3 Yr. Degree Course
(Minor)
based on NEP-2020
CHEMISTRY

(Effective from Session 2024-25)

(Batch: 2024-2027)

SAMBALPUR UNIVERSITY

JYOTI-VIHAR, BURLA, SAMBALPUR, ODISHA-768019

COURSE AT A GLANCE (NEP-U.G.)

SUBJECT: CHEMISTRY *ACADEMICSESSION:* **2024-27**

CORE-I COURSE

Course Number	Semester	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	I	Atomic Structure, Periodicity of elements and Chemical Bonding	P	4	100
Paper-II		Fundamental Organic Chemistry	P	4	100
Paper-III	II	States of matter, and Ionic equilibrium	P	4	100
Paper-IV		Chemical thermodynamics, equilibrium, and Colligative property	P	4	100
Paper-V	III	Acids and Bases, Metallurgy, Chemistry of main group elements	P	4	100
Paper-VI		Chemistry of halogen, oxygen and Sulphur containing organic compounds	P	4	100
Paper-VII		Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	P	4	100
Paper-VIII	IV	Coordination Chemistry, Chemistry of d- and f-block elements, Inorganic Reaction Mechanism and electron transfer reactions	P	4	100
Paper-IX		Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons	P	4	100
Paper-X		Conductance, electrochemistry, electrical properties of atoms and molecules	P	4	100
Paper-XI	V	Organic Spectroscopy	P	4	100
Paper-XII		Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry	P	4	100
Paper-XIII		Chemistry of Organometallic Compounds	P	4	100
Paper-XIV	VI	Chemistry of Biomolecules	P	4	100

Paper-XV		Solid and porous materials, and magneto chemistry and power cells	P	4	100
Paper-XVI	VII	Analytical Methods of Chemistry	NP	4	100
Paper-XVII		Polymer Chemistry	P	4	100
Paper-XVIII		Green Chemistry	P	4	100
Paper-XIX		Oxidation, Reduction, Reagents, Rearrangements and Name Reactions	NP	4	100
Paper-XX	VIII	Quantum chemistry & Statistical Thermodynamics	NP	4	100
Paper-XXI		Chemical group theory, electronic spectra of metal complexes, and nuclear chemistry	P	4	100
Paper-XXII		Pericyclic reactions, Photochemistry and Retrosynthesis	P	4	100
Paper-XXIII		Research Methodology for Chemistry	NP	4	100

CORE-II/CORE-III COURSE

Course Number	Semester Core-II/ Core-III	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	I/II	Atomic Structure, Periodicity of elements and Chemical Bonding	P	4	100
Paper-II	III/IV	Fundamental Organic Chemistry	P	4	100
Paper-III	V/VI	States of matter, and Ionic equilibrium	P	4	100
Paper-IV	VII	Chemical thermodynamics, equilibrium, and Colligative property	P	4	100
Paper-V	VIII	Acids and Bases, Metallurgy, Chemistry of main group elements	P	4	100

CORE COURSE II/ III

Minor (Paper-I) Semester I/II

Atomic Structure, Periodicity of elements and Chemical Bonding

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Atomic Structure, Periodicity of elements and Chemical Bonding		04	03	01

Course Objectives:

To provide the fundamental knowledge on the structure of atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. Various types of periodic properties and bonding have been reviewed to strengthen students for grasping this tricky topic and effectively tackle exam questions. The basics of acid-base titrimetric analysis has been incorporated in order to develop the analytical skills of the students.

Course Outcomes:

1. Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom.
2. Learn the various atomic properties of atoms and their variations in the periodic table.
3. Gain the idea of different types of bondings and their associated properties.
4. Understand the theory and applications of various acid-base titrations.

SYLLABUS

(C L P = 3 3 0; Total Hours = 15 x 3 = 45) **UNIT – I (12 Hours)**

Atomic structure:

Rutherford's nuclear model of atom, Bohr's theory and the origin of hydrogen spectrum,

Sommerfeld's extension of Bohr's theory, de-Broglie equation, Heisenberg's Uncertainty Principle and its significance. Postulates of wave mechanics, Derivation of Schrödinger's wave equation for hydrogen atom, significance of ψ and ψ^2. Radial and angular wave functions, Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of s-, p-, d- and f-orbitals, Relative energies of orbitals. Slater's rule and its limitations, Quantum numbers and their significance. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity and Aufbau principle.

UNIT – II (10 Hours)

Periodicity of elements:

Introduction to long form periodic table, Cause of periodicity, Division of elements into s-, p-, d- and f-blocks. Atomic radius, ionic radius, covalent radius and Van der Walls radius. Periodic trends in ionic and covalent radii. Ionization energy, electron affinity, electronegativity, and their variations in the periodic table. Applications of electronegativities. Pauling's/Mulliken's scale of electronegativity, Sanderson's electron density ratio.

UNIT – III (10 Hours)

Chemical Bonding-I:

Ionic Bond-General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Haber cycle and its application, Born-Lande equation, Madelung constant, importance of Kapustinskii equation for lattice energy. Solvation energy, Covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules and consequences of polarization.

UNIT – IV (13 Hours)

Chemical bonding-II:

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: CH_4, H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3^-, BrF_2^+, PCl_6^-, ICl_2^-, ICl_4^-, NH_4^+, $PO_4^{3-}$and SO_4^{2-}. Valence Bond theory (Heitler-London approach). Hybridization, equivalent and non-equivalent hybrid orbitals. Ionic character in covalent compounds: Dipole moment. Percentage ionic character from dipole moment and electronegativity difference, Mo l e c u l a r orbital diagrams of homo- & hetero-diatomic molecules (N_2, O_2, C_2, B_2, F_2, CO, NO) and their ions. Calculation of bond order. Concept of bent rule.

Metallic bond:

Concept of metallic bond, The free electron model, The valence bond model, The band model (molecular orbital approach), semiconductor and insulators.

Hydrogen bond:

Concept of hydrogen bond, nature of hydrogen bonding, consequences of hydrogen bonding and its importance.

Lab Work

Credit-01

(C L P = 1 0 1; Total Hours = 15 x 2 = 30)
(Laboratory periods: 30 Hours, 15 classes of 2 hours each)

List of experiments

1. Calibration and use of apparatus
2. Preparation of solutions of different Molarity/Normality.
3. Estimation of oxalic acid using standard NaOH solution
4. Estimation of sodium carbonate using standard HCl.
5. Estimation of carbonate and hydroxide present together in a mixture.
6. Estimation of carbonate and bicarbonate present together in a mixture.

Text Books:

1. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Co., 33rd Ed., 2017.
2. A. J. Elias, The Chemistry of the p-Block Elements-Syntheses, Reactions and Applications, University Press (India) Pvt Ltd., 2009.
3. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons, 1989. **Reference Books:**
1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2010.
2. B. E. Douglas, D. H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, John Wiley & Sons, 1994.
3. P. W. Atkins, T. L. Overton, J. P. Rourke, M. T. Weller, F. A. Armstrong, Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press, 2010.

4. P. Chndra, C. Gupta, Chemical Dynamics and Coordination chemistry, 1st Ed., 2022.
5. A. K. Das, M. Das, Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd., 2014.
6. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education, 2009.
7. D. C. Harris, C. A. Lucy, Quantitative Chemical Analysis, 9th Ed, Freeman and Company, 2016.

Minor (Paper-II) Semester III/IV

Fundamental Organic Chemistry

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Fundamental Organic Chemistry		04	03	01

Course Objectives:

To provide the fundamental knowledge on organic chemistry in order to comprehend other organic chemistry courses in coming semesters with greater depth. The purpose of this core paper is to review the basic concepts of electron displacement and the chemistry of aliphatic and aromatic hydrocarbons. Stereochemistry is also introduced to help to student to visualize the organic molecules and their spatial arrangement in three dimensional spaces and hands on experience on detection of organic molecules.

Course Outcomes:

1. Understanding the basic concepts of electronic displacement phenomena in organic molecules, various bond breaking processes and types of organic reactions.
2. Fundamental knowledge on symmetry and asymmetry aspect of organic molecules and their spatial arrangements in two-dimension and three-dimension with their stereochemistry.
3. Learning the synthesis, structure and stability of unsaturated hydrocarbons, understanding the concept of aromaticity and chemical reactions of unsaturated hydrocarbons and aromatic hydrocarbons.
4. Knowledge on selection of suitable solvent for purification and separation of organic compounds and detection of various elements present in it.

Syllabus

Lecture-Credit-03 (45 Hrs)

Unit–I:

Basics of Organic Chemistry (11 hrs)

Electronic Displacements: Inductive, electrometric, resonance and mesmeric effects, hyper conjugation and their applications in dipole moment; organic acids and bases; their relative strength. Hemolytic and heterolysis fission with suitable examples. Curly arrow rules; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stability of carbocation's, carbanions, free radicals and carbines.

Introduction to types of organic reactions with suitable examples: Addition, Elimination, Substitution, Rearrangement and Pericyclic reactions.

Carbon-carbon sigma bonds, chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Corey-House Reactions, Free radical substitutions: Halogenation –relative reactivity and selectivity.

Unit–II:

Stereochemistry (13 hrs)

Concept of Chirality/Asymmetry, Geometrical isomerism and Optical Isomerism: Optical Activity, Specific Rotation. Determination of Relative and absolute configuration in chiral molecules using D/L, R/S, cis/trans,

Syn/Anti and E/Z descriptors using C.I.P rules. Representation by Fischer Projection, Newman and Sawhorse Projection formulae in molecules containing one and two chiral-centers. Enantiomers, Distereoisomers, meso-structures, Racemic mixture and their resolution.

Stability and Conformational analysis: types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of alkanes (ethane and n-butane): Relative stability with energy diagrams. Energy diagrams of cyclohexane: Chair, Half chair, boat and twist boat forms.

Unit–III:

Chemistry of Unsaturated Hydrocarbons (13 hrs)

Carbon-Carbon Pi Bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/AntiMarkownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, syn and antihydroxylation (oxidation).1,2- and 1,4-addition reactions in conjugated dienes and Diels-Alder reaction; Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Unit–IV:

Chemistry of Aromatic Hydrocarbons (8 hrs)

Aromaticity: Hückel's rule, aromaticity in benzenoid and non-benzenoid compounds, cyclic carbocations/ carbanions and heterocyclic compounds with suitable examples.

Electrophilic aromatic substitution with mechanism: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the functional groups.

LAB WORK- Credit-01 (15 classes of 2 hours each)

List of Experiments

1. Detection of extra elements (N, Cl, Br, I and S) in organic compounds by Lassaigne's test.
2. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid groups in known organic compounds.
3. Separation and purification of any one component of following binary solid mixture (Benzoic acid/*p*Toluidine; *p*-Nitrobenzoic acid/*p*-Aminobenzoic acid; *p*-Nitrotolune/*p*- Anisidine) based on the solubility in common laboratory reagents/solvents like water (cold, hot), ethanol (cold, hot), dil. HCl, dil. NaOH, dil.$NaHCO_3$ etc.
4. Determination of melting point and boiling point of different organic compounds

Text Books:

1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Ed., Pearson Education India, 2010.
2. A. Bahl, B. S. Bahl, Advanced Organic Chemistry, 5th Ed., S. Chand, 2012.
3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson Education India, 2003.

Reference Books:

1. T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, Solomons' Organic Chemistry, Global Ed., Wiley, 2024.
2. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., Oxford Publisher, 2012.
3. R. K. Bansal, Organic Reaction Mechanism, 3rd Ed., Tata McGraw-Hill Publications, 1998.
4. D. Nasipuri, Stereochemistry of Organic compounds, 4th Ed., New Age International Publisher, 2020.

5. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Ed., Pearson Education, 2003.
6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part-A and Part-B, 5th Ed., Springer 2007.
7. N. K. Vishnoi, Advanced Practical Organic Chemistry, 3rd Ed., Vikas Publishing House, 2009.
8. O. P. Agarwal, Advanced Practical Organic Chemistry, Krishna Prakashan, 2014.
9. V. K. Ahluwalia, R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press, 2004.
10. H. T. Clarke, A Handbook of Organic Analysis: Qualitative and Quantitative, 4th Ed., CBS Publishers, 2021.

Minor (Paper-III) Semester V/VI

States of matter, and Ionic equilibrium

Course Title	Code	Credit	Credit distribution	
			Lecture	Practical
States of matter, and Ionic equilibrium		04	03	01

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 practical 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 outcomes:

1. Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
2. Apply the concepts of gas equations and liquids while studying other chemistry courses and understand the importance of pH in every-day life.
3. Understand different lattice systems and apply working principles of XRD for understanding crystal structure by powder and single crystal method.

4. Handle stalagmo meter and Ostwald viscometer properly and determine the density of aqueous solutions. Data reduction, interpretation using numerical and graphical methods.

SYLLABUS

Lecture-Credit 03 (45 hours)

Unit-I: Gaseous state (13 hour)

Kinetic molecular model of a gas, Collision frequency, Collision diameter, Collision cross section, Mean free path and viscosity of gases, including their temperature and pressure dependence, Relation between mean free path and coefficient of viscosity, Maxwell distribution of molecular velocities (no derivation); average, root mean square and most probable velocities and average kinetic energy, Law of equipartition of energy, Behavior of real gases: Deviations from ideal gas behavior, Causes of deviation from ideal behavior, Vander

Wall equation and its application, Compressibility factor Z, and its variation with pressure for different gases, Critical Phenomenon and critical constant derivation.

Unit-II: Liquid state (10 hour)

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Capillary action in relation to cohesive and adhesive forces, Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Qualitative discussion of structure of water.

Unit- III: Solid state (12 hour)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analyses of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals (stoichiometric and non- stoichiometric).

Unit-IV: Ionic equilibria (10 hour)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono- and diprotic acids. calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts and its application.

LAB WORK

Credit 01 (15 classes of 2 hours each) List of experiments:

1. Determine the surface tension by (i) drop number (ii) drop weight method.
2. Study the variation of surface tension of detergent solutions with concentration and determination of CMC
3. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
4. Study the variation of viscosity of sucrose solution with the concentration of solute.
5. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
6. Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii)
7. Ammonium chloride-ammonium hydroxide
8. Determination of dissociation constant of a weak acid.
9. Determination of solubility product of PbI_2 by titrimetric method.

Text Books:

1. P. W. Atkins, J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. G. W. Castellan Physical Chemistry 4thEdn. Narosa 2004.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi 2011.

Reference books:

1. Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
2. R. G., Mortimer Physical Chemistry, Elsevier (Academic Press), 3rd Ed, 2008.
3. T. Engel & P. Reid Physical Chemistry, 3rd Ed. Pearson 2013
4. Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017

Minor (Paper-IV)

(With/Without Research)

SEMESTER- VII

Chemical thermodynamics, equilibrium, and Colligative property

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Chemical thermodynamics, equilibrium, and Colligative property		04	03	01

Course Objectives:

The learners should be able to apply principles and laws of thermodynamics to reversible and irreversible systems. In addition, they should be able to use spectroscopic data to calculate thermodynamic properties of ideal & real mixtures. In addition, understand the change in thermodynamic properties, equilibrium constants, partial molar quantities, chemical potential. Also able to identify factors affecting equilibrium constant using the principles and techniques of statistical thermodynamics.

Course outcomes:

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

- Discuss the laws of thermodynamics and applications to natural phenomena.
- Acquire a strong foundation of partial molar properties, its variation with temp and pressure for different systems and able to apply on the thermodynamics of simple mixtures.
- Inculcate firm foundations in the fundamentals and application of chemical equilibrium, and ΔG derive the relationship between different equilibrium constants.
- Understand the basic concept of Solutions of non-volatile solutes, colligative properties. Calculate various thermodynamic properties ($\Delta H_{\text{neutralization}}$, $\Delta H_{\text{hydration}}$ & C_v) for chemical reactions using calorimeter.

SYLLABUS

Lecture-Credit 03 (45 hours)

Unit-I: Chemical thermodynamics (10 hours)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, q, work, w, internal energy, U, and statement of **first law**; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Unit-II (12 hours)

Carnot cycle, efficiency of heat engine, Carnot theorem; **Second Law:** Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. **Third Law:** Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters, inversion temperature, GibbsHelmholtz equation, Maxwell relations, thermodynamic equation of state.

Unit-III : Systems of variable composition (13 hours)

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **Chemical equilibrium**: Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient (vant Hoff's reaction). Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier principle (quantitative treatment) and its applications.

Unit-IV Solutions and Colligative Properties (10 hours) Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

LAB WORK- credit 01 (15 classes of 2 hours each)

List of experiments

1. 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 or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.
4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity/proticity of a polyprotic 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.
6. Determination of enthalpy of hydration of copper sulphate.
7. Determination of heat of solution (ΔH) of oxalic acid/benzoic acid from solubility measurement.

Text Books:

1. P. W. Atkins& J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. D. A. McQuarrie, & J. D Simon. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi 2004.
3. K. L. Kapoor, Text Book of Physical Chemistry, , Mac Grow Hill, 3rdEdn. 2017
4. B. D. Khosla, V. C. Garg, & A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi 2011.

Reference Books:

1. T. Engel & P. Reid, Physical Chemistry 3rd Ed. Pearson 2013.
2. S.C. Kheterpal Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications 2011.
3. Puri, Sharma &Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.

Minor (Paper-V)

(With/Without Research)

SEMESTER-VIII

Acids and Bases, Metallurgy, Chemistry of main group elements

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Acids and Bases, Metallurgy, Chemistry of main group elements		04	03	01

Course Objectives:

To provide the basic knowledge on general principles of acids and bases, principle of metallurgy and chemistry of s- and p-block elements. Students can learn about chronological developments of the concepts of acids and bases. It will help students to get aware of the pH scale and classify a substance as acidic, basic, or neutral based on their pH or hydrogen ion concentration. Students can achieve the knowledge regarding volumetric analysis and preparation of metal complex.

Course Outcomes:

1. Know how the various theories of acid and base, and understand the occurrence and purification of metals
2. Learn the different properties of s- and p-block elements
3. Understand the preparation and properties of inorganic polymers.
4. Achieve knowledge on how to standardize, estimate and prepare inorganic compounds/metal ions.

SYLLABUS

(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

UNIT – I (10 Hours)

Acids and Bases

Different concepts of acids and bases: Arrhenius theory, Bronsted-Lowry theory, Lewis theory, The Lux Flood definition, The Usanovich definition, acids and bases in proton solvents, Concept of

conjugate acid and conjugate base, Concept of pH, Pearson's classification of Lewis acid and Lewis bases into Hard and Soft Acids and Bases (HSAB), HSAB principle, application of HSAB principle.

Principle of metallurgy

Chief modes of occurrence of metals, Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent, electrolytic reduction, hydrometallurgy. Methods of purification of metals: electrolytic process, parting process, Van Arkel-de Boer process, Mond's process and Zone refining.

UNIT – II (12 Hours)

Chemistry of *s*-Block Elements

General characteristics: melting point, flame colour, 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 and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, and sulphates. Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; Hydride and their classifications: ionic, covalent and interstitial, EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties.

UNIT – III (13 Hours)

Chemistry of *p*-Block Elements

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 behavior of first member of each group. interhalogen and pseudohalogen compounds, Structure, bonding and properties (acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat) of the following:

- **Hydrides:** hydrides of Group 13 (only diborane), Group 14, Group 15, Group 16 and Group 17.
- **Oxides**: oxides of phosphorus, sulphur and chlorine

- **Oxoacids:** oxoacids of phosphorus and chlorine; peroxoacids of sulphur • **Halides:** halides of silicon and phosphorus

UNIT – IV (10 Hours)

Noble gases

Occurrence and uses, rationalization of inertness of noble gases, clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6. Molecular shapes of noble gas compounds (VSEPR theory).

Inorganic polymer

Preparation, properties, structure and uses of the following compounds: Borazine, Silicates, silicones, phosphonitrilic halides $\{(PNCl_2)_n$ where n = 3 and 4}, and concept of carbophosphazene.

Lab Work

(Credit-01)

(C L P = 1 0 1; Total Hours = 15 x 2 = 30)

(Laboratory periods: 30 Hours, 15 classes of 2 hours each)

List of experiments

1. Standardization of sodium thiosulphate solution by standard $K_2Cr_2O_7$ solution.
2. Estimation of copper using standard sodium thiosulphate solution (Iodometrically).
3. Estimation of available chlorine in bleaching powder iodometrically.
4. Preparation of Cuprous chloride (Cu_2Cl_2)
5. Preparation of Manganese(III) phosphate ($MnPO_4.H_2O$)
6. Preparation of Lead chromate ($PbCrO_4$)

Text Books:

1. A. J. Elias, The Chemistry of the p-Block Elements-Syntheses, Reactions and Applications, University Press (India) Pvt Ltd., 2009.
2. J. D. Lee, Concise Inorganic Chemistry Wiley India, 5th Edn., 2008.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.

Reference Books:

1. A. K. Das, Fundamentals of Inorganic Chemistry, Vol. I, CBS Publications, 2nd Ed., 2010.
2. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, Advanced Inorganic Chemistry, Vol. I, 7th Ed., S.

   Chand & Company Pvt. Ltd., 2021.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Publication Co., 33rd Ed., 2017.
4. D. E. Shriver, P. W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Ed., 2010.
5. G. L. Miessler, P. J. Fischer, D. A. Tarr, Inorganic Chemistry, 5th Ed., Pearson, 2014.
6. J. Mendham, Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson, 2009.

   V. K. Ahluwalia, S. Dhingra, A. Gulati, College Practical Chemistry, University Press, 2005.