छत्रपति शाहू जी महाराज विश्वविद्यालय, कानपुर

CHHATRAPATI SHAHU JI MAHRAJ UNIVERSITY, KANPUR

(पूर्ववर्ती कानपुर विश्वविद्यालय कानपुर)

Formerly Kanpur University, Kanpur – 208024

A Documentary Support

For

Metric No. – 1.1.1

Programme Outcomes & Course Outcomes

Under the

Criteria - I

(Curriculum Design and Development)

Key Indicator - 1.1

In

Metric No. – 1.1.1

B.Sc. (Hons.) Chemistry

Co-ordinator
Internal Quality Assurance Cell
CSJM University, Kanpur

(Registrar)
C.S.J.M.University
Kanpur

REGISTRAR
C.S.J.M. UNIVERSITY
KANPUR

Department of Chemistry

Vision

Vision of the department is to provide excellent knowledge of the chemistry for under graduate as well as post graduate students. The department provide experimental knowledge to the students and prepare as an industry professional person with sound knowledge of instruments and chemical analysis.

Mission

To prepare the student as a good researcher, smart and skilled person, entrepreneur with ethical values as well as a quick problem solver.

To provide the knowledge of implementation and importance of chemistry in the field of MSME, Electronics, CSE, Chemical engineering and Mechanical Engineering.

B.Sc. (Honours) Chemistry

Program Outcomes (POs)

PO1	Fundamental Knowledge of Basic principles
PO2	Communicate Scientific Information in a clear and Concise Manner
PO3	Solving problems using basic chemistry concept and knowledge
PO4	To Develop the Sustainable and eco-friendly Technology
PO5	Knowledge and handling of Equipment
PO6	Understand and develop ethical awareness/reasoning
PO7	Inculcate Logical Thinking to address the Problem with Solution
PO8	Individual and team work

Program Specific Outcomes (PSOs)

PSO1	Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
PSO2	Students will be able to understand the basic concepts in Chemistry while retaining the exciting aspects of Chemistry so as to develop interest in the study of chemistry as a discipline to be exposed to the different processes used in industries and their applications.

Program Educational Outcomes (PEOs)

1. To provide the foundation in the fundamentals and applications of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistry.
2. To equip student with the advanced tools and techniques used in Analytics domain.
3. To familiarize students with the emerging areas of Chemistry and their applications in various spheres of Chemical sciences globally
4. To develop the skills of students in the proper handling of apparatus and chemicals.
5. To make the students explore new areas of research in chemistry and allied fields of science and technology at national and international level
6. To make the students explain why Chemistry is an integral course for addressing social, economic, and environmental problem for sustainable development at local, national and international level

Curricular Components

Category of courses	Credits offered
Core Courses	**84**
Ability EnhancementCompulsory Course (AECC)	**04**
Generic Elective	**24**
Skill Enhancement Course (SEC)	**04**
Discipline Specific Elective	**24**
Total	**140**

Semester-wise Course Structure

1st Year – Semester I

Sl. No.	Course Code	Course Title	L	T	P	Credits
1	BSCH-101T	Inorganic Chemistry I: Atomic Structure & Chemical Bonding	4	0	0	4
2	BSCH-101P	Inorganic Chemistry I Lab	0	0	2	2
3	BSCH-102T	Physical Chemistry I: States of Matter & Ionic Equilibrium	4	0	0	4
4	BSCH-102P	Physical Chemistry I Lab	0	0	2	2
5	IDC 101T	Atomic Structure, Bonding, General Organic Chemistry and Aliphatic Hydrocarbons	4	0	0	4
6	IDC 101P	Atomic Structure, Bonding, General Organic Chemistry and Aliphatic Hydrocarbons Lab	0	0	2	2
7	AECC-01	English Communication /EnvironmentalScience	2	0	0	2
		Total	14	0	6	20

1st Year – Semester II

Sl. No.	Course Code	Course Title	L	T	P	Credits
1	BSCH-201T	Organic Chemistry I: Basics & Hydrocarbons	4	0	0	4
	BSCH-201P	Organic Chemistry I Lab	0	0	2	2
3	BSCH-202T	Physical Chemistry II: Chemical Thermodynamics & its Applications	4	0	0	4
4	BSCH-202P	Physical Chemistry II Lab	0	0	2	2
5	IDC 201T	Solutions, phase Equilibrium, Conductance, electrochemistry and	4	0	0	4

		functional Group Organic Chemistry-II				
6	IDC 201P	Solutions, phase Equilibrium, Conductance, electrochemistry and functional Group Organic Chemistry-II Lab	0	0	2	2
7	AECC-02	English Communication /Environmental Science	2	0	0	2
		Total	14	0	6	20

2nd Year – Semester III

Sl. No.	Course Code	Course Title	L	T	P	Credits
1	BSCH-301T	Inorganic Chemistry II: s and p-Block Elements	4	0	0	4
2	BSCH-301P	Inorganic Chemistry II Lab	0	0	2	2
3	BSCH-302T	Organic Chemistry II: Oxygen Containing Functional Groups	4	0	0	4
4	BSCH-302P	Organic Chemistry II Lab	0	0	2	2
5	BSCH-303T	Physical Chemistry III: Phase Equilibria & Chemical Kinetics	4	0	0	4
6	BSCH-303P	Physical Chemistry III lab	0	0	2	2
7	IDC 301T	Chemistry of s and p- Block Elements, States of Matter and Chemical Kinetics	4	0	0	4
8	IDC 301P	Chemistry of s and p- Block Elements, States of Matter and Chemical Kinetics	0	0	2	2
9	SEC-01 or SEC-04	• Basic Analytical Chemistry • IT Skills for Chemist	0	0	2	2
		Total	16	0	10	26

2nd Year – Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits
1	BSCH-401T	Inorganic Chemistry III: Coordination Chemistry	4	0	0	4
2	BSCH-401P	Inorganic Chemistry III Lab	0	0	2	2
3	BSCH-402T	Organic Chemistry III: Heterocyclic Chemistry	4	0	0	4
4	BSCH-402P	Organic Chemistry III	0	0	2	2
5	BSCH-403T	Physical Chemistry IV: Electrochemistry	4	0	0	4
6	BSCH-403P	Physical Chemistry IV	0	0	2	2

7	IDC 401T	Chemistry of d-Block Elements, Quantum Chemistry and Spectroscopy	4	0	0	4
8	IDC 401P	Chemistry of d-Block Elements, Quantum Chemistry and Spectroscopy Lab	0	0	2	2
9	SEC-02 or SEC-03	• Chemistry of Cosmetics and Perfumes • Intellectual Property Rights(IPR)	0	0	2	2
		Total	16	0	10	26

3rd Year – Semester V

Sl. No.	Course Code	Course Title	L	T	P	Credits
1	BSCH- 501T	Organic Chemistry IV: Biomolecules	4	0	0	4
2	BSCH- 501P	Organic Chemistry IV Lab	0	0	2	2
3	BSCH- 502T	Physical Chemistry V: Quantum Chemistry & Spectroscopy	4	0	0	4
4	BSCH- 502P	Physical Chemistry V Lab	0	0	2	2
Discipline Selective Electives(_any two)						
5	DSE-1T DSE-1P	• Application of Computer in Chemistry • Application of Computer in Chemistry Lab	4 0	0 0	0 2	6
6	DSE- 2T DSE- 2P	• Analytical Methods in Chemistry • Analytical Methods in Chemistry Lab	4 0	0 0	0 2	6
7	DSE-3T DSE-3P	• Novel Inorganic solids • Novel Inorganic solids Lab	4 0	0 0	0 2	6
8	DSE- 4T DSE- 4P	• Polymer Chemistry • Polymer Chemistry Lab	4 0	0 0	0 2	6
		Total	16	0	8	24

3rd Year – Semester VI

Sl. No.	Course Code	Course Title	L	T	P	Credits
1	BSCH- 601T	Inorganic Chemistry IV: Organometallic Chemistry	4	0	0	4
2	BSCH- 601P	Inorganic Chemistry IV Lab	0	0	2	2
3	BSCH- 602T	Organic Chemistry V: Spectroscopy	4	0	0	4

4	BSCH- 602P	Organic Chemistry V Lab	0	0	2	2
Discipline Selective Elective(any two)						
5	DSE-5T	• Research Methodology for Chemistry	5	1	0	6
6	DSE-6T DSE-6P	• Green Chemistry • Green Chemistry Lab	4 0	0 0	0 2	6
7	DSE-7T DSE-7P	• Industrial Chemicals and Environment • Industrial Chemicals and Environment Lab	4 0	0 0	0 2	6
8	DSE-8T DSE-8P	• Inorganic Materials of Industrial Importance • Inorganic Materials of Industrial Importance Lab	4 0	0 0	0 2	6
9	DSE-9T DSE-9P	• Instrumentals Methods of Chemical Analysis • Instrumentals Methods of Chemical Analysis Lab	4 0	0 0	0 2	6
		Total	16/17	0/1	8/6	24

Detailed Syllabus

Core Courses

Course Code: BSCH 101T

Course Name: INORGANIC CHEMISTRY-I (Credits: Theory-04, Practicals-02)

Theory: 60 Lecture

CO1	Understand the concept of atoms and molecules.
CO2	Understand the concept of periodicity of elements.
CO3	Understand the concept of chemical bonding and its applications
CO4	Understand the concept of oxidation -reduction reaction and its application to inorganic reaction.

Course Details:

Unit I Atomic Structure:

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

(14 Lectures)

Unit II Periodicity of Elements:

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the followingproperties of the elements, with reference to *s* & *p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionizationenergy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

(16 Lectures)

Unit III Chemical Bonding:

(i) *lonic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation

and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.
(ii) *Covalent bond:* Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containinglone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.
(iii) *Metallic Bond:* Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.
(iv) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

(26 Lectures)

Unit IV Oxidation-Reduction:

Redox equations, Standard Electrode Potential and its application to inorganic reactions.Principles involved in volumetric analysis to be carried out in class.

(4 Lectures)

Reference Books:

- Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry,Oxford, 3rd edition, (1970).
- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press (2018).
- Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications (1962).
- Lee, J.D. Concise Inorganic Chemistry for JEE (Main and advance, 4th edition, (2020).

Course Code: BSCH 101P
Course Name: INORGANIC CHEMISTRY-I LAB

60 Lectures

CO1	Learn the preparation of solutions of different molarity and normality
CO2	Fundamentals of acid-base titration and acid base indicator.
CO3	Basics concept of redox titration and function of redox indicator.
CO4	Identify oxidizing/reducing agents in chemical reaction.

(A) Titrimetric Analysis

(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilicacid) and external indicator.

Reference text:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS., John Wiley and Sons. 4th edition, (1978)

Course Code: BSCH 102T

Course Name: PHYSICAL CHEMISTRY I (Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Basics of Kinetic molecular model of gas, Vander Waals equations of states , laws of corresponding states
CO2	Structure of liquid states, radial distribution functions, physical properties of liquids.
CO3	Nature of solid states, Different Laws, Bravais lattice, analysis methods, glasses and liquid crystals, defects in crystals.
CO4	Types, degree of ionization of electrolytes, factors effecting the ionization, salt hydrolysis, pH, buffers.
CO5	Solubility, solubility products and its applications, Qualitative treatment of acids, hydrolysis and hydrolysis constant.

Course Details:

Unit I Gaseous state

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.Maxwell distribution and its use in evaluating molecular velocities (average, root meansquare and most probable) and average kinetic energy, law of equipartition of energy, degreesof freedom and molecular basis of heat capacities.Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

(18 Lectures)

Unit II Liquid state

Qualitative treatment of the structure of the liquid state; Radial distribution function; physicalproperties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.Qualitative discussion of structure of water.

(6 Lectures)

Unit III Solid state

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

(16 Lectures)

Unit IV Ionic equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases,pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity,buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Solubility and solubility product of sparingly soluble salts – applications of solubility productprinciple. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.ultistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

(20 Lectures)

Reference Books:

- Ball, D. W. Physical Chemistry Thomson Press, India (2017).
- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press (2018).

Course Code : BSCH 102P

Course Name: PHYSICAL CHEMISTRY I LAB

60 Lectures

CO1	Surface tension measurements through drop number and drop methods
CO2	Viscosity measurement using Ostwald's viscometer
CO3	pH measurements of different solutions
CO4	Buffer solution preparation

CO5	pH metric titrations

1. **Surface tension measurements.**
    a. Determine the surface tension by (i) drop number (ii) drop weight method.
    b. Study the variation of surface tension of detergent solutions withconcentration.
2. **Viscosity measurement using Ostwald's viscometer**.
    a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
    b. Study the variation of viscosity of sucrose solution with the concentration ofsolute.
3. **Indexing of a given powder diffraction pattern of a cubic crystalline system.**
4. **pH metry**
    a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid,sodium acetate and their mixtures.
    b. Preparation of buffer solutions of different pH
        i. Sodium acetate-acetic acid
        ii. Ammonium chloride-ammonium hydroxide

    c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
    d. Determination of dissociation constant of a weak acid.

Reference Books

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R.Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed*.; McGraw-Hill: New York (2009).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H.Freeman & Co.: New York (2003).

Semester II

Course Code: BSCH 201T

Course Name: ORGANIC CHEMISTRY I (Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	The basic concept of organic chemistry related to electronic displacements, nucleophilicity, basicity and their applications.
CO2	The stereochemistry of organic molecules like projection formulae, isomerism and configuration of chiral molecules.
CO3	Preparation of aliphatic saturated and unsaturated hydrocarbons involving sigma-sigma and pi-pi bonds formation, addition reactions to unsaturated hydrocarbons and their applications.
CO4	The conformational analysis of cycloalkanes, relative stability and energy diagrams.
CO5	1. The aromaticity of various cyclic and heterocyclic compounds and their electrophonic substitution reaction.

Course Details:

Unit I Basics of Organic Chemistry

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.*Electronic isplacements:* Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; theirrelative strength.Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges;Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

(6 Lectures)

Unit II Stereochemistry

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.*Optical Isomerism:* Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

(18 Lectures)

Unit III Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. N *Reactions of alkenes:* Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene.*Reactions of alkynes:* Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

(24 Lectures)

Unit IV Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

(12 Lectures)

Reference Books:

- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), 7th edition, (2010).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education), 4th edition, (1963).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education),5th edition, (2020).
- Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International (2005).
- Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London,(2008).

Course Code: BSCH 201P

Course Name: ORGANIC CHEMISTRY I LAB

60 Lectures

CO1	Checking the calibration of the thermometer.
CO2	Purification of organic compounds by crystallization using water and alcohol solvents.
CO3	Determination of boiling and melting point of unknown compounds by Kjeldahl method and electrically heated melting point apparatus.
CO4	Separation of organic compound by paper and TLC chromatography.

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
   a. Water
   b. Alcohol
   c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organiccompounds (Kjeldahl method and electrically heated melting point apparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organiccompounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and morethan 100 °C by distillation and capillary method)
6. Chromatography
   a. Separation of a mixture of two amino acids by ascending and horizontal paperchromatography
   b. Separation of a mixture of two sugars by ascending paper chromatography
   c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol bythin layer chromatography (TLC)

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education, 4th edition.(2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical OrganicChemistry, 5th Ed.*, Pearson (2012)

Course Code: BSCH 202T

Course Name: PHYSICAL CHEMISTRY II

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	Basics and Laws of thermodynamics, thermochemistry, and free energy functions.
CO2	Systems of variables, chemical potentials of ideal mixtures
CO3	Thermodynamics equilibrium criteria, derivations, equilibrium constants.
CO4	Basics of solutions, laws and their applications, thermodynamics functions
CO5	Colligative properties and their applications.

Course Details:

Unit I Chemical Thermodynamics:

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 andions 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. Adiabatic flame temperature, explosion temperature.

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 absoluteentropy 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; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

(36 Lectures)

Unit II 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 inmixing of ideal gases.

(8 Lectures)

Unit III 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. Coupling of exoergic and endoergic reactions. 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); equilibrium between ideal gases and a pure condensed phase.

(8 Lectures)

Unit IV Solutions and Colligative Properties:

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and theirapplications. Excess thermodynamic functions.Thermodynamic derivation using chemical potential to derive relations between the fourcolligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applicationsin calculating molar masses of normal, dissociated and associated solutes in solution.

(8 Lectures)

Reference Books

- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press (2018).
- Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
- McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.:New Delhi (2004).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY, 1st edition, (2011).
- Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
- Metz, C.R. *2000 solved problems in chemistry*, Schaum Series (2006)

Course Code: BSCH 202P

Course Name: PHYSICAL CHEMISTRY II LAB

60 Lectures

CO1	Heat capacity of calorimeter determination
CO2	Enthalpy of neutralization and enthalpy of ionization determination

CO3	Integral enthalpy determination
CO4	Basicity/proticity determination by thermochemical methods
CO5	Enthalpy of hydration determination and study of solubility

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 or enthalpy of neutralization).
(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization ofhydrochloric acid with sodium hydroxide.
(c) Calculation of the enthalpy of ionization of ethanoic acid.
(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
(e) 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.
(f) Determination of enthalpy of hydration of copper sulphate.
(g) Study of the solubility of benzoic acid in water and determination of ΔH.
Any other experiment carried out in the class.

Reference Books

- Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R.Chand & Co.: New Delhi, 18th edition, (2018).
- Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New AgeInternational: New Delhi (2001).

Semester III

Course Code: BSCH 301T

Course Name: INORGANIC CHEMISTRY-II

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Understand the concept of general principles of metallurgy and their isolation, purification.
CO2	Understand the concept of acids and bases and its application.
CO3	Learn the chemistry of s and p block elements.
CO4	Learn the preparation and properties of noble gases.
CO5	Understand the concept of the inorganic polymers and their applications.

Course Details:

Unit I General Principles of Metallurgy

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. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

(6 Lectures)

Unit II Acids and Bases

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

(8 Lectures)

Unit III Chemistry of *s* and *p* Block Elements

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements.Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.tudy of the following compounds with emphasis on structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

(30 Lectures)

Unit IV Noble Gases

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).

(8 Lectures)

Unit V Inorganic Polymers

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspectsand applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

(8 Lectures)

Reference Books:

- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models ofInorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. (1994).
- Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann (1997).
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH (1999).
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry 4th Ed.*, Pearson (2010).
- Shriver & Atkins, *Inorganic Chemistry 5th Ed. (2016).*
- Lee, J.D. Concise Inorganic Chemistry for JEE (Main and advance, 4th edition (2020).

Course Code: BSCH 301P

Course Name: INORGANIC CHEMISTRY-II LAB

60 Lectures

CO1	Basics concept of iodometric and iodimetric titration.
CO2	Estimation of copper iodimetrically.
CO3	Estimation of chlorine iodometrically.
CO4	Preparation and characterization of inorganic compounds.

(A) Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution(Iodimetrically).
(ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2
(ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$
(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) orChrome alum.

Reference Books:

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS(1978).

Course Code: BSCH 302T

Course Name: ORGANIC CHEMISTRY-II

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	The preparation of alkyl halide and their reactions like SN1, SN2 and elimination reactions, preparation of Aryl halide from diazonium salts, nucleophilic aromatic substitutions. Understand the mechanism of benzyne intermediate.
CO2	The preparation, properties and relative reactivity of alcohols, phenols and ethers and epoxide.
CO3	The preparation, structures and reactions of carbonyl compounds. Understand some name reactions.
CO4	The preparation, structures and properties of some carboxylic acids and their derivatives. Understand some name reactions such as Claisen condensation.

Course Details:

Unit 1 Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.*Aryl halides:* Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.Organometallic compounds of Mg and Li – Use in synthesis of organic compounds. **(16 Lectures)**

Unit 2 Alcohols, Phenols, Ethers and Epoxides:

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

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

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

(**16 Lectures)**

Unit 3 Carbonyl Compounds:

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammoniaderivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α- substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, NaBH4, MPV, PDC and PGC);Addition reactions of unsaturated carbonyl compounds: Michael addition.Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applicationsof diethyl malonate and ethyl acetoacetate. **(14 Lectures)**

Unit 4 Carboxylic Acids and their Derivatives:

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic,tartaric, citric, maleic and fumaric acids;Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann- bromamide degradation and Curtius rearrangement. **(10 Lectures)**

Unit 5 Sulphur containing compounds:

Preparation and reactions of thiols, thioethers and sulphonic acids. **(4 Lectures)**

Reference Books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), 7th edition, (2010).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 5th edition, (2020).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc. 12th edition (2016)

Course Code: BSCH 302P

Course Name: ORGANIC CHEMISTRY-II LAB

60 Lectures

CO1	Functional group test such as alcohol, carboxylic acid etc.
CO2	Preparation of some organic compound like acetanilide
CO3	Oxidation of alocohol and iodoform reaction
CO4	Nitration of compound like salicylic acid

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
   i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylicacid) by any one method:

a. Using conventional method.
b. Using green approach

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

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination of any one of the following:
a. Acetanilide by conventional methods
b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration of any one of the following:
a. Acetanilide/nitrobenzene by conventional method
b. Salicylic acid by green approach (using ceric ammonium nitrate).

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

vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

ix. Semicarbazone of any one of the following compounds: acetone, ethyl methylketone, cyclohexanone, benzaldehyde.

x. *S*-Benzylisothiouronium salt of one each of water soluble and water insoluble acids(benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

xi. Aldol condensation using either conventional or green method.

xii. Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical OrganicChemistry, 5th Ed.*, Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:Preparation and Quantitative Analysis*, University Press (2000).

Course Code: BSCH 303T
Course Name: PHYSICAL CHEMISTRY-III
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	Concepts of phases, component and degree of freedom, phase diagrams
CO2	Basics and laws of chemical kinetics, integrated rate equations
CO3	Temperature dependence of reaction rates and theories, complex reactions
CO4	Catalysis, specificity, selectivity, mechanism , enzyme catalysis
CO5	Physical adsorption, chemisorption, adsorption isotherms, nature of adsorbed states.

Course Details:

Unit 1 Phase Equilibria:

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid- liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.Three component systems, water-chloroform-acetic acid system, triangular plots.*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.Nernst distribution law: its derivation and applications.

(28 Lectures)

Unit 2 Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates. **(18 Lectures)**

Unit 3 Catalysis:

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts.

Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis. **(8 Lectures)**

Unit 4 Surface chemistry:
Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.
(6 Lectures)

Reference Books:

- Peter Atkins & Julio De Paula, *Physical Chemistry 9th Ed.,* Oxford University Press(2010).
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
- McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.:New Delhi (2004).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
- Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
- Ball, D. W. *Physical Chemistry* Cengage India (2012).
- Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
- Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill (2011).
- Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill (2009).

Course Code: BSCH 303P

Course Name: PHYSICAL CHEMISTRY-III LAB

60 Lectures

CO1	Critical solution temperature determination and effects of impurities study
CO2	Phase diagram construction
CO3	Study of rate of reactions

I. Determination of critical solution temperature and composition of the phenol-watersystem and to study the effect of impurities on it.
II. Phase equilibria: Construction of the phase diagram using cooling curves or ignitiontube method:
    a. simple eutectic and
    b. congruently melting systems.
III. Distribution of acetic/ benzoic acid between water and cyclohexane.
IV. Study the equilibrium of at least one of the following reactions by the distributionmethod:

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)$

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n^{2+}$

V. Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methylacetate.

VI. Adsorption

I. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid onactivated charcoal.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R.Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed.*; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H.Freeman & Co.: New York (2003).

Semester IV

Course Code: BSCH 401T

Course Name: INORGANIC CHEMISTRY-III

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Understand the concept of metal-ligand bonding and its application.
CO2	Learn the chemistry of transition metal elements and their magnetic and catalytic properties.
CO3	Learn the chemistry of f-block elements and their separation technique.
CO4	Understand the concept of bio-inorganic chemistry and its biological application

Course Details:

Unit 1 Coordination Chemistry:

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect,polynuclear complexes, Labile and inert complexes. **(26 Lectures**)

Unit 2 Transition Elements:

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

(18 Lectures)

Unit 3 Lanthanoids and Actinoids:

Electronic configuration, oxidation states, colour, spectral and magnetic properties,lanthanide contraction, separation of lanthanides (ion-exchange method only). **(6 Lectures)**

Unit 4 Bioinorganic Chemistry:

Metal ions present in biological systems, classification of elements according to their actionin biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency

of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine.
Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

(10 Lectures)

Reference Books:

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

Course Code: BSCH 401P

Course Name: INORGANIC CHEMISTRY-III LAB

60 Lectures

CO1	Basics concept of gravimetric analysis and chromatographic separation.
CO2	Estimation of copper and nickel gravimetrically.
CO3	Preparation and characterization of transition-metal complexes.
CO4	Chromatographic separation of metal ions.

Gravimetric Analysis:

i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
iv. Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminiumoxinate).

Inorganic Preparations:

i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
ii. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III)
iii. Tetraamminecarbonatocobalt (III) ion
iv. Potassium tris(oxalate)ferrate(III)

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation offollowing metal ions:

i. Ni (II) and Co (II)
ii. Fe (III) and Al (III)

Reference Book:

- 1. Vogel, A.I. A text book of Quantitative Analysis, , 5^{th} edition ELBS (1986).

Course Code: BSCH 402T
Course Name: ORGANIC CHEMISTRY-III

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	The preparation and reaction of some nitrogen containing compound. Understand some name reactions like Mannich reaction.
CO2	The reactions, preparations and structures of some polynuclear hydrocarbon such as naphthalene, phenanthrene and anthracene.
CO3	Classification, nomenclature, structure, aromaticity and synthesis of some 5 and 6 membered hetrocyclic compound.
CO4	Understand the general structure, isolation and physiological action of some alkaloid.
CO5	Occurrence, classification, isoprene rule, synthesis and structure elucidation of some Citral, Neral and o-terpineol.

Course Details:

Unit 1 Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles and isonitriles
Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.
Diazonium Salts: Preparation and their synthetic applications. **(18 Lectures)**

Unit 2 Polynuclear Hydrocarbons

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons. **(8 Lectures)**

Unit 3 Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered ringscontaining one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction

Derivatives of furan: Furfural and furoic acid. **(22 Lectures)**

Unit 4 Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation andsynthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. **(6 Lectures)**

Unit 5 Terpenes

Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral,Neral and α-terpineol. **(6 Lectures)**

Reference Books:

- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education),5th edition, (2020)
- Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, JohnWelly & Sons (1976).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education), 4th edition, (1963).
- Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International (2005).
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan(2010).
- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), 7th edition, (2010).

Course Code: BSCH 402P

Course Name: ORGANIC CHEMISTRY-III LAB

60 Lectures

CO1	Detection of extra elements.
CO2	Functional group test for nitro, amine and amide groups.
CO3	Qualitative analysis of unknown organic compounds containing simple functional groups like alcohols, carboxylic etc.

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functionalgroups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson

Education, 4th edition,(2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical OrganicChemistry, 5th Ed.*, Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry:Qualitative Analysis,* University Press (2000).

Course Code: BSCH 403T
Course Name: PHYSICAL CHEMISTRY-IV

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	Conductance, conductivity, their variation, applications of conductance measurements
CO2	Basics of electrochemistry, applications of electrolysis,
CO3	Free energy, enthalpy and entropy determinations, Concentration cells
CO4	Basics of electrostatics, Clausius-Mosotti equations
CO5	Dipole moments , molecular polarizability and their measurements

Course Details:

Unit I Conductance

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivityand their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.Ionic velocities, mobilities and their determinations, transference numbers and their relationto ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

(20 Lectures)

Unit II Electrochemistry

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pHvalues, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes.Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

(28 Lectures)

Unit III Electrical & Magnetic Properties of Atoms and Molecules

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

(12 Lectures)

Reference Books:

- Atkins, P.W & Paula, J.D. *Physical Chemistry*, 9th Ed., Oxford University Press(2018).
- Castellan, G. W. *Physical Chemistry 4th Ed.*, Narosa (2004).
- Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
- Barrow, G. M., *Physical Chemistry 5th Ed.*, Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
- Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).
- Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry 4th Ed.*, JohnWiley & Sons, Inc. (2005).

Course Code: BSCH 403P

Course Name: ORGANIC CHEMISTRY-IV LAB

60 Lectures

CO1	Cell constant , equivalent conductance determination
CO2	Degree of dissociation and dissociation constant determination
CO3	Conductometric titrations
CO4	Potentiometric titrations

Conductometry

I. Determination of cell constant
II. Determination of equivalent conductance, degree of dissociation and dissociationconstant of a weak acid.
III. Perform the following conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Mixture of strong acid and weak acid vs. strong base
   iv. Strong acid vs. weak base

Potentiometry

I perform the following potentiometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base
   iii. Dibasic acid vs. strong base
   iv. Potassium dichromate vs. Mohr's salt

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R.Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed.;* McGraw-Hill: New York (2009).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H.Freeman & Co.: New York (2003).

Semester V

Course Code: BSCH 501T
Course Name: ORGANIC CHEMISTRY-IV

Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	General principles, introduction and applications of IR, UV, Raman and NMR spectroscopy.
CO2	Occurrence, classification and biological importance of carbohydrates.
CO3	Classification, colour and constitution of some dyes.
CO4	Introduction, classification, synthesis and molecular weight of polymer.

Course Details:

Unit 1 Nucleic Acids
Components of nucleic acids, Nucleosides and nucleotides;
Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine;Structure of polynucleotides.

(9 Lectures)

Unit 2 Amino Acids, Peptides and Proteins
Amino acids, Peptides and their classification.α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pK_a values,isoelectric point and electrophoresis;Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

(16 Lectures)

Unit 3 Enzymes

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes.Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

(8 Lectures)

Unit 4 Lipids

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

(8 Lectures)

Unit 5 Concept of Energy in Biosystems

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism).ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change.Agents for transfer of electrons in biological redox systems: NAD^+, FAD.Conversion of food to energy: Outline of catabolic pathways of carbohydrate-glycolysis,fermentation, Krebs cycle.Overview of catabolic pathways of fat and protein. Interrelationship in the metabolic pathways of protein, fat and carbohydrate.Caloric value of food, standard caloric content of food types.

(7 Lectures)

Unit 6 Pharmaceutical Compounds: Structure and Importance

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

(12 Lectures)

Reference Books:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. Biochemistry. VIth Edition. W.H.Freeman and Co.(2015).
- Nelson, D.L., Cox, M.M. and Lehninger, A.L. Principles of Biochemistry. IVEdition. W.H. Freeman and Co. (2009).
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill. (2009)

Course Code: BSCH 501P

Course Name: ORGANIC CHEMISTRY-IV LAB

60 Lectures

CO1	Extraction of caffeine from tea leaves.
CO2	Preparation of sodium polyacrylate, urea formaldehyde and methyl orange.
CO3	Qualitative analysis of organic compound.
CO4	Identification of organic compound by IR spectroscopy

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

Reference Books:

- Manual of Biochemistry Workshop, Department of Chemistry, Universityof Delhi(2012).
- Arthur, I. V. *Quantitative Organic Analysis*, Pearson, (2011)

Course Code: BSCH 502T
Course Name: PHYSICAL CHEMISTRY-V

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	Basics of quantum chemistry, Schrodinger equation and its applications , communications rules
CO2	Chemical bonding, LCAO-MO treatment of H2. $H2^+$, qualitative MO theory and its application
CO3	Basics of molecular spectroscopy, Rotational spectroscopy, Vibrational spectroscopy, Vibration – rotation spectroscopy and applications
CO4	Basics of electronic and NMR spectroscopy and their applications
CO5	Basics and laws of photochemistry, quantum yield, different photochemical reactions and their applications

Course Details:

Unit 1 Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting upof Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation tospherical polar coordinates. Separation of variables. Spherical harmonics. Discussion ofsolution.Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.Setting up of Schrödinger equation for many-electron atoms (He, Li). Need forapproximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

(24 Lectures)

Unit 2 Molecular Spectroscopy:

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclearspin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmorprecession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR ofsimple radicals.

(24 Lectures)

Unit 3 Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry,examples of low and high quantum yields, photochemical equilibrium and the differentialrate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

(12 Lectures)

Reference Books:

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. TataMcGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

Course Code: BSCH 502P

Course Name: PHYSICAL CHEMISTRY-V LAB

60 Lectures

CO1	Absorbance spectra determination of different given compounds with UV-Visible spectrophotometer

CO2	pH dependence of UV-Visible spectrum
CO3	Lambert's –Beer's law verification and concentration determination of solutions
CO4	Kinetics study and amount of substance present in a sample

UV/Visible spectroscopy

I. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

I. Verify Lambert-Beer's law and determine the concentration of$CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration
II. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
III. Study the kinetics of iodination of propanone in acidic medium.
IV. Determine the amount of iron present in a sample using 1,10-phenathroline.
V. Determine the dissociation constant of an indicator (phenolphthalein).
VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodiumhydroxide.
VII. Analysis of the given vibration-rotation spectrum of HCl(g)

Reference Books

- Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R.Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in PhysicalChemistry 8th Ed.;* McGraw-Hill: New York (2009).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H.Freeman & Co.: New York (2003).

Semester VI

Course Code: BSCH 601T

Course Name: INORGANIC CHEMISTRY-IV

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Understand the concept of qualitative analysis and its application in chemistry.
CO2	Learn the different types of organometallic compounds and their uses in organic synthesis.
CO3	Understand the mechanism and catalytic properties of selective organometallic compounds.
CO4	Understand the kinetics and reaction mechanism of inorganic metal complexes.

Course Details:

Unit 1 Theoretical Principles in Qualitative Analysis (H_2S Scheme)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to removethem after Group II.

(10 Lectures)

Unit 2 Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.

Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substitutedmetal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. □-acceptor behaviour of CO (MO diagram of CO to be discussed), synergiceffect and use of IR data to explain extent of back bonding.Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

(22 Lectures)

Unit 3 Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

(18 Lectures)

Unit 4 Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

(10 Lectures)

Reference Books:

- Vogel, A.I. *Qualitative Inorganic Analysis*, Longman (1972).
- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall (1996).
- Cotton, F.A. G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;*Wiley India (1993).
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles ofStructure and Reactivity 4th Ed.,* Harper Collins (2006).
- Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint ,Pearson Education (2005).
- Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models inInorganic Chemistry3rd Ed.,* John Wiley and Sons, NY (1994).
- Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements, Elsevier 2nd Ed*,1997).
- Lee, J.D. *Concise Inorganic Chemistry 5th Ed.,* John Wiley and sons (2008).
- Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall (1988).
- Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press,(1994).
- Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co.(1977).
- Miessler, G. L. & Donald, A. Tarr, *Inorganic Chemistry 4th Ed.,* Pearson (2010).
- Collman, James P. et al. *Principles and Applications of Organotransition MetalChemistry*. Mill Valley, CA: University Science Books (1987).
- Crabtree, Robert H. *The Organometallic Chemistry of the Transition Metals*. *j* New York, NY: John Wiley (2000).
- Spessard, Gary O., &Gary L. Miessler. *Organometallic Chemistry*. Upper SaddleRiver, NJ: Prentice-Hall (1996).

Course Code: BSCH 601P

Course Name: INORGANIC CHEMISTRY-IV LAB

60 Lectures

CO1	Basics concept of qualitative analysis.
CO2	Qualitative analysis of mixture of cations and anions.
CO3	Measurement of 10 Dq by spectrophotometric method.
CO4	Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.
CO5	Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. Find the λ_{max} of the complex.

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+,Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, Mg^{2+}

Mixtures should preferably contain one interfering anion, **or** insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3)**or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-.
Spot tests should be done whenever possible.

i. Measurement of 10 Dq by spectrophotometric method
ii. Verification of spectrochemical series.
iii. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
iv. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. Find the λ_{max} of the complex.
v. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Reference Books

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS., John Wiley and Sons. 4th edition, (1978)

Course Code: BSCH 602T
Course Name: ORGANIC CHEMISTRY-V

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	General principles, introduction and applications of IR, UV, Raman and NMR spectroscopy.
CO2	Occurrence, classification and biological importance of carbohydrates.
CO3	Classification, colour and constitution of some dyes.
CO4	Introduction, classification, synthesis and molecular weight of polymer.

Course Details:

Unit 1 Organic Spectroscopy

General principles Introduction to absorption and emission spectroscopy.
UV Spectroscopy: Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; applicationin functional group analysis.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift andfactors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpetation of NMR spectra of simple compounds.
Applications of IR, UV and NMR for identification of simple organic molecules.

(24 Lectures)

Unit 2 Carbohydrates

Occurrence, classification and their biological importance.Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation;Disaccharides – Structure elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

(16 Lectures)

Unit 3 Dyes

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

(8 Lectures)

Unit 4 Polymers

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);

Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

(12 Lectures)

Reference Books:

- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan(2010).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education),5th edition, (2020)
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education), 4th edition, (1963).
- Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International (2005).
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).
- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), 7th edition (2010).

Course Code: BSCH 602P

Course Name: ORGANIC CHEMISTRY-V LAB **60 Lectures**

CO1	Extraction of caffeine from tea leaves.
CO2	Preparation of sodium polyacrylate, urea formaldehyde and methyl orange.
CO3	Qualitative analysis of organic compound.
CO4	Identification of organic compound by IR spectroscopy

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

Reference Books:

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

Discipline Specific Elective (ELECTIVES)

Course Code: DSE 1T

Course Name: APPLICATION OF COMPUTER IN CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	The concept of basic knowledge of computer.
CO2	Numerical methods of roots of equation.
CO3	Knowledge of differential calculus & integral calculus.
CO4	Simultaneous equations.
CO5	Interpolation and extrapolation.

Course Details:

Unit I Basics:

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

Unit II Numerical methods:

Roots of equations: Numerical methods for roots of equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.
Differential calculus: Numerical differentiation.*Integral calculus:* Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.
Simultaneous equations: Matrix manipulation: addition, multiplication. Gauss-Siedal method.*Interpolation, extrapolation and curve fitting:* Handling of experimental data.*Conceptual background of molecular modelling:* Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Reference Books:

- Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007).
- Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis,* Cambridge Univ. Press (2001)
- Noggle, J. H. *Physical chemistry on a Microcomputer*. Little Brown & Co. (1985).
- Venit, S.M. *Programming in BASIC: Problem solving with structure and style.* JaicoPublishing House: Delhi (1996).

Course Code: DSE 1P

Course Name: APPLICATION OF COMPUTER IN CHEMISTRY LAB

60 Lectures

CO1	The concept of molecular visualization software
CO2	Numerical methods of roots of equation.
CO3	Knowledge of numerical differentiation.
CO4	Numerical integration.
CO5	Matrix operation.

Course Details:

Computer programs based on numerical methods for
1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pHof a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van derWaals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probabilitydistributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

Reference Books:

- Mc Quarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
- Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
- Steiner, E. The Chemical Maths Book Oxford University Press (1996).
- Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
- Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.
- Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis* Cambridge Univ. Press (2001)
- Noggle, J. H. *Physical Chemistry on a Microcomputer*. Little Brown & Co. (1985).
- Venit, S.M. *Programming in BASIC: Problem solving with structure and style.* JaicoPublishing House: Delhi (1996).

Course Code: DSE 2T

Course Name: ANALYTICAL METHODS IN CHEMISTRY

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	Learned the concept of qualitative and quantitative aspects of analysis
CO2	Understood optical methods of analysis
CO3	Learned thermal methods of analysis
CO4	Get knowledge of electro analytical methods
CO5	Learned separation techniques.

Course Details:

Unit I Qualitative and quantitative aspects of analysis:

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q andt test, rejection of data, and confidence intervals.

(5 Lectures)

Unit II Optical methods of analysis:

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;
Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.Structural illustration through interpretation of data, Effect and importance of isotope substitution.
Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

(25 Lectures)

Unit III Thermal methods of analysis:

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

(5 Lectures)

Unit IV Electroanalytical methods:

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pK_a values.

(10 Lectures)

Unit V Separation techniques:

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation.Technique of extraction: batch, continuous and counter current extractions.Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange.Development of chromatograms: frontal, elution and displacement methods.Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).Role of computers in instrumental methods of analysis.

(15 Lectures)

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H.Jeffery and others) 5th Ed. The English Language Book Society of Longman,(1989).
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. WardsworthPublishing Company, Belmont, California, USA (1988).
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York (2004).
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman (2007).
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, InternationalPublisher (2009).

Course Code: DSE 2P

Course Name: ANALYTICAL METHODS IN CHEMISTRY LAB

60 Lectures

CO1	Practical knowledge of separation techniques.

CO2	Practical aspects of solvent extraction methods
CO3	Determination of biological oxygen demand (BOD)
CO4	Determination of dissolved oxygen (DO) in water
CO5	Determination of chemical oxygen demand (COD)

I. Separation Techniques

1. Chromatography:

(a) Separation of mixtures

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture(glucose & fructose) by paper chromatography. Reporting the R_f values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify themon the basis of their R_f values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of ironsand gallium.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometrictechniques.

5. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

6. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

III Spectrophotometry

1. Determination of pK_a values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen in water.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).
6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex byJob's method.

Reference Books:

- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. WardsworthPublishing Company, Belmont, California, USA (1988).
- Christian, Gary D; Analytical Chemistry, 6th Ed. John

Wiley & Sons, New York (2004).
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher (2009).
- Ditts, R.V. Analytical Chemistry – Methods of separation. (2009).

Course Code: DSE 3T

Course Name: NOVEL INORGANIC SOLIDS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Learned the concept of synthesis and modification of inorganic solids.
CO2	Understood nanomaterial.
CO3	Learned about engineering materials applicable in mechanical construction.
CO4	Get knowledge of composite materials.
CO5	Learned speciality polymers

Course Details:

Unit I Synthesis and modification of inorganic solids:

Conventional heat and beat methods, Co-precipitation method, Sol-gel methods,Hydrothermal method, Ion-exchange and Intercalation methods.

(10 Lectures)

Unit II Inorganic solids of technological importance:

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white andblack pigments.Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.

(10 Lectures)

Unit III Nanomaterials:

Overview of nanostructures and nanomaterials: classification.Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-controlof nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisical nanomaterials, bionano composites.

(10 Lectures)

Unit V Introduction to engineering materials for mechanical construction:

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

(10 Lectures)

Unit VI Composite materials:

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

(10 Lectures)

Unit VII Speciality polymers:

Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrole, applications of conducting polymers, Ion-exchange resins and their applications. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

(10 Lectures)

Reference Books:

- Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2012)
- Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry,(1974).
- Charles P Poole., Frank J. Ovens, Introduction to Nanotechnology, Wiley. (2003)

Course Code: DSE 3P

Course Name: NOVEL INORGANIC SOLIDS LAB

60 Lectures

CO1	Learned the concept of synthesis and modification of inorganic solids.
CO2	Understood nanomaterial.
CO3	Learned about engineering materials applicable in mechanical construction.
CO4	Get knowledge of composite materials.
CO5	Learned speciality polymers.

1. Determination of cation exchange method
2. Determination of total difference of solids.
3. Synthesis of hydrogel by co-precipitation method.
4. Synthesis of silver and gold metal nanoparticles.

Reference Book:

- Fahan, *Materials Chemistry*, Springer,2nd edition, (2011).

Course Code: DSE 4T

Course Name: POLYMER CHEMISTRY

(Credits: Theory-06, Practicals-02)

Theory: 60 Lectures

CO1	Students learned practical knowledge of cation exchange method
CO2	Determination of total difference of solids
CO3	Synthesis of hydrogel by co-precipitation method
CO4	Practical related to inorganic solid such as cement
CO5	Practical related to polymers

Course Details:

Unit I Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces andchemical bonding in polymers, Texture of Polymers.

(4 Lectures)

Unit II Functionality and its importance:
Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi- functional systems, Poly-functional systems.

(8 Lectures)

Unit III Kinetics of Polymerization:
Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

(8 lectures)

Unit IV Crystallization and crystallinity:
Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

(4 Lectures)

Unit V Nature and structure of polymers-Structure Property relationships.

(2 Lectures)

Unit VI Determination of molecular weight of polymers (M_n, M_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution andits significance. Polydispersity index.

(8 Lectures)

Unit VII Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).

(8 Lectures)

Unit VII Polymer Solution – Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

(8 Lectures)

Unit IX Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

(10 Lectures)

Reference Books:

- Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary PolymerChemistry, 3rd ed. Prentice-Hall (2003)
- Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
- Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
- Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nded. John Wiley & Sons (2002)
- L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons(2005)
- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford UniversityPress (2005)
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Course Code: DSE 4P

Course Name: POLYMER CHEMISTRY LAB

60 Lectures

CO1	Preparation of nylon 6,6/6
CO2	Polymerization of acrylamide and acrylonitrile
CO3	Preparation of urea-formaldehyde resin.
CO4	Microscale Emulsion Polymerization of Poly(methylacrylate).

1. **Polymer synthesis**

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) /Methyl Acrylate (MA) / Acrylic acid (AA).
    a. Purification of monomer
    b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutylonitrile(AIBN)
2. Preparation of nylon 66/6
1. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC)and phenolphthalein
    a. Preparation of IPC
    b. Purification of IPC
    c. Interfacial polymerization
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
    (a) Polyacrylamide-aq.$NaNO_2$ solution
    (b) (Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol)(PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG)(OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

*at least 7 experiments to be carried out.

Reference Books

- Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A.
  Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow(2017).
- Hibbert, D. B. & Gooding, J. J. *Data analysis for chemistry*. OxfordUniversity Press(2006).
- Topping, J. *Errors of observation and their treatment.* Fourth Ed., ChapmanHall, London(1984).
- Harris, D. C. *Quantitative chemical analysis*. 6th Ed., Freeman (2007).
- Levie, R. de, *How to use Excel in analytical chemistry and in general scientific dataanalysis.* Cambridge Univ. Press (2001)
- Chemical safety matters – IUPAC – IPCS, Cambridge University Press (1992).

Course Code: DSE 5T

Course Name: RESEARCH METHODOLOGY FOR CHEMISTRY

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

CO1	The basic concepts of literature survey.
CO2	Information technology and library resources
CO3	Scientific research and writing scientific papers
CO4	Chemical safety and ethical handling of chemicals
CO5	Data analysis and electronic knowledge

Course Details:

Unit I Literature Survey:

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.
Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

(20 Lectures)

Unit II Methods of Scientific Research and Writing Scientific Papers:

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work.Writing ethics. Avoiding plagiarism.

(20 Lectures)

Unit III Chemical Safety and Ethical Handling of Chemicals:

Safe working procedure and protective environment, protective

apparel, emergencyprocedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation oflaboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

(12 Lectures)

Unit IV Data Analysis

The Investigative Approach: Making and Recording Measurements. SI Units and their use.Scientific method and design of experiments.
Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse. Basic aspects of multiple linear regression analysis.

(13 Lectures)

Unit V Electronics

Basic fundamentals of electronic circuits and their components used in circuits of common instruments like spectrophotometers, typical circuits involving operational amplifiers for electrochemical instruments. Elementary aspects of digital electronics.

(10 Lectures)

Reference Books

- Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A.
  Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow(2017).
- Hibbert, D. B. & Gooding, J. J. *Data analysis for chemistry*. OxfordUniversity Press(2006).
- Topping, J. *Errors of observation and their treatment.* Fourth Ed., ChapmanHall, London(1984).
- Harris, D. C. *Quantitative chemical analysis*. 6th Ed., Freeman (2007)
- Levie, R. de, *How to use Excel in analytical chemistry and in general scientific dataanalysis.* Cambridge Univ. Press (2001).
- Chemical safety matters – IUPAC – IPCS, Cambridge University Press (1992).

Course Code: DSE 6T

Course Name: GREEN CHEMISTRY

(Credits: Theory-04, Practicals-02) **Theory: 60 Lectures**

CO1	Introduction, need, goals of green chemistry.
CO2	Principles, designing and chemical synthesis of green chemistry.
CO3	Green synthesis of compounds like adipic acid, catechol, BHT, methyl methacrylate and urethane etc.
CO4	Microwave assisted reactions in water such as Hofmann Elimination and hydrolysis of benzyl chloride.
CO5	Understand Ultrasound assisted reactions like esterification, saponification and substitutions reactions.

Course Details:

Unit I Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry.Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

(4 Lectures)

Unit II Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products (Atom Economy); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energyrequirements for reactions - use of microwaves, ultrasonic energy; selection of startingmaterials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents;designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

(24 Lectures)

Unit III Examples of Green Synthesis/ Reactions

1. Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis), citral, ibuprofen, paracetamol, furfural.

2. Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzole acid), Oxidation (of toluene, alcohols).Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-

Alder Reaction, Decarboxylation.Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2-dihydrotriazine derivatives; benzimidazoles.

3. Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.

4. Selective methylation of active methylene group using dimethylcarbonate: Solid-statepolymerization of amorphous polymers using diphenylcarbonate; Use of "Clayan", a nonmetallic oxidative reagent for various reactions; Free Radical Bromination; Role of Tellurium in organic syntheses; Biocatalysis in organic syntheses.

(24 Lectures)

Unit IV Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry in sustainable development.

(8 Lectures)

Reference Books:

- V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry,
- Anamalaya Publishers (2005).
- P.T. Anastas & J.K. Warner: Oxford Green Chemistry-Theory and Practical,University Press (1998).
- A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
- M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, AmericanChemical Society, Washington (2000).
- M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American ChemicalSociety, Washington (2002).

Course Code: DSE 6P

Course Name: GREEN CHEMISTRY LAB

60 Lectures

CO1	The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine.
CO2	Hydrogen peroxide and liquid laundry starch.
CO3	Principle of atom economy.
CO4	Illustration of Green chemistry by atom economy.

1. Safer starting materials

The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxideand liquid laundry starch.

- Effect of concentration on clock reaction

- Effect of temperature on clock reaction. (if possible)

2. Using renewable resources

Preparation of biodiesel from vegetable oil.

3. Avoiding waste

Principle of atom economy.

Use of molecular model kit to stimulate the reaction to investigate how the atom economycan illustrate Green Chemistry.

Preparation of propene by two methods can be studied

(I) Triethylamine ion + OH^- → propene + trimethylpropene + water

(II) 1-propanol $\xrightarrow{H_2SO_4/\square}$ propene + water

The other types of reactions, like addition, elimination, substitution and rearrangement shouldalso be studied for the calculation of atom economy.

4. Use of enzymes as catalysts

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide

Alternative Green solvents

5. Diels Alder reaction in water

Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.

6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.

7. Mechanochemical solvent free synthesis of azomethines

8. Co-crystal controlled solid state synthesis (C^2S^3) of N-organophthalimide using phthalicanhydride and 3-aminobenzoic acid.

Alternative sources of energy

9. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).

10. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

- Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
- Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
- Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment:A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN 978-93-81141-55-7 (2013).

- Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, AmericanChemical Society (2008).
- Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry*, American ChemicalSociety (2008).
- Pavia, D. L. Lamponan, G. H. &Kriz, G.S. *W B Introduction to organic laboratory (2010)*

Course Code: DSE 7T

Course Name: INDUSTRIAL CHEMICALS AND ENVIRONMENT

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	About industrial gases and inorganic chemicals
CO2	Concepts of industrial metallurgy
CO3	Basic environmental knowledge.
CO4	Knowledge of different forms of energy and its utilization.
CO5	About bio-catalysis and biocatalyst.

Course Details:

Unit I Industrial Gases and Inorganic Chemicals

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt,borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chromealum, potassium dichromate and potassium permanganate.

(10 Lectures)

Unit II Industrial Metallurgy

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

(06 Lecture)

Unit III Environment and its segments

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smelling gases. Methods of estimationof CO, NO_x, SO_x and control procedures.Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, hlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of waterpollution on hydrological and ecosystems.

Water purification methods. Effluent treatment plants (primary, secondary and tertiarytreatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc.Sludge disposal.
Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

(30 Lectures)

Unit IV Energy & Environment

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.
Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

(10 Lectures)

Unit V Biocatalysis

Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

(6 Lectures)

Reference Books:

- K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi, 7th edition(1992).
- S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi(2018).
- S.E. Manahan, Environmental Chemistry, CRC Press (2005).
- G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
- A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

Course Code: DSE 7P

Course Name: INDUSTRIAL CHEMICALS AND ENVIRONMENT LAB

60 Lectures

CO1	Students understood about determination of biological oxygen demand (BOD)
CO2	Determination of dissolved oxygen (DO) in water
CO3	Determination of chemical oxygen demand (COD)

CO4	Measurement of dissolved carbon dioxide
CO5	Preparation of boric acid

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titrationmethod ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titrationmethod.
7. Measurement of dissolved CO_2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Reference Books:

- K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi, 7th edition(1992).
- S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
  (2018).
- S.E. Manahan, Environmental Chemistry, CRC Press (2005).
- G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
- A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

Course Code: DSE 8T

Course Name: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Knowledge of silicate industries
CO2	Fertilizers
CO3	Surface coatings
CO4	Knowledge of alloys and batteries
CO5	Chemical explosives and catalysis.

Course Details:

Unit I Silicate Industries

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

(16 Lectures)

Unit II Fertilizers

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

(8 Lectures)

Unit III Surface Coatings

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

(10 Lectures)

Unit IV Batteries

Primary and secondary batteries, battery components and their role,

Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

(6 Lectures)

Unit V Alloys

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

(10 Lectures)

Unit VI Catalysis

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.

Phase transfer catalysts, application of zeolites as catalysts.

(6 Lectures)

Unit VII Chemical explosives

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

(4 Lectures)

Reference Books:

- R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi, 3rd edition, 2010.
- P. C. Jain, M. Jain: *Engineering Chemistry,* Dhanpat Rai & Sons, Delhi., 16th edition.(2015)
- B. K. Sharma: *Engineering Chemistry*, Goel Publishing House, Meerut, 2000.

Course Code: DSE 8P

Course Name: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE LAB

60 Lectures

CO1	Students understood about determination of free acidity in ammonium sulphate fertilizer
CO2	Estimation of calcium in calcium ammonium nitrate fertilizer
CO3	Estimation of phosphoric acid in super phosphate fertilizer
CO4	Determination of composition of dolomite by complexometric titration

CO5	Preparation zinc oxide pigment

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

Reference Books:

- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK(1990).
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, WileyPublishers, New Delhi, 2nd edition, (1976).
- R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi, 3rd edition(2010).
- P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi., 16th edition.(2015)
- B. K. Sharma: *Engineering Chemistry*, Goel Publishing House, Meerut (2000).

Course Code: DSE 9T

Course Name: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Learned the basic concepts of spectroscopy
CO2	Understood infrared spectroscopy and ultra violet-visible spectroscopy.
CO3	Learned about separation techniques.
CO4	Elemental method of analysis
CO5	NMR spectroscopic technique and radiochemical methods of analysis.

Course Details:

Unit I Introduction to spectroscopic methods of analysis:

Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

(4 Lectures)

Unit II Molecular spectroscopy:

Infrared spectroscopy:

Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

UV-Visible/ Near IR – emission, absorption, fluorescence and photoaccoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time,photoacoustic, fluorescent tags).

(16 Lectures)

Unit III Separation techniques

Chromatography: Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis(use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

Immunoassays and DNA techniques

Mass spectroscopy: Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

(16 Lectures)

Unit IV Elemental analysis

Mass spectrometry (electrical discharges).Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

(8 Lectures)

Unit V NMR spectroscopy

Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications.

(4 Lectures)

Unit VI

(i) **Electroanalytical Methods** Potentiometry & Voltammetry

(ii) **Radiochemical Methods**

(iii) **X-ray analysis and electron spectroscopy (surface analysis)**

(4 Lectures)

Reference books:

- Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler,and Stanley Crouch (ISBN 0-495-01201-7) (2016).
- Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle (1989).
- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press (2018).
- Ball, D. W. Physical Chemistry Thomson Press, India (2017).

- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).

Course Code: DSE 9P

Course Name: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS LAB

60

Lectures

CO1	Students learned practical knowledge safety practices in chemistry laboratory
CO2	Understood titration curve of an amino acid
CO3	Determination of void volume of a gel filtration column
CO4	Study of electronic transition in organic molecules
CO5	IR absorption spectral analysis

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform andcarbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do “presumptive tests” to identify blood or other body fluids.
16. Use of “presumptive tests” for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Ychromosome only or multiple

chromosome)

19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants orexplosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

At least 10 experiments to be performed.

Reference Books:

- Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler,and Stanley Crouch (ISBN 0-495-01201-7) (2016).

Skill Enhancement Course

(Credit: 02 each)

Course Code: SEC 01

Course Name: BASIC ANALYTICAL CHEMISTRY 30 Lectures.

CO1	Importance of accuracy, precision and error in analytical measurements.
CO2	Water purification methods
CO3	Paper, Thin Layer and Ion exchange chromatographic separations
CO4	Analysis of deodorants, antiperspirants, talcum powder.

Course Details:

Unit I Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Unit II Analysis of soil

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

a. Determination of pH of soil samples.
b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometrictitration.

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample.
b. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products: Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida,chilli powder, turmeric powder, coriander powder and pulses, etc.

b. Analysis of preservatives and colouring matter.

Unit III Chromatography

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

a. Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}).
b. To compare paint samples by TLC method.

Ion-exchange: Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batchprocedure if use of column is not feasible).

Analysis of cosmetics: Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zincoxide and Calcium carbonate by complexometric titration.

Suggested Applications (Any one):

a. To study the use of phenolphthalein in trap cases.
b. To analyze arson accelerants.
c. To carry out analysis of gasoline.

Suggested Instrumental demonstrations:

a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flamephotometry.
b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in SoftDrink.

Reference Books:

1. Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6th Ed.*, Saunders College Publishing, Fort Worth (1992).
2. Freifelder, D. Physical Biochemistry *2nd Ed.*, W.H. Freeman and Co., N.Y. USA(1982).
3. Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y. USA. 16 (1977).
4. Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7th Ed.*, Prentice Hall (2002).
5. Robinson, J.W. *Undergraduate Instrumental Analysis 5th Ed.*, Marcel Dekker, Inc., New York(1995).

Course Code : SEC 02
Course Name : CHEMISTRY OF COSMETICS & PERFUMES
(30 Lectures)

CO1	Preparation and uses of Hair dye, hair spray, hair remover, shampoo
CO2	Preparation and uses of nail enamel, lipsticks
CO3	Preparation and uses of face cream, cold cream

Course Details:

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil,eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Practicals

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover

Reference Books:

- E. Stocchi: *Industrial Chemistry*, Vol -I, Ellis Horwood Ltd. UK(1990).
- P.C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi. (2015)
- B.K. Sharma: *Industrial Chemistry,* Goel Publishing House, Meerut(2016).

Course Code : SEC 03

Course Name: INTELLECTUAL PROPERTY RIGHTS (IPR) (30 Lectures)

CO1	Types and importance of IP
CO2	Copyrights, Trade Marks, Patents
CO3	Industrial design, Geographical indications, Trade secrets
CO4	Different International Agreements like WTO,WIPO, IPR and Plant Breeders Rights

Course Details:

Unit I Introduction to Intellectual Property:
Historical Perspective, Different Types of IP, Importance of protecting IP.
Copyrights
Introduction, How to obtain, Differences from Patents.
Trade Marks
Introduction, How to obtain, Different types of marks – Collective marks, certification marks,service marks, Trade names, etc.
Differences from Designs.
Patents
Historical Perspective, Basic and associated right, WIPO, PCT system, TraditionalKnowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.
Geographical Indications
Definition, rules for registration, prevention of illegal exploitation, importance to India.
Industrial Designs
Definition, How to obtain, features, International design registration.
Layout design of integrated circuits
Circuit Boards, Integrated Chips, Importance for electronic industry.
Trade Secrets
Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

Unit II Different International agreements

(a) World Trade Organization (WTO):

(i) General Agreement on Tariffs & Trade (GATT),
(ii) TradeRelated Intellectual Property Rights (TRIPS) agreement
(iii)General Agreement on Trade related Services (GATS)
(iv) Madrid Protocol
(v) Berne Convention
(vi) Budapest Treaty

(b) Paris Convention
WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity

Unit III IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assets and their valuation, Intellectual Property in the Indian Context – Various laws in India Licensing and technology transfer.

Reference Books:

- N.K. Acharya: *Textbook on intellectual property rights*, Asia Law House (2021).
- Manjula Guru & *M.B.* Rao, *Understanding Trips: Managing Knowledge inDeveloping Countries*, Sage Publications (2003).
- P. Ganguli, Intellectual Property Rights: *Unleashing the Knowledge Economy*, TataMcGraw-Hill (2001).
- Arthur Raphael Miller, Micheal H.Davis; *Intellectual Property: Patents, Trademarksand Copyright in a Nutshell*, West Group Publishers (2000).

Course Code: SEC 04
Course Name : IT SKILLS FOR CHEMISTS **30**
Lectures

CO1	Fundamental of mathematics, algebraic operations, differential calculus.
CO2	Basic of computers, logical and relative operators, basic programs
CO3	Introductory writing activities through word processor, use of Chemsketch,, Handling numeric data
CO4	Numeric modeling , excel functions, statistical analysis, presentation graphics

Course Details:

Unit I Mathematics

Fundamentals, mathematical functions, polynomial expressions, logarithms, the exponential function, units of a measurement, interconversion of units, constants and variables, equation of a straight line, plotting graphs.Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities.Uncertainty in measurement: types of uncertainties, combining uncertainties. Statistical treatment. Mean, standard deviation, relative error. Data reduction and the propagation of errors. Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression).Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms).Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary –bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

Unit II Computer programming:

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.
BASIC programs for curve fitting, numerical differentiation and

integration (Trapezoidal rule, Simpson's rule), finding roots (quadratic formula, iterative, Newton-Raphson method).

Unit III HANDS ON

Introductory writing activities: Introduction to word processor and structure drawing (ChemSketch) software. Incorporating chemical structures, chemical equations, expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waals equation, etc.) into word processing documents.

Handling numeric data: Spreadsheet software (Excel), creating a spreadsheet, entering and formatting information, basic functions and formulae, creating charts, tables and graphs. Incorporating tables and graphs into word processing documents. Simple calculations, plotting graphs using a spreadsheet (Planck's distribution law, radial distribution curves for hydrogenic orbitals, gas kinetic theory-Maxwell-Boltzmann distribution curves as functionof temperature and molecular weight), spectral data, pressure-volume curves of van der Waals gas (van der Waals isotherms), data from phase equilibria studies. Graphical solution of equations.

Numeric modelling: Simulation of pH metric titration curves. Excel functions LINEST and Least Squares. Numerical curve fitting, linear regression (rate constants from concentration- time data, molar extinction coefficients from absorbance data), numerical differentiation (e.g.handling data from potentiometric and pH metric titrations, pK_a of weak acid), integration (e.g. entropy/enthalpy change from heat capacity data).**Statistical analysis:** Gaussian distribution and Errors in measurements and their effect on data sets. Descriptive statistics using Excel. Statistical significance testing: The *t* test. The *F* test.**Presentation:** Presentation graphics

Reference Books:

- McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
- Steiner, E. The Chemical Maths Book Oxford University Press (1996).
- Yates, P. Chemical calculations. 2nd Ed. CRC Press (2007).
- Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007).
- Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*,Cambridge Univ. Press (2001) .
- Noggle, J. H. *Physical chemistry on a Microcomputer.* Little Brown & Co. (1985).
- Venit, S.M. *Programming in BASIC: Problem solving with structure and style.* JaicoPublishing House: Delhi (1996).

Generic Elective Papers (GE) (Minor-Chemistry) for other Departments/Disciplines

(Credit: 06 each)

Course Code: IDC 101T
Course Name: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

CO1	Understand the concept of atoms and molecules.
CO2	Understand the concept of chemical bonding and molecular structure and its applications
CO3	Understand the concept related to fundamentals of organic chemistry.
CO4	Understand the concept of stereochemistry and its application.
CO5	Learn the different types of hydrocarbon and their chemistry

Course Details:

Section A: Inorganic Chemistry-1 **(30 Periods)**

Unit I Atomic Structure:
Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radialand angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for1s, 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 m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stabilityof half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(14 Lectures)

Unit II Chemical Bonding and Molecular Structure

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, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.*Covalent bonding:* VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR 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.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *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^+. Comparison of VB and MO approaches.

(16 Lectures)

Section B: Organic Chemistry

Unit III Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonanceand Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.
Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.
Strength of organic acids and bases: Comparative study with emphasis on factors affectingpK values. Aromaticity: Benzenoids and Hückel's rule.

(8 Lectures)

Unit IV Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms).

Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis - trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

(10 Lectures)

Unit V Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to bestudied in context to their structure.
Alkanes: (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.
Alkenes: (Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

(12 Lectures)

Reference Books:

- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education),5th edition, (2020)
- Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, JohnWelly & Sons (1976).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education), 4th edition, (1963).
- Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International (2005).
- Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan(2010).
- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), 7th edition, (2010).

Course Code: IDC 101P

Course Name: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

60 Lectures

CO1	Basics concept of volumetric analysis.
CO2	Estimation of Mohr's salt and oxalic acid.
CO3	Estimation of carbonate and bicarbonate present in a mixture.
CO4	Detection of special elements in organic compounds.
CO5	Separation of mixtures by paper chromatography: Measure the R_f value in each case.

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto twoextra elements)

2. Separation of mixtures by Chromatography: Measure the Rf value in each case(combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine,aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. (1978)

Course Code: IDC 201T

Course Name: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANICCHEMISTRY-II

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	Understand the concepts of ideal and non-ideal solutions and its applications.
CO2	Concepts of phases, component and degree of freedom, phase diagrams and its applications
CO3	Understand the electrochemical reaction, conductance and their variation, applications of conductance measurements.
CO4	Learn the preparation and properties of carboxylic acids and their derivatives.
CO5	Learn the preparation and properties of amines and diazonium salts.
CO6	Understand the chemistry of bi-organic molecules like carbohydrates, aminoacids and proteins and their applications.

Course Details*:*

Section A: Physical Chemistry-2 **(30Lectures)**

Unit I Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature- composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partialmiscibility of liquids. Immiscibility of liquids-Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

(6 Lectures)

Unit II Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its

importance in phase equilibria. Phase diagrams of one-component systems (water and

sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H2O and Na-K only).

(6 Lectures)

Unit III Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid- base).

(8 Lectures)

Unit IV Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transferenceand without transference. Liquid junction potential and salt bridge.

pH determination using hydrogen electrode and quinhydrone electrode.Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

(10 Lectures)

Section B: Organic Chemistry-3 **(30 Lectures)**

Functional group approach for the following reactions (preparations & reactions) to bestudied in context to their structure.

Unit V Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters.*Reactions:* Hell – Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

(6 Lectures)

Unit VI Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons)

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.
Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: *Preparation:* from aromatic amines.
Reactions: conversion to benzene, phenol, dyes.

(6 Lectures)

Unit VII Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.
Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.Determination of Primary structure of Peptides by degradation Edmann degradation (N- terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C- activating groups and Merrifield solid-phase synthesis.

(10 Lectures)

Unit VIII Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

(8 Lectures)

Reference Books:

- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press (2018).
- G. W. Castellan: *Physical Chemistry* 4th Ed. Narosa (2004).
- J. C. Kotz, P. M. Treichel, J. R. Townsend, *General Chemistry*, Cengage LearningIndia Pvt. Ltd.: New Delhi (2009).
- B. H. Mahan: *University Chemistry*, 3rd Edn. Narosa (1998).

- R. H. Petrucci, *General Chemistry*, 5th Edn., Macmillan Publishing Co.: New York(1985).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education),5th edition, (2020)
- Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* JohnWelly & Sons (1976).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education), 4th edition, (1963).
- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), 7th edition, (2010).

Course Code : IDC 201P

Course Name: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANICCHEMISTRY-II LAB

60 Lectures

CO1	Qualitative analysis of organic compounds and preparation of their derivatives.
CO2	Separation of amino acids by paper chromatography.
CO3	Differentiation between a reducing / nonreducing sugar.
CO4	Conductometric titration.
CO5	Phase diagram construction.
CO6	Potentiometric titrations.

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions
by the distribution method: $I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$
$Cu^{2+}(aq) + xNH_2(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$

Phase equilibria

a) Construction of the phase diagram of a binary system (simple eutectic) usingcooling curves.
b) Determination of the critical solution temperature and composition of the phenolwater system and study of the effect of impurities on it.
c) Study of the variation of mutual solubility temperature with concentration for thephenol water system and determination of the critical solubility temperature.

Conductance

IV. Determination of cell constant
V. Determination of equivalent conductance, degree of dissociation and dissociationconstant of a weak acid.
VI. Perform the following conductometric titrations:
    v. Strong acid vs. strong base
    vi. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:
    v. Strong acid vs. strong base
    vi. Weak acid vs. strong base
    vii. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

I Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. Titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Determination of the saponification value of an oil/fat.
7. Determination of the iodine value of an oil/fat
8. Differentiation between a reducing/nonreducing sugar.
9. Extraction of DNA from onion/ cauliflower

Reference Books:

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. (1978).
- F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman (1960).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press., (2004).

Course Code : IDC 301T

Course Name: CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OFMATTER & CHEMICAL KINETICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	General principles of metallurgy and purification technique.
CO2	Chemistry of s and p block elements and their compounds.
CO3	Basics of Kinetic molecular model of gas, Vander Waals equations of states , laws of corresponding states
CO4	Concepts of suface tension and viscosity of liquid, their determination and effect of temperature.
CO5	Nature of solid states, symmetry elements, Bravais lattice, bragg's law, defects in crystals, structure analysis, glasses and liquid crystals.
CO6	Concepts of reaction rate, effect on reaction rate, activation energy and integrated rate equations.

Course Details:

Unit I General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellinghamdiagrams for reduction of metal oxides using carbon as reducing agent.
Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process.

(4 Lectures)

Unit II s- and *p*-Block Elements

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred-Rochow scales). Allotropy in C, S, and P.Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Compounds of *s*- and *p*-Block Elements

Hydrides and their classification (ionic, covalent and interstitial), structure and propertieswith respect to stability of hydrides of p- block elements.Concept of multicentre bonding (diborane).Structure, bonding and their important properties like oxidation/reduction, acidic/basic natureof the following compounds and their applications in industrial, organic and environmental chemistry.Hydrides of

nitrogen (NH_3, N_2H_4, N_3H, NH_2OH) Oxoacids of P, S and Cl.Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2

(26 Lectures)

Section B: Physical Chemistry-3 **(30 Lectures)**

Unit III Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2.Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.Temperature dependence of these distributions. Most probable, average and root mean squarevelocities (no derivation). Collision cross section, collision number, collision frequency,collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Liquids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equationsfor zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Reference Books:

- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press(2018).

- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel & J. R. Townsend: *General Chemistry* Cengage LeningIndia Pvt. Ltd., New Delhi (2009).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York(1985)
- Lee, J.D. Concise Inorganic Chemistry for JEE (Main and advance, 4th edition (2020).

Course Code : IDC 301P

Course Name: CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OFMATTER & CHEMICAL KINETICS LAB

60 Lectures

CO1	Surface tension measurements through drop number and drop methods
CO2	Viscosity measurement using Ostwald's viscometer
CO3	Study of rate of reactions by initial rate method.
CO4	Study of rate of reactions by intitegrated rate method.

Section A: Inorganic Chemistry

Semi-micro qualitative analysis using H2S of mixtures- not more than four ionic species (twoanions and two cations and excluding insoluble salts) out of the following:

Cations : NH^{4+}, Pb^{2+}, Ag^{+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^{+}

Anions : CO_3^{2-} , S^{2-}, SO^{2-}, $S_2O_3^{2-}$, NO_3^{-}, CH_3COO^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3^{-},SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^{-}

(Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

(I) Surface tension measurement (use of organic solvents excluded).

a) Determination of the surface tension of a liquid or a dilute solution using astalagmometer.

b) Study of the variation of surface tension of a detergent solution with concentration.

(II) Viscosity measurement (use of organic solvents excluded).

a) Determination of the relative and absolute viscosity of a liquid or dilute solutionusing an Ostwald's viscometer.

b) Study of the variation of viscosity of an aqueous solution with concentration ofsolute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

3. Initial rate method: Iodide-persulphate reaction
4. Integrated rate method:
   c. Acid hydrolysis of methyl acetate with hydrochloric acid.
   d. Saponification of ethyl acetate.
   e. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis ofmethyl acetate

Reference Books:

- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn. (1996).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co. (2018).

Course Code: IDC 401T

Course Name: CHEMISTRY OF D-BLOCK ELEMENTS, QUANTUMCHEMISTRY & SPECTROSCOPY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

CO1	General principles of metallurgy and purification technique.
CO2	Concepts of transition elements, inner-transition elements, and their oxidation states, color, magnetic, and catalytic properties.
CO3	Understand the Concepts of VBT, CFT, and their applications.
CO4	Basics of quantum chemistry, Born- Oppenheimer approximation, particle in 1-D box and zero point energy.
CO5	Basics of molecular spectroscopy, Rotational spectroscopy, Vibrational spectroscopy, UV-Vis spectroscopy, and its applications.
CO6	Concepts and laws of photochemistry, quantum yield, different photochemical reactions, and their applications

Course Details*:*

Section A: Inorganic Chemistry-3 **(30 Lectures)**

Unit I Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

(12 Lectures)

Unit II Coordination Chemistry

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6.Drawbacks of VBT. IUPAC system of nomenclature.

(8 Lectures)

Unit III Crystal Field Theory

Crystal field effect, octahedral symmetry. Crystal field stabilization

energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry.Jahn-Teller distortion, Square planar coordination.

(10 Lectures)

Section B: Physical Chemistry-4 **(30 Lectures)**

Unit IV Quantum Chemistry & Spectroscopy

Spectroscopy and its importance in chemistry. Wave-particle duality. Link between spectroscopy and quantum chemistry. Electromagnetic radiation and its interaction withmatter. Types of spectroscopy. Difference between atomic and molecular spectra. Born- Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.Postulates of quantum mechanics, quantum mechanical operator.Free particle. Particle in a 1-D box (complete solution), quantization, normalization of wavefunctions, concept of zero-point energy.*Rotational Motion:* Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.Microwave (pure rotational) spectra of diatomic molecules. Selection rules. Structural information derived from rotational spectroscopy.*Vibrational Motion:* Schrödinger equation of a linear harmonic oscillator and brief discussionof its results (solution not required). Quantization of vibrational energy levels. Selection rules, IR spectra of diatomic molecules. Structural information derived from vibrational.spectra. Vibrations of polyatomic molecules. Group frequencies. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.*Electronic Spectroscopy:* Electronic excited states. Free Electron model and its application to electronic spectra of polyenes. Colour and constitution, chromophores, auxochromes, bathochromic and hypsochromic shifts.

(24 Lectures)

Unit V Photochemistry

Laws of photochemistry. Lambert-Beer's law. Fluorescence and phosphorescence. Quantum efficiency and reasons for high and low quantum yields. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions. Photoelectric cells.

(6 Lectures)

Reference Books:

- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel & J. R. Townsend: *General Chemistry*, Cengage LeningIndia Pvt. Ltd., New Delhi (2009).

- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York(1985).
- Lee, J.D. Concise Inorganic Chemistry for JEE (Main and advance, 4th edition , 2020.
- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 11th Ed., Oxford University Press (2018).

Course Code: IDC 401P

Course Name: CHEMISTRY OF D-BLOCK ELEMENTS, QUANTUMCHEMISTRY & SPECTROSCOPY LAB

60 Lectures

CO1	Concepts of gravimetric analysis, complexometric titration and spectrophotometric separation.
CO2	Estimation of nickel, magnesium and zinc ion.
CO3	ermination of total hardness of water.
CO4	sorbance spectra determination of different given compounds with UV-Visible spectrophotometer
CO5	Lambert's –Beer's law verification and concentration determination of solutions

Section A: Inorganic Chemistry

1. Estimation of the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oxinate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.
4. To draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound and estimate the concentrationof the same in a given solution.
5. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} - phenanthroline complex in solution by Job's method.
6. Determination of concentration of Na+ and K+ using Flame Photometry.

Section B: Physical Chemistry

UV/Visible spectroscopy

I. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).

II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.

III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

I. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration

II. Analyse the given vibration-rotation spectrum of HCl(g)

Reference Books:

- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn. (1996).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co. (2018).