- Explain the meaning of the terms Δo, Δt, pairing energy, CFSE, high spin and low spin and how
- CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy

Theory:

Unit 1: Coordination Chemistry (4 Hours)

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands.

Unit 2: Bonding in coordination compounds (7 Hours)

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes of Cr, Fe, Co and Ni. Drawbacks of VBT.

Unit 3: Crystal Field Theory (7 Hours)

Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields. Crystal field stabilization energy (CFSE), concept of pairing energy. Factors affecting the magnitude of Δo. Spectrochemical series. Splitting of d orbitals in tetrahedral symmetry. Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry. Jahn Teller distortion, square planar coordination.

Unit 4: Organometallic Compounds (12 Hours)

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structure and bonding of methyl lithium and Zeise's salt. Structure and physical properties of ferrocene. 18-electron rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Practicals: 30 Hours

1. **Gravimetry**

   Discuss basic principles of gravimetry (precipitation, co-precipitation and post precipitation, digestion, washing etc)

(i) Estimation of Ni(II) using dimethylglyoxime (DMG).

(ii) Estimation of copper as CuSCN. (iii) Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)3 (aluminium oxinate).

2. **Inorganic Preparations**

(i) Schiff's base involving ethylenediamine and salicylaldehyde (or any other amine and aldehyde/ketone) and to check its purity using TLC.

(ii) Nickel/ Copper complex of the above prepared Schiff's base and its characterisation using UV/Vis spectrophotometer. The IR spectra also to be interpreted

(iii) tetraamminecopper (II) sulphate

(iv) potassium trioxalatoferrate (III) trihydrate.

(v) tetraamminecarbonatocobalt(III) nitrate

References: Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, W. H. Freeman and Company.

2. Miessler, G. L.; Fischer P.J.; Tarr, D.A. (2014), Inorganic Chemistry, Pearson.

3. Huheey, J.E.; Keiter, E.A., Keiter; R.L., Medhi, O.K. (2009), Inorganic Chemistry Principles of Structure and Reactivity, Pearson Education.

4. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.

5. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry Wiley-VCH.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

2. Schiff Base Complex of Cu (II) with Antibacterial and Electrochemical Study, Arjun C. Bhowmick, Majharul I. Moim, Miththira Balasingam , American Journal of Chemistry 2020, 10(2): 33-37, DOI: 10.5923/j.chemistry.20201002.

03 Keywords: Organometallic compounds, metal carbonyls, synergistic effect, Coordination compounds, VBT, Crystal field theory, Splitting of d levels, Dq

Course Code: GE 3

Course Title: Bioinorganic Chemistry

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives:

- To introduce students to bioinorganic chemistry, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry and biology.
- To make students learn about the importance of inorganic chemical species, especially metals, in biological systems, through discussions on topics such as the sodium-potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions and their antidotes.

Course Learning Outcomes: At the end of this course, the students will be able to,

- Classify metal ions in biological systems as essential, non-essential, trace & toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system
- Explain the use of chelating agents in medicine

THEORY (Credit: 03; 45 Hours)

Theory:

Unit 1: Introduction (6 Hours)

A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non-proteins). Brief idea about membrane transport, channels, pumps.

Unit 2: Role of s-block Elements in Biological System **(8 Hours)**

Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump, role of Mg2+ ions in energy production and chlorophyll. Role of calcium in bone formation.

Unit 3: Role of iron in Biological System **(8Hours)**

Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism,

Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon monoxide. Storage and transport of iron in humans (ferritin and transferrin).

Unit 4: Toxicity of Heavy Metal Ions **(8 Hours)**

Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes

Practicals: (60 Hours) (Laboratory Periods: 30)

1. Spectrophotometric estimation:

(i) Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$/$CoSO_4$ in a solution of unknown concentration

(ii) Spectrophotometric estimation of Fe^{2+} ions by using 1, 10- phenanthroline

(iii) Determination of the composition of the Fe^{3+} - salicylic acid complex in solution by Job's method.

2. Complexometric titrations using disodium salt of EDTA:

(i) Estimation of Zn^{2+} using EBT / Xylenol orange as indicator

(ii) Estimation of Mg^{2+}

(iii) Estimation of Ca^{2+} by substitution method

(iv) To estimate the concentration of Ca in commercially available medicines.

(v) To estimate the Mg present in multivitamins.

References:

Theory:

1. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry Principles of Structure and Reactivity, Pearson Education.

2. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), Inorganic Chemistry 2nd Ed., Oxford University Press.

3. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. Basic Inorganic Chemistry, 3rd Edition, Wiley India.

4. Crichton, R.R. (2008), Biological Inorganic Chemistry: An Introduction. Amsterdam, Elsevier.

5. Kaim, W., B. Schwederski and A. Klein. (2014), Bioinorganic Chemistry: Inorganic Elements in the

Chemistry of Life: A n Introduction and Guide. 2nd Edition, Wiley.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Additional Resources:

1. Lippard, S.J.; Berg, J.M. (1994), Principles of Bioinorganic Chemistry, Panima Publishing Company.

2. Greenwood, N.N.; Earnshaw, A. (1997), Chemistry of the Elements, 2nd Edition, Elsevier

Course Code: GE 4

Course Title: Basic Concepts of Organic Chemistry (GE-4)

Total Credits: 04 (Credits: Theory: 03, Practical: 01)

Total Hours: Theory: 45, Practical: 30

Course Objectives:

- To teach the fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three- dimensional space.
- To establish the applications of these concepts, different types of organic reactions are introduced.

Course Learning Outcomes: At the end of this course, the students will be able to,

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reaction mechanisms including free radical substitution, electrophilic addition and electrophilic aromatic substitution.
- Differentiate between various types of organic reactions possible on the basis of reaction conditions

THEORY (Credit: 03; 45 Hours)

Theory:

Unit 1: Basic Concepts (6 Hours)

Electronic displacements and their applications: Inductive, electromeric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity. Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions and free radicals. Electrophiles and nucleophiles Concept of Aromaticity: Huckel's rule

Unit 2: Stereochemistry (10 Hours)

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers,

diastereomers. specific rotation; Configuration and projection formulae: Newmann, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration. CIP rules: Erythro/Threo, D/L and R/S designations. Geometrical isomerism: cis-trans, syn-anti and E/Z notations.

Unit 3: Types of Organic Reactions (6 Hours)

Introduction to substitution, addition, elimination, isomerization, rearrangement, oxidation and reduction reactions.

Free radical substitutions (Halogenation), concept of relative reactivity v/s selectivity. Free radical reactions in the biological reactions differential equations. Legendre and Bessel Differential Equations.

Mechanisms of E1, E2, Saytzeff, Hoffmann eliminations and Cope elimination. Biological dehydration reactions

Unit 4: Electrophilic Additions reactions of alkenes and alkynes (8 Hours)

Mechanism with suitable examples, (Markownikoff/Antimarkownikoff addition), syn and anti-addition; addition of H2, X2, hydroboration-oxidation, ozonolysis, hydroxylation.

Nucleophilic substitution reactions – SN1 and SN2 mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. elimination. Biological methylating agents

Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/ acylation with their mechanism. Directing effects of groups in electrophilic substitution.

Practicals: (30 Hours) (Laboratory Periods: 30)

1. Calibration of a thermometer and determination of the melting points of the organic compounds (Kjeldahl method, electrically heated melting point apparatus and BODMEL)

2. Purification of the organic compounds by crystallization using the following solvents:

a. Water b. Alcohol c. Alcohol-Water

3. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL)

4. Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, salicylic acid) either by conventional or green method.

5. Bromination of acetanilide/aniline/phenol either by conventional or green method.

6. Nitration of chlorobenzene/nitrobenzene.

References:

Theory: 1. Sykes, P. (2005), A Guide Book to Mechanism i n Organic Chemistry, Orient Longman.

2. Eliel, E. L. (2000), Stereochemistry of Carbon Compounds, Tata McGraw Hill.

3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Mehta B.; Mehta M. (2015), Organic Chemistry, PHI Learning Private Limited

5. Bahl, A; Bahl, B. S. (2012), Advanced Organic Chemistry, S. Chand.

Practicals:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Pearson.

2. Mann, F.G.; Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.

SKILL ENHANCEMENT COURSE (SEC)

Course Code: SEC 1

Course Title: Chemistry of Cosmetics and Hygiene Product

Total Credits: 02 (Credits: Theory: 00, Practical: 02)

Total Hours: Theory: 00, Practical: 60

Course Objectives:

- To introduce the concept of cosmetics in terms of chemistry and their formulation.
- To make students understand the role of each ingredients in the preparation of the cosmetic products.
- To give an idea about the role of herbal ingredients in the making of any cosmetic

Course Learning Outcomes: At the end of this course, the students will be

- Be familiar with the basic principles of various cosmetic formulations
- Be aware of different ingredients and their roles in cosmetic products.
- Appreciate the role of herbal ingredients in various cosmetic products
- Use safe, economic and body-friendly cosmetics
- Prepare new innovative formulations to achieve the aimed efficacies and effects

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PRACTICAL (Credit: 02; 60 Hours)

Practicals/Hands-on-training 60 hours

1. Definition, History and Classification of cosmetic & cosmeceutical products.
   Skin Care Products: Basic structure and function of skin. Principles of formulation of skin care products. Role of herbs in Skin Care: Aloe and turmeric. General Ingredients and preparation of
   (a) Preparation of Talcum powder (chemical based and herbal)
   (b) Face cream/ vanishing cream/ cold cream/ suntan cream/lather shaving cream (any two)
   (c) Body lotion Chemistry of Cosmetics and Hygiene Products
   2. Hair Care Products: Basic structure of hair and classification of hair. Principles of formulation of Hair care products. Types of shampoo and conditioners. Role of herbs in Hair care:

Henna and amla. Role of primary and secondary surfactants in shampoo. General Ingredients and preparation of

(a) Shampoo (chemical based and herbal)

(b) Conditioners

3. **Hand Care and hygiene Products:** Principles of formulation of hand sanitizers and hand wash. General Ingredients and preparation of:

(a) Hand wash

(b) Hand sanitizer

4. **Nail preparation:** Structure of nail, Nail lacquers, Nail polish remover. General Ingredients and preparation of:

(a) Nail polish and nail polish remover

5. **Personal hygiene products**: Total fatty matter, alkali content and pH of soaps. Bathing soap and toilet soap. Antiperspirants and deodorants. General Ingredients and preparation of

(a) Soaps

(b) Cream Soaps

6. **Oral hygiene products:** Common problem associated with teeth and gums. Role of herbs in oral care: Neem and clove. Principles of formulation of Oral hygiene products. Flavours and essential oils. General Ingredients and preparation of

(a) Tooth powder (chemical based and herbal)

(b) Tooth paste

Essential Readings

1. Barel, A.O.; Paye, M.; Maibach, H.I. (2014), Handbook of Cosmetic Science and Technology, CRC Press.
2. Garud, A.; Sharma, P.K.; Garud, N. (2012), Text Book of Cosmetics, Pragati Prakashan.
3. Gupta, P.K.; Gupta, S.K. (2011), Pharmaceutics and Cosmetics, Pragati Prakashan
4. Butler, H. (2000), Poucher's Perfumes, Cosmetic and Soap, Springer

Suggestive Readings:

1. Flick, E.W. (1990), Cosmetic and toiletry formulations, Noyes Publications / William Andrew Publishing.
2. Natural Ingredients for Cosmetics; EU Survey 2005
3. Formulation Guide for cosmetics; The Nisshin OilliO Group, Ltd
4. Functional Ingredients & Formulated Products for Cosmetics & Pharmaceuticals; NOF Corporation

Course Code: SEC 2

Course Title: Water Quality Analysis

Total Credits: 02 (Credits: Theory: 00, Practical: 02)

Total Hours: Theory: 00, Practical: 60

Course Objectives:

- To apply basic chemical principles to better understand water quality for drinking water treatment and for wastewater treatment.
- To apply basic analytical chemistry principles to understand how to measure common water and wastewater constituents.
- To provide employability for students

Course Learning Outcomes: At the end of this course, the students will be expected to

- Understand National Primary Drinking Water Regulations.
- Comprehend knowledge about sources, cause and impacts of water pollutants.
- Measure the concentration of constituents in quantity for characterization of water for different uses.
- Experiment water quality criteria and parameters.
- Evaluate the various parameters essential for potable water.

PRACTICAL (Credit: 02; 60 Hours)

Every student must perform all experiments from the following list:

1. Determination of Total Alkalinity of water.
2. Determination of the total hardness of the water sample.
3. Determination of Chemical oxygen demand of waste water
4. Determination of Biological oxygen demand of waste water
5. Determination of Acidity of water.
6. Determination of salinity of the given water sample.
7. Determination of Turbidity of various water sample
8. Determination of pH of waste water.

9. Determination of Dissolved oxygen of waste water.
10. Estimation of the Chloride level in Water sample
11. Determination of TDS in water sample.

Suggested Reading:

1. AGS. Reddy, A Textbook on Water Chemistry: Sampling, Data Analysis and Interpretation, , Rajiv Gandhi National Ground Water Training and Research Institute, Raipur, CG, India,2020
2. Yuncong Li & Kati Migliaccio, Water Quality Concepts, Sampling, and Analyses, Taylor & Francis Ltd,2019
3. J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., &Jones, Practical Skills in Chemistry, 2nd Ed., Prentice Hall Harlow, 2011