DAYANAND COLLEGE HISAR

Affiliated to Guru Jambheshwar University of Science & Technology, Hisar

Under DAV College Managing Committee, New Delhi

(Accredited with Grade 'A' by NAAC)

Session: 2021-2022

DEPARTMENT OF CHEMISTRY

Programme Outcome,

Programme Specific Outcome,

Course Outcome

Department of Chemistry

Programme Outcomes:

B.Sc. Medical & Non-Medical with Chemistry

After successful completion of Three Years Degree Programme in B.Sc. Medical & Non-Medical with Chemistry a student should be able to:

PO-1. Demonstrate, solve and an Understand the basic concepts in all disciplines of chemistry.

PO-2. Solve the problem and also think methodically, inddently and draw a logical conclusion.

PO-3. Employ critical thinking and the scientific knowledge to design, carry out, record and analyze the results of chemical reactions.

PO-4. Create an awareness of the impact of chemistry on the environment, society, and other culture outside the scientific community.

PO-5. Find out the green route for chemical reaction for sustainable development.

PO-6. To inculcate the scientific temperament and scientific attitude with logical thinking in various aspects of daily life..

PO-7. Provide an intellectually stimulating environment to develop skills and enthusiasm of students to the best of their potential.

PO-8. Use modern techniques, decent equipments and Chemistry software‟s

Department of Chemistry

Programme Specific Outcomes:

B.Sc. Medical & Non-Medical with Chemistry

After successful completion of Three Years Degree Programme in B.Sc. Medical & Non-Medical with Chemistry a student should gain the following skills:

PSO-1. Gain the knowledge of Chemistry through lectures, laboratory, tutorials and interaction with eminent academicians.

PSO-2. Develop laboratory skill for qualitative and quantitive analysis, organic synthesis, distillation, filtration, crystallization and chromatogrphy

PSO-3. To explain nomenclature, stereochemistry, structures, reactivity, and mechanism of the chemical reactions. Identify chemical formulae and solve numerical problems.

PSO-4. Use modern chemical tools, advance instruments and Equipments.

PSO-5. Develop research oriented skills.

PSO-6. Understand safe working procedure, chemical toxicology, environmental concerns and handling of chemicals.

PSO-7. Kindle the urge for higher studies, entrepreneurship and lifelong learning.

Department of Chemistry

COURSE OUTCOMES

B.Sc. Medical & Non-Medical with Chemistry

To teach fundamental concepts of Chemistry and their applications at undergraduate level, this will enable to impart comprehensive knowledge in Chemistry and its societal applications through a 3 year programme. The syllabi of B.Sc. in Chemistry is arranged in such a manner that due importance is given to intellectual and laboratory skills according to UGC module based upon Choice Based Credit System (CBCS).

Semester-I							
Paper Code	**Course opted**	**Nomenclature**	**Credits**	**Hr/ Week**	**Marks**		
					Ext.	**Int.**	**Total**
CCL-104	Core Course-I (Chemistry)	Inorganic Chemistry-I (Atomic Structure And Bonding)	2	2	80	20	100
CCL-105	Core Course-II (Chemistry)	Organic Chemistry-I(General Organic Chemistry & Aliphatic Hydrocarbons	2	2	80	20	100
CCP-109	Practical-I (Chemistry)	Chemistry Lab-I	2	4	50	-	50
Semester-II							
CCL-204	Core Course-III (Chemistry)	Physical Chemistry- I (Chemical Energetics And Equilibria)	2	2	80	20	100
CCL-205	Core Course-IV (Chemistry)	Organic Chemistry- II (Functional Group Organic Chemistry)	2	2	80	20	100
CPP-209	Practical-II (Chemistry)	Chemistry Lab-II	2	4	50	-	50

Semester-III							
CCL-304	Core Course-V	Physical Chemistry-II: (Solutions, Phase Equilibrium, Conductance & Electrochemistry)	2	2	80	20	100
CCL-305	Core Course-VI	Organic Chemistry-III: (Functional Group Organic Chemistry-II)	2	2	80	20	100
CCP-309	Practical-III	Chemistry Lab-III: (Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry)	2	4	50	-	50
Semester-IV							
CCL-404	Core Course-VII	Inorganic Chemistry-II: Transition Metals & Coordination Chemistry	2	2	80	20	100
CCL-405	Core Course-VIII	Physical Chemistry-III: States Of Matter & Chemical Kinetics	2	2	80	20	100
CCP-409	Practical-IV	Chemistry Lab IV: (Transition Metal & Coordination Chemistry, States Of Matter & Chemical Kinetics)	2	4	50	-	50
Semester-V							
CCL-503(i)	Discipline Specific Course-I(I)	Polymer Chemistry-I	2	2	80	20	100
CCL-504(i)	Discipline Specific Course-I(I)	Polymer Chemistry-II	2	2	80	20	100
CCP-	Practical-V(I)	Chemistry Dsc Lab V(I)	2	4	100	-	100

509(i)		Polymer Chemistry					
Or							
CCL-503(ii)	Discipline Specific Course-I(ii)	Chemistry Of Main Group Elements, Theories Of Acids And Bases-I	2	2	80	20	100
CCL-504(ii)	Discipline Specific Course-I(ii)	Chemistry Of Main Group Elements-Ii	2	2	80	20	100
CCP-509(ii)	Practical-V(ii)	Chemistry DSE Lab V(ii) Chemistry Of Main Group Elements, Theories Of Acids And Bases	2	4	100	-	100
CCS-505(i)	Skill Enhancement Course	Pesticide Chemistry	2	2	50	50	100
CCS-505(ii)	Skill Enhancement Course	Fuel Chemistry	2	2	50	50	100
CCS-505(iii)	Skill Enhancement Course	Green Methods In Chemistry	2	2	50	50	100
Semester-VI							
CCL-603(i)	Discipline Specific Course-III(i)	Organometallics And Bioinorganic Chemistry	2	2	80	20	100
CCL-604(i)	Discipline Specific Course-IV(i)	Polynuclear Hydrocarbons And UV, IR Spectroscopy	2	2	80	20	100
CCP-609(i)	Practical-VI(i)	Chemistry DSC Lab VI Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons And UV, IR Spectroscopy	2	4	100	-	100
Or							

CCL-603(ii)	Discipline Specific Course-III(ii)	Quantum Chemistry	2	2	80	20	100
CCL-604(ii)	Discipline Specific Course-IV(ii)	Spectroscopy & Photochemistry	2	2	80	20	100
CCP-609(ii)	Practical-VI(ii)	Chemistry DSE Lab 6(ii): Quantum Chemistry, Spectroscopy & Photochemistry	2	4	100	-	100

SEMESTER-I

CCL- 104

Core Course-I

INORGANIC CHEMISTRY—I(ATOMIC STRUCTURE AND BONDING)

UNIT-I

Atomic Structure-I **(8 Hours)**

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. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation).

UNIT-II

Atomic Structure-II **(7 Hours)**

Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers *ml* and *ms*. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (*ms*).Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

UNIT-III

Chemical Bonding **(8 Hours)**

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalentcompounds, 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 octahedralarrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

UNIT-IV

Molecular Structure **(7 Hours)**

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 MOapproaches.

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rded., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models inInorganic Chemistry*, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India,2006.

Course outcomes:

- **By the end of the course a student is expected to have the:**

- **CO1** : To understand the behaviour and interactions between matter and energy at both the atomic and molecular level.
- **CO2**: To understand the significance of quantum numbers, orbital angular momentum and quantum numbers *and* shapes of *s*, *p* and *d* atomic orbitals, nodal planes.
- **CO3** To familiarize about the chemical bonding, Ionic bonding and covalent bonding. Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalentcompounds, bond moment, dipole moment and percentage ionic character.
- **CO4**: To learn about 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

SEMESTER-I

CCL- 105

Core Course-II

ORGANIC CHEMISTRY--I (GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS)

UNIT-I

Fundamentals of Organic Chemistry (7 Hours)

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organicmolecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factorsaffecting pK values. Aromaticity: Benzenoids and Hückel's rule.

UNIT-II

Stereochemistry (8 Hours)

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).

UNIT-III

Aliphatic Hydrocarbons-I (8 Hours)

Functional group approach for the following reactions (preparations & reactions) to be studied 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.

UNIT-IV

Aliphatic Hydrocarbons-II **(7 Hours)**

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

Alkynes: (Upto 5 Carbons) *Preparation:* Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation ofvicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. KMnO4.

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* OrientLongman, New Delhi (1988).
- Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hilleducation, 2000.
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1** : Learn about fundamentals of organic chemistry and Structure, shape and reactivity of organicmolecules: Nucleophiles and electrophiles.
- **CO2**: To understand the Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds. Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature
- **CO3** To know about preparation and reactions of Alkanes & alkenes.
- **CO4**: To learn about Preparation: Acetylene from CaC2 and conversion into higher alkynes
- **CO-5**. Distinguish between type of addition, elimination and substitution reaction.

SEMESTER-I

CCP- 109 Practical Chemistry

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 KMnO4.
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
4. Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator.
5. Estimation of Cu (II) ions iodometrically using Na2S2O3.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing uptotwo extra 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 two 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:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbookof Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

- **By the end of the course a student is expected to have the:**
- **CO-1.** Study the volumetric analysis & determine the strength of various Inorganic compound.
- **CO-2**. To Learn about the preparatione a various Organic compounds and determine its % purity.
- **CO-3**. Learn about detection of extra elements in given organic compounds.
- **CO-4**.To understand the chromatographic techniques.

SEMESTER-II

CCL- 204

Core Course-III

PHYSICAL CHEMISTRY—I (CHEMICAL ENERGETICS AND EQUILIBRIA)

UNIT-I

Chemical Energetics **(8 Hours)**

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

UNIT-II

Chemical Equilibrium **(8 Hours)**

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G^{o}, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

UNIT-III

Ionic Equilibria-I **(7 Hours)**

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.

UNIT-IV

Ionic Equilibria-II **(7 Hours)**

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH fordifferent salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).

• Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: NewYork (1985).

Course outcomes

➢ **By the end of the course a student is expected to have the:**

- ❖ **CO1** : To understand the Important principles and definitions of thermochemistry
- ❖ **CO2**: Learn about the Variation of enthalpy of a reaction with temperature (Kirchhoff's equation).
- ❖ **CO3** To familiarize about the Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution.
- ❖ **CO4**: To learn about different applications of Le Chatelier's principle
- ❖ **CO5:** Distinction between G and G^{o}
- ❖ **CO 6:** To Understands the Solubility and solubility product of sparingly soluble salts & applications of solubility product principle.

SEMESTER-II

CCL 205

Core Course-IV

ORGANIC CHEMISTRY—II (FUNCTIONAL GROUP ORGANIC CHEMISTRY)

UNIT-I

Aromatic hydrocarbons **(7 Hours)**

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

UNIT-II

Alkyl and Aryl Halides **(8 Hours)**

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. *Preparation:* from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyland aryl halides.

UNIT-III

Alcohols, Phenols and Ethers (Upto 5 Carbons) **(8 Hours)**

Alcohols: *Preparation:* Preparation of 1^{o}, 2^{o} and 3^{o} alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk.$KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben– Hoesch Condensation, Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

UNIT-IV

Aldehydes and ketones (aliphatic and aromatic) (7 Hours)

(Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein- Pondorff Verley reduction.

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry,* 7th Ed. CengageLearning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* OrientLongman, New Delhi (1988).
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.

Course outcomes

By the end of the course a student is expected to have the:

- **CO1** : Learn SN1, SN2 and SNi Mechanism and stereochemistry.To understand the Important principles and definitions of thermochemistry
- **CO2**: Distinguish between type of addition, elimination and substitution reaction.
- **CO3** To understand the Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyland aryl halides
- **CO4**: To familiarize about the esterification, oxidation Pinacol-Pinacolone rearrangement.
- **CO5:** To Understands the Name Reactions i.e. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction.

SEMESTER-II

CCP 209 Practical -II

Chemistry Lab-II

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodiumhydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of *H*. **Ionicequilibria** pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to preventdamage to the glass electrode) using pH-meter.

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values withtheoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) anddistillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Reference Books

•Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.

•Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman,1960.

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R.Chand & Co.: New Delhi (2011).

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO-1.** Learn about enthalpy of neutralization , enthalpy of Ionisation and integral enthalpy
- **CO-2**. To Learn about the mechanisium & preparatione a various Organic compounds and determine its % purity.
- **CO-3**. Learn about solubility of benzoic acid.
- **CO-4**.To understand the preparation of buffer solutions.

SEMESTER-III

CCL-304

CORE COURSE-V

PHYSICAL CHEMISTRY-II: (SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE & ELECTROCHEMISTRY)

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.Azeotropes.Colligative properties of solutions.Thermodynamic derivations of relation between amount of solute and elevation in boiling point and depression in freezing point.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation.

(8 Hours)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, and Na-K only).

(7 Hours)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, 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).Concept of pH and pKa, buffer solution, buffer action, Handerson Hazel Blac equation.

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 transference and 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).

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co.: New York (1985).

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1** : Learn about Azeotropes & Colligative properties ofsolutions.
- **CO2**: To understand the effect of impurity on partial miscibility of liquids
- **CO3** To understand the Thermodynamic derivations of relation between amount of solute and elevation in boilingpoint and depression in freezing point.
- **CO4**: To familiarize about Phase diagrams of one-component systems (water and sulphur) andtwo component systems
- **CO 5** To 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
- **CO6:** To Understands the Concept of pH and pKa
- **CO 7:** To calculate the equilibrium constant from EMF data

SEMESTER-III

CCL-305

CORE COURSE-VI

ORGANIC CHEMISTRY-III*:* (FUNCTIONAL GROUP ORGANIC CHEMISTRY-II)

UNIT-I

Functional group approach for the following reactions (preparations & reactions) to be studied incontext to their structure for Units I-IV.

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, Perkincondensation.

UNIT-II

Amines and Diazonium Salts

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

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, HofmannBromamide 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.

UNIT-III

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.

UNIT-IV

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.

Reference Books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2),* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.*, W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. &Stryer, L. *Biochemistry*, W.H. Freeman, 2002. Kotz, J.C., Treichel, P.M.& Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co.: New York (1985).

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1** : Learn about derivatives of Carboxalic acid.
- **CO2**: To understand the name reactions I,e Gabriel's Phthalimide synthesis, HofmannBromamide reaction
- **CO3** To understand the Primary, Secondary, Tertiary and Quaternary Structure of proteins.
- **CO4**: To familiarize about Classification, and General Properties, Glucose and Fructose
- **CO 5** To determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides

SEMESTER-III

CCP-309

PRACTICAL-III

CHEMISTRY LAB-III:(SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUPORGANIC CHEMISTRY)

Section A: Physical Chemistry

Solutions: Determination of molecular weight of non volatile solute by Rast Method.

Phase equilibria: i.Construction of the phase diagram of a binary system (simple eutectic) usingcooling curves.

ii. Determination of the critical solution temperature and composition of the phenol water systemand study of the effect of impurities on it.

iii. Study of the variation of mutual solubility temperature with concentration for the phenol watersystem and determination of the critical solubility temperature.

Conductance: i.Determination of cell constant

ii. Determination of equivalent conductance, degree of dissociation and dissociation constant of aweak acid.

iii. Perform the following conductometric titrations:

a. Strong acid vs. strong base

b. Weak acid vs. strong base

Potentiometry: Perform the following potentiometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. 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/thin layer 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. Differentiation between a reducing and a nonreducing sugar.

Reference Books:

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of PracticalOrganic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. &Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.:New Delhi (2011).
- Ahluwalia, V.K. &Aggarwal, R. *Comprehensive Practical Organic Chemistry*, Universities Press.

Course outcomes

➢ **By the end of the course a student is expected to have the:**

❖ **CO1** : Determination of the critical solution temperature and composition of the phenol water system

❖ **CO2**: To understand the cell constant

❖ **CO3** Determination of equivalent conductance, degree of dissociation and dissociation constant of aweak acid.

❖ **CO4**: Differentiation between a reducing and a nonreducing sugar.

❖ **CO 5** To determination Qualitative Organic Analysis of Organic Compounds

❖ **CO 6** To understands the Action of salivary amylase on starch

SEMESTER-IV

CCL-404

CORE COURSE-VII

INORGANIC CHEMISTRY-II: TRANSITION METALS & COORDINATION CHEMISTRY

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.

UNIT-II

Lanthanoids and actinoids

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

UNIT-III

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.

UNIT-IV

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- orbital splittings.Spectrochemical series. Comparison of CFSE for *Oh* and *Td* complexes, Tetragonal distortion of octahedral geometry.Jahn-Teller distortion, Square planar coordination.

Reference Books:

- Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry*, Wiley.
- Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
- Wulfsberg, G. *Inorganic Chemistry*, Viva Books Pvt. Ltd.

• Rodgers, G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd., 2008.

Course outcomes

➢ **By the end of the course a student is expected to have the:**

❖ **CO1** : Know the meaning of various terms involved in co-ordinationchemistry

❖ **CO2**: To understand Werner‟s formulation of complexes and identify the types of valences

❖ **CO3** Know the limitations of VBT

❖ **CO4**: Know the shapes of d-orbital‟s and degeneracy of d-orbital‟s

❖ **CO 5** Draw the geometrical and optical isomerism of complexes

❖ **CO 6** To understands the lanthanide contraction

❖ **CO 7**: Learn about the Crystal field effects for weak and strong fields.

❖ **CO 8:** To understand the Spectrochemical series & Jahn-Teller distortion

SEMESTER-IV

CCL-405

CORE COURSE-VIII

PHYSICAL CHEMISTRY-III:STATES OF MATTER & CHEMICAL KINETICS

UNIT-I

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 square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules.

UNIT-II

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).

UNIT-III

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.

UNIT-IV

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 equations for 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:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd.,New Delhi (2009).
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1** : To understand the Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation
- **CO2**: Learn about the Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.
- **CO3** Know the effect of temperature on surface tension and coefficient of viscosity of a liquid
- **CO4**: Know the Bravais lattice types and identification of lattice planes
- **CO 5** Effect of temperature, pressure, catalyst andother factors on reaction rates
- **CO 6** To understands the Miller indices
- **CO 7**: Learn about the General methods for determination of order of a reaction.
- **CO 8:** To compare the Collision theory and Activated Complex theory of bimolecular reactions.

SEMESTER-IV

CCP-409

PRACTICAL-IV

CHEMISTRY LAB IV: (TRANSITION METAL & COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS)

Section A: Inorganic Chemistry

Semi-micro qualitative analysis (using H_2S or other methods) of mixtures - not more than four ionic species (two anions and two cations, excluding insoluble and interfering salts) out of the following: Cations : NH_4^+, Pb^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+

Anions: CO_3^{2-}, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, NO_2^-, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$,

(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato)nickel (II) 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.

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 a stalagmometer.

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 viscosity of a liquid or dilute solution using an Ostwald's viscometer.

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

III. Chemical Kinetics

Study the kinetics of the following reactions by integrated rate method:

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl

acetate

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. &Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: NewDelhi (2011).

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1** : Identyify the salt analysis qualitative methods
- **CO2**: Determine the total hardness of water by complexometric titrations
- **CO3** Determination of the surface tension and viscosity of a liquid
- **CO4**: Study of the variation of viscosity of an aqueous solution with concentration of solute
- **CO 5** To Study the kinetics of methyacetate.

SEMESTER-V

CCL-503(i)

Discipline Specific Course-I(i)

POLYMER CHEMISTRY-I

UNIT-I

Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemicalbonding in polymers, Texture of polymers.

Nature and structure of polymers-Structure Property relationships.

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. **Properties of Polymer**s (Physical, thermal, flow & mechanical properties).

UNIT-III

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.

UNIT-IV

Polycarbonates,Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole,polythiophene)].

Reference Books:

- Seymour, R.B.&Carraher, C.E. *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York,1981.
- Odian, G. *Principles of Polymerization*, 4th Ed. Wiley, 2004.
- Billmeyer, F.W. *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
- Ghosh, P. *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.

• Lenz, R.W. *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers, New York, 1967.

Course outcomes

➢ **By the end of the course a student is expected to have the:**

❖ **CO1** : To understand the classification of polymers, Polymer nomenclature

❖ **CO2**: Learn about the Physical, thermal, flow & mechanical properties of polymers.

❖ **CO3** To study the Physical, thermal, flow & mechanical properties of polymers

SEMESTER-V

CCL-504(i)

Discipline Specific Course-I(i)

POLYMER CHEMISTRY-II

UNIT-I

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.

UNIT-II

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

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

UNIT-III

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 and its significance.Polydispersity index.

UNIT-IV

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.

Reference Books:

- Seymour, R.B.&Carraher, C.E. *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York,1981.
- Odian, G. *Principles of Polymerization*, 4th Ed. Wiley, 2004.
- Billmeyer, F.W. *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
- Ghosh, P. *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
- Lenz, R.W. *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers, New York, 1967.

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1** : To understand the Mechanism and kinetics of polymerization
- **CO2**: Learn about Glass transition temperature (Tg) and determination of Tg.
- **CO3** Know the effect of Criteria for polymer solubility & Solubility parameter

SEMESTER-V

CCP-509(i)

PRACTICAL-V(i)

CHEMISTRY DSC LAB V(i)POLYMER CHEMISTRY

I. 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-bisisobutylonitrile (AIBN)

2. Preparation of nylon 66/6

3.Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC)and phenolphthalein

a. Preparation of IPC

b. Purification of IPC

c. Interfacial polymerization

4. Redox polymerization of acrylamide

5. Precipitation polymerization of acrylonitrile

6. Preparation of urea-formaldehyde resin

7. Preparation of novalac resin/resold resin

8. Microscale emulsion polymerization of poly(methylacrylate).

II. 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 lcohol) (PVOH) andthe fraction of "head-to-head" monomer linkages in the polymer.

3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).

III. Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method

2. Instrumental Techniques

3. Preparation of polyacrylamide and its electrophoresis

*at least 7 experiments to be carried out.

Reference Books:

- M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press, 1999.
- H.R. Allcock, F.W. Lampe & J.E. Mark, *Contemporary Polymer Chemistry*, 3rd ed. Prentice-Hall (2003)
- F.W. Billmeyer, *Textbook of Polymer Science*, 3rded.Wiley-Interscience (1984)
- J.R. Fried, *Polymer Science and Technology*, 2nded.Prentice-Hall (2003)
- P. Munk& T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nded.John Wiley & Sons(2002)
- L. H. Sperling, *Introduction to Physical Polymer Science*, 4thed.John Wiley & Sons (2005)
- M.P. Stevens, *Polymer Chemistry: An Introduction*3rded.Oxford University Press (2005).
- Seymour/ Carraher's Polymer Chemistry, 9th ed.by Charles E. Carraher, Jr. (2013).

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1** : To determine the molecular weight by viscometry
- **CO2**: Learn about preparation of polymer and its purification.

SEMESTER-V

CCL-503(ii)

Discipline Specific Course-I(ii)

Chemistry of Main Group Elements, Theories of Acids and Bases-I

UNIT-I

Acids and Bases: Bronsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept.Hard and soft acids and bases (HSAB concept), applications of HSAB process.

UNIT-II

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 agents. Hydrometallurgy with reference to cyanide process for gold and silver. Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn, Au): electrolytic refining, zone refining, van Arkel-de Boer process, Parting Process, Mond's process and Kroll Process.

UNIT-III

***s*- and *p*-Block Element**

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electronegativity (Pauling scale). General characteristics of *s*-block metals like density, melting and boiling points, flame colour and reducing nature. Oxidation states of *s*- and *p*-block elements, inert-pair effect, diagonal relationships and anomalous behaviour of first member of each group. Allotropy in C, P and S.

UNIT-IV

Complex forming tendency of *s* block elements and a preliminary idea of crown ethers and cryptates, structures of basic beryllium acetate, salicylaldehyde/ acetylacetonato complexes of Group 1 metals. Solutions of alkali metals in liquid ammonia and their properties.

Common features, such as ease of formation, solubility and stability of oxides, peroxides, superoxides, sulphates and carbonates of *s*-block metals.

Recommended texts:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, JohnWiley & Sons.
- Greenwood, N.N. &Earnshaw. *Chemistry of the Elements*, ButterworthHeinemann. 1997.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4thEd.,Pearson, 2010.

Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1** : To give an extended Knowledge of acids and bases
- **CO2**: Learn about the Metallurgy process.
- **CO3** Get concrete knowledge on s-block and p-block elements.

SEMESTER-V

CCL-504(ii)

Discipline Specific Course-II(ii)

Chemistry of Main Group Elements-II

UNIT-I

Structure, bonding and properties (acidic/ basic nature, oxidizing/ reducing nature and hydrolysis of the following compounds and their applications in industrial and environmental chemistry wherever applicable: Diborane and concept of multicentre bonding, hydrides of Groups 13 (EH_3), 14, 15, 16 and 17. Oxides of N and P, Oxoacids of P, S and Cl.

UNIT-II

Halides and oxohalides of P and S (PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2) Interhalogen compounds. A brief idea of pseudohalides

UNIT-III

Noble gases: Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6 ,bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory

UNIT-IV

Inorganic Polymers: Types of inorganic polymers and comparison with organic polymers, structural features, classification and important applications of silicates. Synthesis, structural features and applications of silicones. Borazines and cyclophosphazenes – preparation, properties and reactions. Bonding in $(NPCl_2)_3$.

Recommended texts:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, JohnWiley & Sons.
- Greenwood, N.N. &Earnshaw. *Chemistry of the Elements*, ButterworthHeinemann. 1997.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4thEd.,Pearson, 2010.
- Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1** : To give an extended Knowledge hydrides of Groups 13 , 14, 15, 16 and 17
- **CO2**: Learn about the idea of pseudohalides.
- **CO3** To understand the preparation and properties xenon compounds.
- **CO 4:** To familiarize the classification and important applications of silicates.

SEMESTER-V

CCP-509(ii) PRACTICAL-V(ii)

CHEMISTRY DSC LAB V

Chemistry of Main Group Elements, Theories of Acids and Bases

1. Iodometric estimation of potassium dichromate and copper sulphate
2. Iodimetric estimation of antimony in tartaremetic
3. Estimation of amount of available chlorine in bleaching powder and household bleaches
4. Estimation of iodine in iodized salts.
5. Iodimetric estimation of ascorbic acid in fruit juices.
6. Estimation of dissolved oxygen in water samples.
7. Gravimetric estimation of sulphate as barium sulphate.
8. Gravimetric estimation of aluminium as oximato complex
9. Preparation of the following: potash alum, chrome alum, tetraamminecopper(II) sulphate monohydrate, potassium trioxalatoferrate(III) (any two, including one double salt and one complex).

Recommended Texts:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1** : To give an extended Knowledge Iodometri estimation
- **CO2 :** To familiarize the the preparation of inorganic complexes.
- **CO3** Gravimetric estimation of aluminium as oximato complex.

SEMESTER-V

CCS-505(i)

Skill Enhancement Course-I

PESTICIDE CHEMISTRY

UNIT-I

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changingconcepts of pesticides.

UNIT-II

Structure activity relationship, synthesis and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene, Aldrin, Dialdrin); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Skill Enhancement Course-I PESTICIDE CHEMISTRY (Practicals)

1.To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.

2.Preparation of simple organophosphates, phosphonates and thiophosphates

Reference Book

- Cremlyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, New York, 1978.

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1 :** To give an extended Knowledge to pesticides (natural and synthetic).
- **CO2 :** To familiarize the benefits and adverse effects, changingconcepts of pesticides.

SEMESTER-V

CCS-505(ii)

Skill Enhancement Course-III

FUEL CHEMISTRY

UNIT-I

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorificvalue.

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different typesof petroleum products and their applications.

UNIT-II

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Lubricants: Classification of lubricants, lubricating oils (conducting and nonconducting) Solid andsemisolid lubricants, synthetic lubricants.

Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

Reference Books:

Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).

- Jain, P.C. & Jain, M. *Engineering Chemistry*DhanpatRai& Sons, Delhi.
- Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut (1996).

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1 :** To give an extended Knowledge of renewable and non-renewable energy sources.
- **CO2 :** To understand the Refining and different typesof petroleum products and their applications.
- **CO 3:** Know the properties of lubricants (viscosity index, cloud point, pore point) and their determination

SEMESTER-VI

CCL-603(i)

Discipline Specific Course-III(i)

ORGANOMETALLICS AND BIOINORGANIC CHEMISTRY

UNIT-I

Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co.

A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$.

UNIT-II

Organometallic Compounds

Definition and Classification with appropriate examples based on nature of metalcarbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied tocarbonyls.

UNIT-III

Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)-(MO diagram of COcan be referred to for synergic effect to IR frequencies).

UNIT-IV

Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

Reference Books:

- James E. Huheey, Ellen Keiter& Richard Keiter: *Inorganic Chemistry:Principles of Structure and Reactivity*, Pearson Publication.
- G.L. Miessler& Donald A. Tarr: *Inorganic Chemistry*, Pearson Publication.
- J.D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley & Sons.

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1 :** To understand the structure, bonding and reactivity of organometallic compounds sources.
- **CO2 :** To apply and analyze the methods of synthesis and mechanism of organometallic compounds.
- **CO 3:** Study the Bio-inorganic chemistry.

SEMESTER-VI

CCL-604(i)

Discipline Specific Course-IV(i) POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

UNIT-I

Polynuclear and heteronuclear aromatic compounds:

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine.

UNIT-II

Activemethyl compounds:

Preparation: Claisen ester condensation. Keto-enoltautomerism.

Reactions: Synthetic uses of ethyl acetoacetate (preparation of non-hetero molecules having having upto 6carbon).

UNIT-III

Application of Spectroscopy to Simple Organic Molecules

Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions, λmax&εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax ofconjugated dienes and α,β-unsaturated compounds.

UNIT-IV

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

(8 Hours)

Reference Books:

- I.L. Finar: *Organic Chemistry* (Vol. I & II), E.L.B.S.
- John R. Dyer: *Applications of Absorption Spectroscopy of Organic Compounds,* Prentice Hall.
- R.M. Silverstein, G.C. Bassler& T.C. Morrill*: Spectroscopic Identification of Organic Compounds,* JohnWiley & Sons.
- R.T. Morrison & R.N. Boyd: *Organic Chemistry,* Prentice Hall.
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman

- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1 :** To understand the Polynuclear and heteronuclear aromatic compounds,
- **CO2 :** To study UV, IR and NMR spectroscopy.
- **CO 3:** Study the Bio-inorganic chemistry.

SEMESTER-VI

CCP-609(i) PRACTICAL-VI(i)

CHEMISTRY DSC LAB VI

Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy

Section A: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the *Rf* value in each case. (Combination of two ions to be given)
   a. Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or
   b. Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}
2. Preparation of any two of the following complexes and measurement of their conductivity:
   a. tetraamminecarbonatocobalt (III) nitrate
   b. tetraamminecopper (II) sulphate
   c. potassium trioxalatoferrate (III) trihydrate

Compare the conductance of the complexes with that of M/1000 solution of NaCl, $MgCl_2$ and $LiCl_3$.

Section B: Organic Chemistry

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

Reference Books:

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1 :** To understand the Qualitative Organic Analysis of Organic Compounds,
- **CO2 :** Learn about prepration of complexes and measurement of their conductivity.

SEMESTER-VI

CCL-603(ii)
Discipline Specific Course-III(ii)
QUANTUM CHEMISTRY

UNIT-I

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.

UNIT-II

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomicmolecules 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.

UNIT-III

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

UNIT-IV

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).

Reference Books:

- 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).

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1 :** Students will be able to revise and update the fundamental ideas, mathematical concepts and application of group theory to molecular systems.
- **CO2 :** Expertise in categorising common molecules into various point groups and applying GOT to derive the character tables of various point groups.
- **CO 3:** Understand and solve particle in a box model, harmonic oscillator model, particle on a ring and gain a deep understanding in the application of tunnelling effect.

SEMESTER-VI

CCL-604(ii)

Discipline Specific Course-IV(ii)

SPECTROSCOPY & PHOTOCHEMISTRY

UNIT-I

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.

UNIT-II

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin,

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.

UNIT-III

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spinspin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

UNIT-IV

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 differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

Reference Books:

- Banwell, C. N. &McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill:New Delhi (2006).
- Kakkar, R. *Atomic & Molecular Spectroscopy*: *Concepts & Applications*, Cambridge University Press(2015).

Course outcomes

- **By the end of the course a student is expected to have the:**
- **CO1 :** To understand the basic principles and theory of microwave, NMR, IR, Raman, UVVis spectroscopy..
- **CO2 :** To understand about inorganic spectroscopic methods and other analytical methods
- **CO 3:** To know about inorganic photochemistry and nanomaterials CO 4 To familiarize about acids and bases and non-aqueous solvents
- **Co 4:** Study of photochemistry: Carbonyl compounds, alkenes, dienes, polyenes and aromatic compounds.

SEMESTER-VI

CCP-609(ii)

Practical-VI(ii)

CHEMISTRY DSE LAB 6B: QUANTUM CHEMISTRY, SPECTROSCOPY & PHOTOCHEMISTRY

UV/Visible spectroscopy

1. 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).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
3. 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.

Colorimetry

1. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$ / $KMnO_4$ /$K_2Cr_2O_7$ in a solution of unknown concentration
2. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenathroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Analyse the given vibration-rotation spectrum of HCl(g)

Reference Books

- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- 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 Chemistry3rd Ed.;* W.H. Freeman & Co.: NewYork (2003).

Course outcomes

- **By the end of the course a student is expected to have the:**

- **CO1 :** To understand the Analyse the given vibration-rotation spectrum
- **CO2 :** Determine colorimetrically the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.