FOUR YEAR UG (FYUGP) PROGRAME(B.Sc.)
KRISHNAGURU ADHYATMIK VISVAVIDYALAYA
DEPARTMENT OF CHEMISTRY

Semester I:

COURSE TITLE: PHYSICAL CHEMISTRY, ORGANIC CHEMISTRY (THEORY)

Course Code: CHEM-C-01

Theory: 45 Lectures **Credit :03**

Course objective: **Full Marks: 75**
Theory=60, IA=15)

This course may be divided into two broad parts physical and organic chemistry. In physical chemistry, students will be taught liquid state, gaseous state and chemical kinetics. The organic chemistry part contains fundamental of organic chemistry and aliphatic hydrocarbons.

Learning outcome :

After completion of this course the students will learn the basic concepts of organic and physical chemistry. They will understand viscosity , surface tension. In organic part the students are expected to learn basic ideas used in organic chemistry like functional groups , alkanes, alkenes ,alkynes etc.

Section- A :Physical Chemistry:

Unit -1
Liquid state:

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison.

(8 lectures)

Unit-2

Gaseous State:

Kinetic molecular model of 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, variation of viscosity with temperature and pressure. Behavior of real gases.

(8 lectures)

Unit-3

Chemical kinetics:

The concept of reaction rates. Effect of temperatures, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations of zero, first and second order reaction

Section-B: Organic Chemistry Unit- 4

Fundamentals of Organic Chemistry

Electronic Displacement:

Inductive effect; electrometric effect, Hyperconjugation, Bronsted-lowry concepts of acid and bases, effect of H-bonding on boiling point and solubility of organic compounds.

Nucleophiles and electrophiles. Reactive intermediates: Carbocations, carbonions and free radieals. Strength of organic acids and bases: comparatively with emphasis on factors affecting p^{ka} values, Benzenoids and Hückel's rule.

(10 lectures)

Unit -5

Aliphatic Hydrocarbons:

Functional group approach for the following actions (preparation & reactions) to be studies in context to their structure

Alkanes: (up to 5 carbons)

Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent, free radical substitution: Halogenation.

Alkenes (up to 5 carbons) preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule): cis-alkenes partical catalytic dehydration) and trans-alkenes (Birch reduction) Reactions: cis-addition (alk, $KMnO_4$) and trans-addition (bromine). Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, Oxymercuration-demercuration. Hydroboration- oxidation.

Alkynes (up to 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 $KMnO_4$.

(13 lectures)

COURSE TITLE: PHYSICAL CHEMISTRY, ORGANIC CHEMISTRY (PRACTICAL)

Course code: CHEM-C-01 **Credit: 01**

Section -A: Physical Chemistry Practical **Full Marks: 25**

1. Surface tension measurement (Use of organic solvents excluded) Class: 15 Nos.

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

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

2 Viscosity measurement (Use of organic solvents excluded)

a) Determination of the relative and absolute viscosity of a liquid of dilute solution using an Ostwald s viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

Section -B: Organic Chemistry Practical

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements)
2. Separation of mixtures by chromotohraphy; Measure the R_f value in each case (combination of two compounds to be given)
3. 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.
4. Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

1. A text book of physical chemistry: Atkins P.W. & Raula, J. Oxford Press, 2006.

2. I.L. Fibar: Organic Chemistry (vol I & II) E.L.B.S.

3. R.T. Morrison & R.N. Boyd: Organic chemistry, Prentice Hall

4. Khosla, B.D; garg, V.C. & Gulati, A. Senior Practical physical chemistry, R. Chand & Co New Delhi (2011)

5. Textbook of Practical organic chemistry, A.I. Vogel, Prentice Hall, 5th edition

COURSE TITLE: PHYSICAL CHEMISTRY, ORGANIC CHEMISTRY (THEORY)

Course Code: CHEM-M-01

Theory: 45 Lectures **Credit :03**

Course objective: **Full Marks: 75**
Theory=60, IA=15)

This course may be divided into two broad parts physical and organic chemistry. In physical chemistry, students will be taught liquid state, gaseous state and chemical kinetics. The organic chemistry part contains fundamental of organic chemistry and aliphatic hydrocarbons.

Learning outcome :

After completion of this course the students will learn the basic concepts of organic and physical chemistry. They will understand viscosity , surface tension. In organic part the students are expected to learn basic ideas used in organic chemistry like functional groups , alkanes, alkenes ,alkynes etc.

Section- A :Physical Chemistry:

Unit -1
Liquid state:

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison.

(8 lectures)

Unit-2

Gaseous State:

Kinetic molecular model of 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, variation of viscosity with temperature and pressure. Behavior of real gases.

(8 lectures)

Unit-3

Chemical kinetics:

The concept of reaction rates. Effect of temperatures, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations of zero, first and second order reaction.

(6 lectures)

Section-B: Organic Chemistry

Unit- 4

Fundamentals of Organic Chemistry

Electronic Displacement:

Inductive effect; electrometric effect, Hyperconjugation, Bronsted-lowry concepts of acid and bases, effect of H-bonding on boiling point and solubility of organic compounds.

Nucleophiles and electrophiles. Reactive intermediates: Carbocations, carbonions and free radieals. Strength of organic acids and bases: comparatively with emphasis on factors affecting p^{ka} values, Benzenoids and Hückel's rule.

(10 lectures)

Unit -5

Aliphatic Hydrocarbons:

Functional group approach for the following actions (preparation & reactions) to be studies in context to their structure

Alkanes: (up to 5 carbons)

Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent, free radical substitution: Halogenation.

Alkenes (up to 5 carbons) preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule): cis-alkenes partical catalytic dehydration) and trans-alkenes (Birch reduction) Reactions: cis-addition (alk, $KMnO_4$) and trans-addition (bromine). Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, Oxymercuration-demercuration. Hydroboration- oxidation.

Alkynes (up to 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 $KMnO_4$.

(13 lectures)

COURSE TITLE: PHYSICAL CHEMISTRY, ORGANIC CHEMISTRY (PRACTICAL)

Course code: CHEM-M-01 **Credit: 01**

Section -A: Physical Chemistry Practical **Full Marks: 25**

2. Surface tension measurement (Use of organic solvents excluded) Class: 15 Nos.

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

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

2 Viscosity measurement (Use of organic solvents excluded)

a) Determination of the relative and absolute viscosity of a liquid of dilute solution using an Ostwald s viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

Section -B: Organic Chemistry Practical

5. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements)
6. Separation of mixtures by chromotohraphy; Measure the R_f value in each case (combination of two compounds to be given)
7. 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.
8. Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

1. A text book of physical chemistry: Atkins P.W. & Raula, J. Oxford Press, 2006.

2. I.L. Fibar: Organic Chemistry (vol I & II) E.L.B.S.

3. R.T. Morrison & R.N. Boyd: Organic chemistry, Prentice Hall

4. Khosla, B.D; garg, V.C. & Gulati, A. Senior Practical physical chemistry, R. Chand & Co New Delhi (2011)

5. Textbook of Practical organic chemistry, A.I. Vogel, Prentice Hall, 5th edition

2nd Semester:

COURSE TITLE: s-AND p-BLOCK ELEMENTS, TRANSITION ELEMENTS, COORDINATION CHEMISTRY, SOLIDS, CHEMICAL THERMODYNAMICS & THERMO CHEMISTRY

Course code: CHEM-C-02

Theory: 45 lectures **Credit : 03**

Course objective: **Full Marks: 75**
(Theory: 60, IA = 15)

The course may be divided into two broad parts physical and inorganic chemistry. In physical chemistry students will be taught solids, chemical thermodynamics , systems of variable composition. Three unit -main group elements, transition elements and coordination chemistry will be taught in the inorganic part.

Learning outcome:

After completion of this course the students will learn the basic concepts of physical chemistry and inorganic chemistry. They will understand the Bragg's law , structures of NaCl, defects in crystals, glasses and liquid crystals, first law of thermos dynamics, partial molar quantities, periodic properties in main group elements, transition metals (3d series) .

Section A: Physical Chemistry

Unit 1:

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.

(8 lectures)

UNIT 2:

Chemical Thermodynamics

Basic Definition and Mathematical background of Thermodynamics.

Intensive and extensive variables; state and path functions; isolated, closed and open systems; Zeroth Law
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 under isothermal and adiabatic conditions.
Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion; Hess's Law and Application.
Calculation of bond energy, bond dissociation energy and resonance energy from thermodynamics data, Variation of Heat of reactions with temperature (Kirchhoff's equation) on enthalpy of reactions.
Second law: Statement of the Second law of thermodynamics; Carnot's Cycle and its efficiency. Thermodynamic Scale of Temperature. Concept of Entropy, Entropy change for reversible and irreversible

processes.

Third law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy: Variation of S, G, A with T, V, P. Free energy change and spontaneity. Joule-Thomson coefficient; Inversion temperature; Gibbs- Helmholtz equation; Maxwell relations; thermodynamic equation of state. (10lectures)

UNIT 3:

Systems of Variable Composition

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures.

(4 lectures)

Section-B: Inorganic Chemistry

Unit 4:

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

(13 lectures)

UNIT 5 :

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.

(10 Lectures)

COURSE TITLE: s-AND p-BLOCK ELEMENTS, TRANSITION ELEMENTS, COORDINATION CHEMISTRY, SOLIDS, CHEMICAL THERMODYNAMICS & THERMO CHEMISTRY(PRACTICAL)

COURSE CODE: CHEM-C-02 **Credit :01**

Section-A : Physical Chemistry Practical **Full Marks: 25**
Class: 15 Nos.

1. Determination of pH of a solution by Colour Matching.
2. Study of the solubility of benzoic acid in water and determination of ΔH.
3. Study of reaction rates of the following:
   a) Reaction of iodine ion hydrogen peroxide of room temperature using different concentration of iodide ions.
   b) Reaction between potassium iodate (KIO_3) & sodium sulphite (Na_2SO_3) using starch solution as indicator (clock reaction)
4. Determination of conc/molarity of $KMnO_4$ solution by titration it against a solution of
   a) Oxalic acid
   b) Ferrous ammonium sulphate

Section-B: Inorganic Chemistry Practical

Semi-micro qualitative analysis using H_2S mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, $CH3COO^-$, F^-, Cl^-, Br^-, I^-, NO^{3-}, BO_3^{3-}, 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+}

(Spot tests should be carried out wherever feasible)

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

2. Draw calibration curve (absorbance at λmax vs. concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.

3. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Job's method.

4. Estimation of (i) $^{Mg2+}$ (ii) Zn^{2+} by complexometric titrations using EDTA.

Reference Books :

1. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
2. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
3. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
4. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
5. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

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

COURSE TITLE: s-AND p-BLOCK ELEMENTS, TRANSITION ELEMENTS, COORDINATION CHEMISTRY, SOLIDS, CHEMICAL THERMODYNAMICS & THERMO CHEMISTRY(PRACTICAL)

COURSE CODE: CHEM-M-02 **Credit :01**

Section-A: Physical Chemistry Practical **Full Marks: 25**
Class: 15 Nos.

5. Determination of pH of a solution by Colour Matching.
6. Study of the solubility of benzoic acid in water and determination of ΔH.
7. Study of reaction rates of the following:
   a) Reaction of iodine ion hydrogen peroxide of room temperature using different concentration of iodide ions.
   b) Reaction between potassium iodate (KIO_3) & sodium sulphite (Na_2SO_3) using starch solution as indicator (clock reaction)
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Semi-micro qualitative analysis using H_2S mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

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(Spot tests should be carried out wherever feasible)

5. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.

6. Draw calibration curve (absorbance at λmax vs. concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.

7. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Job's method.

8. Estimation of (i) $^{Mg2+}$ (ii) Zn^{2+} by complexometric titrations using EDTA.

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1. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
2.Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
9. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
10. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
11. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

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

B.SC Chemistry 3rd Semester

EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY (I)

Corse Code: CHEM-C-03 **Credit:03**

Full Marks: 75

(Theory= 60, IA = 15)

Theory: 45 lectures

Course Objective: *This course contains two broad parts- physical and and organicchemistry. In physical chemistry part the students will be taught chemical equilibrium and ionic equilibrium. In organic chemistry part, the students will be introduced to different classes of organic compounds.*

Learning Outcome: *After completion of this course the students will able to understand the chemical system from thermodynamic points of view. They will also learn two very important topics in chemistry- chemical equilibrium and ionic equilibrium. In organic chemistry part, the students are expected to learn various classes of organic molecules-alkyl halides, aryl halides, alcohols, phenols.*

Section A: Physical Chemistry-1

Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG_o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

(10 Lectures)

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

(12 Lectures)

Section B: Organic Chemistry-2

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

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, 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).

(10 Lectures)

Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni)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: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(13 Lectures)

Recommended Books:

1. T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons.*
2. Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
3. I.L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
4. R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
5. Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.
6. G. M. Barrow: *Physical Chemistry* Tata McGraw---Hill (2007).

Equilibria and functional organic chemistry practical

Course Code: CHEM-C-03 Credit: 01

Full Marks: 25

Class: 15 Nos.

Section -A: Physical Chemistry Practical

Ionic equilibria

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 prevent damage 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 with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
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

Recommended Books

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

B.Sc. Chemistry 3rd Semester

Course Title: Coordination compounds, periodic table functional organic chemistry (II) Theory
Course Code: CHEM-C-04 Credit: 03
Theory: 45 Lecture Full Marks: 75
(Theory=60, IA = 15)

Course Objective:

This course is divided into two parts, inorganic & organic chemistry. Students will be taught about coordination chemistry, periodic table & various functional group.

Learning outcome:

After completion of this course students will learn the basic concepts of inorganic & organic chemistry. They will understand about coordination chemistry, periodic table & functional group.

Section-A: Inorganic Chemistry:

Unit : I Coordination Chemistry

Coordination compounds, types of ligands, Werner's theory, IUPAC nomenclature and isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Drawbacks of VBT. 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 Oh and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

(10 lectures)

Unit: 2 Periodic Table:

Need of classification of elements, genesis of periodic classification, modern periodic low & present form of the periodic table, nomenclature of elements with atomic number>100, electronic configuration of elements & the periodic table, electronic configuration of type of elements: s, p, d, f & periodic trends of properties
of elements.

(12 lectures)

Section-B: organic Chemistry:

Unit 3: Alcohol, Phenol & Ether:

Classification, Methods & Preparation of chemical reaction, difference between 1^0, 2^0 & 3^0 alcohols, phenols & ethars.

(13 lectures)

Unit 4: Carboxylic acid:

Method of preparation of aliphatic & aromatic compounds, their physical properties, chemical properties.

Dicarboxylic acid: Oxalic acid, nalonic acid, suecinic aicd, preparation & chemical properties. (10 lectures)

Recommended Books:

Shriver & Alkins, Inorganic chemistry, Peter Alkins, Tina Overton, Jonathan Rourkem Mark Weller & Freser Armstrong, 5th Edition, Oxford University Press (2011-2012)

IL. Fibar: Organic Chemistry (Vol I & II) E.L.B.S.

Course Title: coordination compounds, periodic table, functional organic chemistry (II) (Practical)

Course Code: CHEM-C-04

Credit: 01
Full Marks: 25
Class: 15 Nos.

Section A: Inorganic Practical:

Preparation: Preparation of phthalic anhydride
Preparation of iodeform from acetone
Preparation of trioxalat Ferrate
Preparation of Mohr's salt
Preparation of double salt & potassium ammonium sulphate (Potash-alum)

Section B: Organic Practical:

Organic estimation:
Estimation of glucose by using Fehling's solution.

Recommended books:

Wulfsberg, G Inorganic Chemistry, Viva Books Pvt Ltd

Textbook of Practical organic chemistry, AI voyel, Prentice Hall 5th edition.

Equilibria and functional organic chemistry practical

Course Code: CHEM-M-04 Credit: 01

Full Marks: 25

Class: 15 Nos.

Section -A: Physical Chemistry Practical

Ionic equilibria

pH measurements
c) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
d) 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 with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
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

Recommended Books

4. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
5. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
6. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

B.SC. Chemistry 4th Semester

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE & FUNCTIONAL GROUP ORGANICCHEMISTRY

Course Code: CHEM-C-05 **Credit:03**

Theory: 45 Lectures **Full Marks: 75**
(Theory= 65, IA = 15)

Course Objective: *This course may be divided into two broad parts-physical and organic chemistry. In 1st part of this course students will be introduced to solutions, phase equilibrium . The 2nd part contains carboxylic acid and derivatives, and biochemistry.*

Learning Outcome: *After completion of this course the students learn solutions, phase rule and its application in specific cases, basics of conductance. Studentswill also learn some important topics of organic and biochemistry- carboxylic acids, peptides, proteins and carbohydrates.*

Section A: Physical Chemistry- **Solutions**

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperaturecomposition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule.
Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. (7 Lectures)

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, $FeCl_3$-H_2O and Na-K only). . (7 Lectures)

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 acidbase). (8 Lectures)

Section B: Organic Chemistry

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

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)

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 (Nterminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & Cactivating groups and Merrifield solid-phase synthesis.

(10 Lectures)

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. **(7 Lectures)**

Recommended Books:

1. G. M. Barrow: *Physical Chemistry* Tata McGraw---Hill (2007).

2. G. W. Castellan: *Physical Chemistry* 4th Ed. Narosa (2004).
3. J. C. Kotz, P. M. Treichel, J. R. Townsend, *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. B. H. Mahan: *University Chemistry*, 3rd Edn. Narosa (1998).
5. R. H. Petrucci, *General Chemistry*, 5th Edn., Macmillan Publishing Co.: New York (1985).
6. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.*, W. H. Freeman.
10. Berg, J. M., Tymoczko, J. L. & Stryer, L. *Biochemistry 7th Ed.*, W. H. Freeman

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE & FUNCTIONAL GROUP ORGANIC CHEMISTRY

Course Code: CHEM-C-05 **Credit:01**

Section -A: Physical Chemistry Practical **Full Marks: 25**
Class: 15 Nos.

Phase equilibria

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

Conductance

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

Section B: Organic Chemistry

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.

Determination of the iodine value of an oil/fat

7. Differentiation between a reducing/nonreducing sugar.
8. Extraction of DNA from onion/ cauliflower

Recommended Books:

1. A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
2. F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
3. B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

B.Sc. Chemistry 4th Semester

Chemical Energetics, Electro Chemistry, Ether, amine and diazonium salts

Course Code: CHEM-C-06 **Credits: 03**

Full Marks: 75
(Theory=60, IA=15)

Course objectives: The course Chemical energetics, Electro Chemistry may be divided into two broad parts Physical Chemistry and Organic Chemistry. In Physical Chemistry students will be taught Chemical Energetics, Electro Chemistry, Ether amine and diazonium salts.

Learning outcome: After completion of the course the students will learn the chemical energetics, electro chemistry in Physical part. They will understand and learn about Aldehydes, ketones, amine, diazonium salts in organic part.

Section-A: Physical Chemistry:

Chemical Energetics

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.

(10 Lectures)

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).

(12 Lectures)

Section B: organic Chemistry:

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

Aldehydes and ketones (aliphatic and aromatic): (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.

(14 Lectures)

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**.** **(9 Lectures)**

Chemical Energetics, Electro Chemistry, Ether, amine and diazonium salts

Course Code: CHEM-C-06

Credits: 01
Full Marks: 25
Class: 15 Nos.

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 sodium hydroxide.
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 ΔH.

Ionic equilibria

pH measurements
c) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
d) Preparation of buffer solutions:
(iii) Sodium acetate-acetic acid

(iv) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

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.

Recommended Books:

5. A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
6. F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
7. B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
8. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

B.Sc Chemistry 4th Semester

Molecular modelling

Course Code: CHEM-C-07

Credits: 04
Full Marks: 100
(Theory=80, IA=20)

Course Objective: *The course introduces students to the basic principles of modelling and the important theoretical concepts and programming.*

Learning Outcome: *Students will be able to identify basic components of computer and modelling of molecules.*

Introduction to Molecular Modelling:

Introduction. Useful Concepts in Molecular Modelling: Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

(15 Lectures)

Force Fields:

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force Field Models for the Simulation of Liquid Water.

(15 Lectures)

Energy Minimization and Computer Simulation:

Minimization and related methods for exploring the energy surface. Non-derivative method, First and second order minimization methods. Computer simulation methods. Simple thermodynamic properties and Phase Space. Boundaries. Analyzing the results of a simulation and estimating Errors.

(15 Lectures)

Molecular Dynamics & Monte Carlo Simulation:

Molecular Dynamics Simulation Methods. Molecular Dynamics using simple models. Molecular Dynamics with continuous potentials. Molecular Dynamics at constant temperature and pressure. Metropolis method. Monte Carlo simulation of molecules. Models used in Monte Carlo simulations of polymers.

(15 Lectures)

Recommended Books:

1. A.R. Leach, Molecular Modelling Principles and Application, Longman, 2001.
2. J.M. Haile, Molecular Dynamics Simulation Elementary Methods, John Wiley and Sons, 1997.
3. Satya Prakash Gupta, QSAR and Molecular Modeling, Springer - Anamaya Publishers, 2008.

B.Sc Chemistry 4th Semester

Application of Computers in Chemistry

Course Code: CHEM-C-08

Credit: 03
Full Mark: 75
(Theory: 60, IA:15)

Course Objective: *This course intends to make learners familiar with basics of computer language, computer programming, handling of experimental data, curve fitting etc to analyze experimental results. This basic knowledge will help the students to perform and interpret results of various chemistry practicals.*

Learning Outcome: *After the completion of this course it will help the student to interpret laboratory data, curve fitting of experimental work, also perform quantum mechanical calculations for various molecular models.*

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. (20 Lectures)

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. (25 Lectues)

Recommended Books:

1. Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.

2. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ. Press (2001) 487 pages.
3. Noggle, J. H. *Physical chemistry on a Microcomputer.* Little Brown & Co. (1985).
4. Venit, S.M. *Programming in BASIC: Problem solving with structure and style.* Jaico Publishing House: Delhi (1996).

Application of Computers in Chemistry

Course Code: CHEM-C-08 Credits: 01

Full Mark: 25

Class: 15 Nos.

Computer programs based on numerical methods for

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).

2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).

3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.

4. Matrix operations. Application of Gauss-Siedel method in colourimetry.

5. Simple exercises using molecular visualization software.

Recommended Books:

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
5. Harris, D. C. *Quantitative Chemical Analysis*. 6th Ed., Freeman (2007) Chapters 3-5.
6. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ. Press (2001) 487 pages.
7. Noggle, J. H. *Physical Chemistry on a Microcomputer*. Little Brown & Co. (1985).
8. Venit, S.M. *Programming in BASIC: Problem solving with structure and style*. Jaico Publishing House: Delhi (1996).

B.SC. Chemistry 4th Semester

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE & FUNCTIONAL GROUP ORGANICCHEMISTRY

Course Code: CHEM-M-04 **Credit:03**

Theory: 45 Lectures **Full Marks: 75**
(Theory= 65, IA = 15)

Course Objective: *This course may be divided into two broad parts-physical and organic chemistry. In 1st part of this course students will be introduced to solutions, phase equilibrium . The 2nd part contains carboxylic acid and derivatives, and biochemistry.*

Learning Outcome: *After completion of this course the students learn solutions, phase rule and its application in specific cases, basics of conductance. Studentswill also learn some important topics of organic and biochemistry- carboxylic acids, peptides, proteins and carbohydrates.*

Section A: Physical Chemistry- **Solutions**

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperaturecomposition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule.
Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. (7 Lectures)

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, $FeCl_3$-H_2O and Na-K only). . (7 Lectures)

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 acidbase). (8 Lectures)

Section B: Organic Chemistry

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

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)

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 (Nterminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & Cactivating groups and Merrifield solid-phase synthesis.

(10 Lectures)

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. **(7 Lectures)**

Recommended Books:

11. G. M. Barrow: *Physical Chemistry* Tata McGraw---Hill (2007).

12. G. W. Castellan: *Physical Chemistry* 4th Ed. Narosa (2004).
13. J. C. Kotz, P. M. Treichel, J. R. Townsend, *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
14. B. H. Mahan: *University Chemistry*, 3rd Edn. Narosa (1998).
15. R. H. Petrucci, *General Chemistry*, 5th Edn., Macmillan Publishing Co.: New York (1985).
16. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
17. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
18. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
19. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.*, W. H. Freeman.
20. Berg, J. M., Tymoczko, J. L. & Stryer, L. *Biochemistry 7th Ed.*, W. H. Freeman

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE & FUNCTIONAL GROUP ORGANIC CHEMISTRY

Course Code: CHEM-M-05 **Credit:01**

Section -A : Physical Chemistry Practical **Full Marks: 25**
Class: 15 Nos.

Phase equilibria

d) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
e) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
f) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Conductance

VII. Determination of cell constant
VIII. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
IX. Perform the following conductometric titrations:
vii. Strong acid vs. strong base
viii. Weak acid vs. strong base

Section B: Organic Chemistry

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.

Determination of the iodine value of an oil/fat

7. Differentiation between a reducing/nonreducing sugar.
8. Extraction of DNA from onion/ cauliflower

Recommended Books:

9. A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
10. F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
11. B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
12. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

B.sc Chemistry 5th Semester

NOVEL INORGANIC SOLIDS

Course Code: CHEM-C-09 Credit: 04

Full Marks: 100

(Theory: 80, IA: 20)

Theory: 60 Lectures

Course Objective: *This introductory course intends to make learners familiar with a wide variety of technologically important and emerging materials. It will prepare the learners for studying materials further at the master's level. Prior completion of one introductory UG level course on inorganic and physical chemistry will be essential.*

Learning outcome: *After the completion of this course it will also be possible for the students to opt for studying an interdisciplinary master's programme with an emphasis on the synthesis and applications of various materials or take up a job in the materials production and/or processing industry.*

Synthesis and modification of inorganic solids:

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

(12 Lectures)

Inorganic solids of technological importance:

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments.

Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, metal containing liquid crystals.

(12 Lectures)

Nanomaterials:

Overview of nanostructures and nanomaterials: classification.
Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bioinorganic DNA and nano materials.

(8 Lectures)

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, aluminium and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

(12 Lectures)

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.

(12 Lectures)

Recommended Books:

1. Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
2. Smart, L. E., Moore, E. A., Solid State Chemistry: An Introduction, 4th Ed., CRC Press, 2012.
3. Poole, C. P., Ovens, F. J., Introduction to Nanotechnology, Wiley India, 2009.

Murty, B. S., Shankar, P., Raj, B., Rath, B, B., Murday, J. Textbook of Nanoscienceand Nanotechnology, Springer, 2013

B.Sc Chemistry 5th Semester

Course Title: Polymer Chemistry

Course Code: CHEM-C-10 Credit:03

Theory: 45 Lectures Full Marks: 75
(Theory: 60, IA: 15)

Course objective: *This is an introductory level course in polymer chemistry. The aim of the course is to introduce the theory and applications of polymer chemistry to the students.*

Learning outcome: *After completion of this course the students will learn the definition and classifications of polymers, kinetics of polymerization, molecular bonding, function and importance of polymer, crystallization and crystallinity and nature and structure of polymers.*

Introduction and history of polymeric materials:

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

(12 Lectures)

Functionality and its importance:

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems.

(9 Lectures)

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.

(10 lectures)

Crystallization and crystallinity:

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

(9 Lectures)

Nature and structure of polymers-Structure Property relationships.

(5 Lectures)

Course Title: POLYMER CHEMISTRY (PRACTICAL)

Course Code: CHEM-C-10 **Credit: 01**

Full Marks: 25

Class: 15 Nos.

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.

B.Sc. Chemistry 5th Semester

Course Title: SPECTROSCOPY

Course Code: CHEM-C-11 Credit: 03

Full Marks: 75

(Theory: 60, IA: 15)

Theory: 45 Lectures ***Course Objective:*** *Students shall be introduced to the fundamental concepts/theory andapplication of different spectroscopic techniques, as applied to chemistry.*

Learning Outcome: *Students shall be able to explain the theoretical basis of different spectroscopical techniques, identify the experimental requirements and compare/analyze the data/results thereof.*

Introduction to spectroscopic method 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.

(8 Lectures)

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, photoaccoustic, fluorescent tags).

(22 Lectures)

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 ionicspecies, matrix effects, other interferences).

(10Lectures)

NMR Spectroscopy: principle, instrumentation factor effecting chemical shift.

(5 lectures)

Recommended books:

1. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. JamesHoller, and Stanley Crouch (ISBN 0-495-01201-7).
2. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.
3. P.W. Atkins: Physical Chemistry.
4. G.W. Castellan: Physical Chemistry.
5. C.N. Banwell: Fundamentals of Molecular Spectroscopy.
6. Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
7. W.J. Moore: Physical Chemistry.

Course Title: SPECTROSCOPY (PRACTICAL)

Course Code: CHEM-C-11

Credit: 01
Full Marks: 25
Class: 15 Nos.

1. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
2. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
3. IR Absorption Spectra (Study of Aldehydes and Ketones)
4. Nuclear Magnetic Resonance
5. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids.
6. Collection, preservation, and control of blood evidence being used for DNA testing

1. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Ychromosome only or multiple chromosome)

Recommended Books:

1. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. JamesHoller and Stanley Crouch (ISBN 0-495-01201-7).
2. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

B.Sc Chemistry 5th Semester

Course title: GREEN CHEMISTRY

Course Code: CHEM-C-12 Credit:03

Theory: 45 Lectures Full Marks: 75

(Theory: 60, IA: 15)

Course Objective: *The learners will be taught about the emerging discipline of green chemistry particularly to differentiate as to how the principles of green chemistry may be applied to organic synthesis.*

Learning Outcome: *Apart from introducing learners to the principles of green chemistry, this course will make them conversant with applications of green chemistry to organic synthesis. Students will be prepared for taking up entry level jobs in the chemical industry. They also will have the option of studying further in the area.*

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)

Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples; Designing aGreen 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 – differentbasic approaches to do so; selection of appropriate auxiliary substances (solvents, separationagents), 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/protectinggroups; 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 hazardoussubstances in chemical processes.

(14 Lectures)

Examples of Green Synthesis/ Reactions

1. Green Synthesis of the following compounds: adipic acid, catechol, BHT,

methylmethacrylate, urethane, citral, ibuprofen, paracetamol, furfural.
2. Microwave assisted reactions in water: Oxidation of toluene, alcohols.
Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement,
Microwave assisted solid state reactions: Deacetylation, Deprotection.
Saponification ofesters, Alkylation of reactive methylene compounds, reductions, benzimidazoles.
3. 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.

(18Lectures)

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Solventlessreactions; Green chemistry in sustainable development.

(9 Lectures)

Recommended Books:

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

Course Title: GREEN CHEMISTRY (PRACTICAL)

Course code: CHEM-C-12 Credit: 01

Full Marks: 25

Class: 15 Nos.

1. Safer starting materials

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

(i) Effect of concentration on clock reaction

(ii) Effect of temperature on clock reaction.

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 $\xrightarrow[H_2SO_4/\Delta]{}$ propene + water

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 inbenzene 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.

Recommended Books:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice,* OxfordUniversity Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistryexperiment*. American Chemical Society, Washington DC (2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American ChemicalSociety, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. *Green Chemistry Experiment: A monograph*, I.K International Publishing House Pvt Ltd. New Delhi. BangaloreCISBN 978-93-81141-55-7 (2013).
5. Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, AmericanChemical Society (2008).
6. Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry,* American ChemicalSociety (2008).
7. Pavia, D. L. Lampman, G. H. & Kriz, G.S. *W B Introduction to Organic LaboratoryTechniques: A Microscale Approach,* 4th Ed., Brooks/Cole; 2007.

B.sc Chemistry 5th Semester

NOVEL INORGANIC SOLIDS

Course Code: CHEM-M-05 Credit: 04

Full Marks: 100

(Theory: 80, IA: 20)

Theory: 60 Lectures

Course Objective: *This introductory course intends to make learners familiar with a wide variety of technologically important and emerging materials. It will prepare the learners for studying materials further at the master's level. Prior completion of one introductory UG level course on inorganic and physical chemistry will be essential.*

Learning outcome: *After the completion of this course it will also be possible for the students to opt for studying an interdisciplinary master's programme with an emphasis on the synthesis and applications of various materials or take up a job in the materials production and/or processing industry.*

Synthesis and modification of inorganic solids:

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

(12 Lectures)

Inorganic solids of technological importance:

Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments.

Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, metal containing liquid crystals.

(12 Lectures)

Nanomaterials:

Overview of nanostructures and nanomaterials: classification.
Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bioinorganic DNA and nano materials.

(8 Lectures)

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, aluminium and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.

(12 Lectures)

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.

(12 Lectures)

Recommended Books:

1. Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
2. Smart, L. E., Moore, E. A., Solid State Chemistry: An Introduction, 4th Ed., CRC Press, 2012.
3. Poole, C. P., Ovens, F. J., Introduction to Nanotechnology, Wiley

India, 2009. Murty, B. S., Shankar, P., Raj, B., Rath, B, B., Murday, J. Textbook of Nanoscienceand Nanotechnology, Springer, 2013

B.Sc Chemistry 6th Semester

Course Title: INDUSTRIAL CHEMICAL AND ENVIRONMENTAL CHEMISTRY

Course Code: CHEM-C-13 Credit: 03

Full Marks: 75

(Theory: 60, IA: 15)

Theory:45 Lectures

Course Objectives: *This course provides an introduction to the various industrial gases and inorganic chemicals, their manufacturing processes, applications, storage and the hazards ofhandling them. Contribution of these industrial chemicals towards air and water pollution and their effects on living organisms and the environment has also been covered. Students are also expected to learn about energy generation industry and the pollution threat they pose. This course also discusses about management of the different kinds of wastes, their safe disposal and the importance of practicing green chemistry in chemical industry.*

Learning Outcomes: *After successful completion of the course, students would have learnt about the manufacture, applications and safe ways of storage and handling gaseous and inorganic industrial chemicals. Students will get to know about industrial metallurgy and the energy generation industry. Students will also learn about environmental pollution by variousgaseous, liquid wastes and nuclear wastes and their effects on living beings. Finally, the students will learn about industrial waste management, their safe disposal and the importance of environment friendly "green chemistry" in chemical industry.*

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, chrome alum, potassium dichromate and potassium permanganate.

(8 Lectures)

Industrial Metallurgy

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

(2 Lectures)

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, chlorofluorocarbons and Halogens, removalof 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 water pollution on hydrological and ecosystems. . Effluent treatment plants (primary, secondary and tertiary treatment). 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.

(25 Lectures)

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)

Recommended Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
8. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

Course Title: INDUSTRIAL CHEMICAL AND ENVIRONMENT (PRACTICAL)

Course Code: CHEM-C-13 Credit:01

Full Marks: 25

Class: 15 Nos.

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.

Recommended Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

B.Sc. Chemistry 6th Semester

Course Title : POLYMER AND ITS APPLICATION

Course Code: CHEM-C-14

Credit:03
Full Marks: 75
(Theory: 60, IA: 15)

Theory: (45 Lectures)

Course objective: *This is an introductory level course in polymer chemistry. The aim of the course is to introduce the theory and applications of polymer chemistry to the students. They will learn about glass transition temperature polymer solution and properties of polymer*

Learning outcome: *After completion of this course the students will learn determination molecular weight of polymer, Flory-Huggins Theory, Physical, thermal flow and mechanical properties of polymers.*

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. **(12 Lectures)**

Glass transition temperature (Tg) and determination of Tg, Free volume theory,

Factors affecting glass transition temperature (Tg). **(12 Lectures)**

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. **(11 Lectures)**

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 relatedpolymers, 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)

Recommended Books:

1. *Seymour's Polymer Chemistry,* Marcel Dekker, Inc.
2. G. Odian: Principles of Polymerization, John Wiley.
3. F.W. Billmeyer: Text Book of Polymer Science, John Wiley.
4. P. Ghosh: Polymer Science & Technology, Tata Mcgraw-Hill.
5. R.W. Lenz: Organic Chemistry of Synthetic High Polymers.

Course Title: POLYMER AND ITS APPLICATION

Course Code: CHEM-C-14 Credit: 01

Full Marks: 25

Class: 15 Nos.

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

Recommended Books:

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

B.Sc Chemistry 6th Semester

Course Title: ELECTROANALYTICAL METHOD AND VARIOUS SEPARATION TECHNIQUE

Course Code: CHEM-C-15 Credit: 03

Full Marks: 100
(Theory: 80, IA: 20)

Course Objective: *Students shall be introduced to the fundamental concepts/theory and application of different analytical techniques, and separation techniques as applied to chemistry.*

Learning Outcome: *Students shall be able to explain the theoretical basis of different analytical techniques and separation identify the experimental requirements and compare/ analyze the data/results thereof.*

Basic Concept of Separation:

Definition, type, principle of chromatography, differential extraction. ***(10 Lectures)***

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. **(35 lectures)**

Electroanalytical Methods: Potentiometry & Voltammetry **(10 lectures)**

Radiochemical Methods **(5 lectures)**

Recommended books:

1. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. JamesHoller, and Stanley Crouch (ISBN 0-495-01201-7).
2. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.
3. P.W. Atkins: Physical Chemistry.
4. G.W. Castellan: Physical Chemistry.
5. C.N. Banwell: Fundamentals of Molecular Spectroscopy.

6. Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
7. W.J. Moore: Physical Chemistry.

B.Sc. Chemistry 6th Semester

Course Title: INORGANIC MATERIAL OF INDUSTRIAL IMPORTANCE

Course Code: CHEM-C-16 Credit:03

Theory: 45 Lectures Full Marks: 75

(Theory: 60, IA: 15)

Course Objectives: *To learn the synthetic process, properties and the utility of the industrially important inorganic materials (such as silicates, ceramics, cements, fertilizers, paints, batteries, alloys and explosives).*

To provide opportunity to learn some of the industrial process such as surface coating and catalysis in relevant to industry where heterogeneous catalysis dominates.

Experiments are aimed at helping learners acquire hands on experience in qualitative and quantitative analysis of the inorganic materials which are basically manufactured in chemical industries.

To learn some industrial techniques such as surface coating etc..

Learning Outcome: *This course will establish the basic foundation of industrial inorganic chemistry among the students. This will be helpful for pursuing further studies of industrial chemistry in future. Experiments will help the Students to gather the experience of qualitative and quantitative chemical analysis. Students will be capable of doing analysis of the inorganic materials which are used in our daily life. They will have insight of the industrial processes.*

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 thesetting process, quick setting cements.

(9 Lectures)

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.

(6 Lectures)

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.

(8 Lectures)

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.

(5 Lectures)

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.

(8 Lectures)

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)

Chemical explosives:

Origin of explosive properties in organic compounds, preparation and explosive

properties oflead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.
(3 Lectures)

Recommended Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, WileyPublishers, New Delhi.
4. Karl Heinz Büchel, Hans-Heinrich Moretto Peter, Woditsch; *Industrial InorganicChemistry*, Wiley-VCH.
5. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.

Course Title: PROJECT WORK

Course Code: CHEM-C-16 Credit:01

Full Mark: 25

Projects: (Any one)

1. On water chemistry with special reference is drinking water.

2. On soil quality of agricultural field.

6th Semester:

Course Title: INDUSTRIAL CHEMICAL AND ENVIRONMENTAL CHEMISTRY

Course Code: CHEM-M-06 Credit: 03

Full Marks: 75

(Theory: 60, IA: 15)

Theory:45 Lectures

Course Objectives: *This course provides an introduction to the various industrial gases and inorganic chemicals, their manufacturing processes, applications, storage and the hazards ofhandling them. Contribution of these industrial chemicals towards air and water pollution and their effects on living organisms and the environment has also been covered. Students are also expected to learn about energy generation industry and the pollution threat they pose. This course also discusses about management of the different kinds of wastes, their safe disposal and the importance of practicing green chemistry in chemical industry.*

Learning Outcomes: *After successful completion of the course, students would have learnt about the manufacture, applications and safe ways of storage and handling gaseous and inorganic industrial chemicals. Students will get to know about industrial metallurgy and the energy generation industry. Students will also learn about environmental pollution by variousgaseous, liquid wastes and nuclear wastes and their effects on living beings. Finally, the students will learn about industrial waste management, their safe disposal and the importance of environment friendly "green chemistry" in chemical industry.*

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, chrome alum, potassium dichromate and potassium permanganate.

(8 Lectures)

Industrial Metallurgy

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

(2 Lectures)

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, chlorofluorocarbons and Halogens, removalof 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 water pollution on hydrological and ecosystems. . Effluent treatment plants (primary, secondary and tertiary treatment). 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.

(25 Lectures)

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)

Recommended Books:

10. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
11. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
12. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
13. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
14. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
15. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
16. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
17. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
18. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

Course Title: INDUSTRIAL CHEMICAL AND ENVIRONMENT (PRACTICAL)

Course Code: CHEM-M-06 Credit:01

Full Marks: 25

Class: 15 Nos.

11. Determination of dissolved oxygen in water.
12. Determination of Chemical Oxygen Demand (COD)
13. Determination of Biological Oxygen Demand (BOD)
14. Percentage of available chlorine in bleaching powder.
15. Measurement of chloride, sulphate and salinity of water samples by simple titrationmethod ($AgNO_3$ and potassium chromate).
16. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titrationmethod.
17. Measurement of dissolved CO_2.
18. Study of some of the common bio-indicators of pollution.
19. Estimation of SPM in air samples.
20. Preparation of borax/ boric acid.

Recommended Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

SEMESTER VII

PAPER I:

Course Title : SPCTROSCOPY- I
Course Code: CHEM-C-17

Credit:03
Full Marks: 75
(Theory: 60, IA: 15)
Theory: (45 Lectures)

Course objective: *This is an introductory level course in spectroscopic chemistry. The aim of the course is to introduce the theory and applications of spectroscopic chemistry to the students. They will learn about determining chemical composition, molecular structures, and concentrations in fields like forensics, pharmacology, materials science, astronomy, and environmental monitoring*

Learning outcome: *After completion of this course the students will learn about spectroscopy and how chemical compounds are identified and separated using contemporary methods and instruments.*

Unit I:

Introduction to spectroscopic method 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.

Unit II:

Rotational Spectroscopy:

Rotational spectra of diatomic molecules – rigid rotator concept – determination of bond length – effect of isotopic substitution – spectra of non-rigid rotator.

Unit III:

Vibrational and Raman Spectroscopy:

Vibrational spectra of diatomic molecules – harmonic and anharmonic oscillator model – Morse potential - calculation of force constants – effect of isotope - vibrations of polyatomic molecules, fundamental modes of vibration of H_2O & CO_2 molecules. Diatomic vibrating rotor – vibration rotation spectrum of CO. Basic principles of IR spectroscopy. Principle of Raman spectroscopy – rotational and vibrational Raman spectra of linear molecules, stokes and anti-stokes lines, rule of mutual exclusion. Symmetry and IR/Raman activity of normal modes of vibration. Interpretation of IR and Raman spectra of simple inorganic and coordination compounds.

Unit IV:

Electronic spectroscopy:

Basic principles. Electronic transitions and selection rule - spectrum of atomic hydrogen – fine structure, spectra of H-like atoms. Electronic transitions in diatomic molecules – Selection rule - Born Oppenheimer approximation – vibrational coarse structure - Frank Condon principle – electronic transitions in polyatomic molecules. chromophore, auxochrome – absorption due to ethylenic chromophore. Effect of solvents on electronic transition, quantitative estimation by spectrophotometry.

Unit V:

ESR spectroscopy: Electron spin resonance and hyperfine splitting. g value and hyperfine constant, Bohr magneton, electron Zeeman splitting, electron nuclear hyperfine splitting, illustration using simple examples like H atom, methyl radical.

Recommended books :

1. Organic Spectroscopy, 3rd Edition, William Kemp.
2. NMR Spectroscopy, 2nd Edition, Harald Günther
3. Physical Methods in Inorganic Chemistry, Russel S. Drago.
4. Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, 4th Edition.
5. Electroanalytical methods, Bard and Faulkner.
6. Atkins Physical Chemistry, Atkins, de Paula and Keeler, 11th Edition.
7. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012.
8. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press.
9. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition

Course Title: SPECTROSCOPY (PRACTICAL)

Course Code: CHEM-C-17

Credit: 01

Full Marks: 25
Class: 15 Nos.

6. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
7. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
8. IR Absorption Spectra (Study of Aldehydes and Ketones)
9. Nuclear Magnetic Resonance
10. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids.
11. Collection, preservation, and control of blood evidence being used for DNA testing
12. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Ychromosome only or multiple chromosome)

Recommended Books:

3. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. JamesHoller and Stanley Crouch (ISBN 0-495-01201-7).
4. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

PAPER II:

Course Title : ANALYTICAL CHEMISTRY-I

Course Code: CHEM-C-18

Credit:04
Full Marks: 100
(Theory: 80, IA: 20)
Theory: (60 Lectures)

Objective: This course aims to develop a foundational understanding of both classical and instrumental analytical techniques, focusing on the interpretation of analytical data, chemical equilibria, and the application of statistical and thermodynamic principles for solving analytical problems and evaluating real-world applications.

Course outcome: After successful completion of this course, students will be able to:

1. Evaluate and compare analytical techniques for accuracy, precision, and suitability.
2. Understand the theoretical foundation of gravimetric and volumetric analysis.
3. Apply chemical equilibrium concepts in complexometric, redox, and acid-base titrations.
4. Explain the principles behind spectroscopic, electrochemical, and chromatographic methods.

Content:

Unit I: Basic Concepts and Errors in Chemical Analysis

Introduction to analytical chemistry and its classification, Concepts of accuracy, precision, significant figures, and errors (systematic and random), Methods of error minimization, Statistical treatment of analytical data, Mean, median, standard deviation.

Unit II: Classical Methods of Analysis

A. Gravimetric Analysis: Principles, precipitation techniques, solubility product, coprecipitation, post-precipitation, peptization.
B. Volumetric Analysis: Principles of titrimetry, Types of titrations: acid-base, redox, complexometric, precipitation, Indicators and their selection.

Unit III: Electroanalytical Methods

Conductometry and conductometric titrations, Potentiometry and redox electrodes, Ion-selective
electrodes and pH-metry, Coulometry and voltammetry: principles and applications.

Unit IV: Spectroscopic Techniques in Analysis

A. UV-Visible Spectroscopy: Principles, Beer-Lambert law, instrumentation, Quantitative analysis.
B. Atomic Absorption and Emission Spectroscopy: Principles, instrumentation, applications.

References/ Textbooks:

1. Analytical Chemistry" by G. D. Christian and P. K. Sharma;
(Adapted Indian edition; Sharma is Indian contributor) Publisher: Wiley India.
2. "Instrumental Methods of Chemical Analysis" by B.K. Sharma;

Publisher: Krishna Prakashan Media (Comprehensive book with both theoretical and instrumental details).
3. "Analytical Chemistry: Principles" by S. M. Khopkar; Publisher: New Age International Publishers (Well-known for Indian university syllabi)
4. "Textbook of Analytical Chemistry" by A. I. Vogel, adapted by G. H. Jeffery, J. Bassett, and Indian adaptations by S. S. Mendham and D. A. Sethi (Classic text, often used in Indian universities; Indian edition available).
5. "Fundamentals of Analytical Chemistry" by D. K. Sahu; Publisher: Narosa Publishing House
6. "Analytical Chemistry" by G. Chatwal and S. Anand; Publisher: Himalaya Publishing

PAPER III:

Course Title : Name reactions and reagents in organic chemistry

Course Code: CHEM-C-19

Credit:04
Full Marks: 75
(Theory: 60, IA: 15)
Theory: (45 Lectures)

Objective:
The objective of Name reactions and reagents in organic chemistry is to provide concept related to reagents and reactions involved in synthetic organic reactions.

Course Outcome:
After completion of this coarse student will Understand the concept involved in various name reactions. The mechanisms involved in various name reactions.The reagents for the conversion of one functional group into other functional group in one or more number of steps. The role of organic reagents in various organic transformations.

UNIT I:

Selective Name Reactions-I:
Aldol condensation, Perkin reaction, Stobbe reaction, Dieckmann condensation, Diels-Ader reactions, Robinson annulation, Michael reaction, Mannich, Stork enamine, Sharpless asymmetric epoxidation, Barton, Ene, Suzuki reaction, Heck reaction, Buckwald reaction.

UNIT II:

Selective Name Reactions-II:
Hoffman-Loffler- Freytag, Shapiro reaction, Chichibabin, Cannizaro, Bayer-Hilman, Darens, Benzoin condensation, Knoevenegel, Reimer-Tieman reaction, Wolf- Kishner reduction, Clemmenson reduction, Moningo reduction, Meerwein-PondorfVerley reduction, Oppenauer oxidation, Dess-Martin oxidation, Swern oxidation, Reformatsky reaction.

UNIT III:

Reagents in organic synthesis-I:
Complex metal hydrides, DIBAL-H, Gilman's reagent, LDA, DCC, 1,3-propane dithiane, Trimethyl-silyl-tin hydride, Tri-nbutyl-tin hydride, Woodwords and Prevost hydroxylation, DDQ, SeO2, Methods of generation, properties and reactions of organo magnesium, lithium, cadmium, copper, Grignard reagent and its application.

UNIT IV: Reagents in organic synthesis-II:

PPC, PDC, Merifield resins, Peterson's synthesis, Baker's yeast, Chromic acid, Potassium dichromate, Jones reagent, Collins reagent, Birch reduction, Periodic acid, Lead tetra acetate, Osmium tetra oxide, Ozonolysis, m-CPBA, Wittig reagent.

Text Books:
1. Advanced organic chemistry: Reactions, mechanism and structure; March Jerry; 7th edition; John Wiley.
2. Organic Chemistry, Finar I. L. 6th edition, (Low price), 2017, Pearson Education.
Reference Books:
1. Peter Sykes, A guidebook to mechanisms in Organic Chemistry, 6th edition, 2003, published by Pearson India.
2. Kalsi P.S.,Organic Reactions and their Mechanisms, 3nd edition, 2017, New Age International.
3. Organic Chemistry, Stanley H. Pine, 5th edition, 2010, McGraw-Hill Bool.
4. Organic Chemistry, Solomons T. J., 11th revised edition, 2013, John Wiley & Sons

PAPER IV:

Course Title : Research methodology

Course Code: CHEM-C-20

Credit:03
Full Marks: 75
(Theory: 60, IA: 15)
Theory: (45 Lectures)

Course Objectives: This course is introduced to impart knowledge about the basic concepts of research and to provide a road map for conducting research.
Learning Outcomes: After completing this course, students are expected to identify, explain and apply basic concepts of research; acquire information, recognize various issues related to research, lab safety and software/computer-based applications for research.

Unit 1.

Research methodology
Definitions, Purpose of Research, Types of research, Research approaches, Research Method, Stages of the research process, Background reading & information gathering: Literature survey (different sources of literature survey including online databases), Hypothesis: Identification of Research Problem; Ethical issues in research, Data collection, Data recording and reproducibility, Importance of documentation.

Unit 2.

Research ethics and Publication
Presentation of research findings: Elements of research publications; Seminar presentation; Patent; Paper writing; Journal impact factor, h-index; review process.

Unit 3.

Laboratory safety
General health and safety concerns; What to do after splash/cut, Chemical hazards, commonly used hazardous laboratory chemicals (azide, perchlorate, nBuLi, acid chlorides, bromine, cyanide, mercury, etc), Personal protective equipment, Environmental safety issues: Fume hood safety, Safety data sheet, Waste handling, Disposal of chemical and plastic-waste; precautionary measure for the maintenance of laboratory equipment.

Unit 4. Statistical Methods and Computer Applications in Chemistry
Errors, precision and accuracy; Average Mean Deviation, Standard Deviation, Variance, f-test, t-test, Chi-square Test. Applications of Curve Fitting, Straight Line Fitting, Interpolation in solving chemical problems. Applications of commonly used Computer Softwares, such as Chemdraw, Chemoffice, Mercury, Origin, Excel, X'Pert HighScore, ImageJ, etc)

RESEARCH METHODOLOGY REFERENCES:

1. National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition. National Academies Press.
2. K. Prathapan, Research Methodology for Scientific Research, Dreamtech Press (2019)
3. R. Ridley, Handbook of Good Laboratory Practices, 2nd Edition, WHO (2009).
4. Ramesh Kumari, Computers and their Applications to Chemistry, 2nd Ed., Narosa Publishing House, 2007.
5. K. Atkinson, Elementary Numerical Analysis, 2nd Ed., John Willy and Sons, 2003.
6. R. Ridley, Handbook of Good Laboratory Practices, 2nd Edition, WHO (2009).

Research Methodology LAB

Course Code: CHEM-C-20 Credit: 01
Full Marks: 25
Class: 15 Nos.

1. Use of Chemdraw for drawing chemical structure, Reaction and Reaction Scheme.
2. Use of Origin software, Preparation of tables, figures, flowchart, and PowerPoint presentation.
3. Application of f-test, t-test, Chi-square Test in data analysis.
4. Applications of Curve Fitting, Straight Line Fitting, Interpolation in solving chemical problems

MINOR:

Course Title : SPCTROSCOPY- I

Course Code: CHEM-M-7

Credit:03
Full Marks: 75
(Theory: 60, IA: 15)
Theory: (45 Lectures)

Course objective: *This is an introductory level course in spectroscopic chemistry. The aim of the course is to introduce the theory and applications of spectroscopic chemistry to the students. They will learn about determining chemical composition, molecular structures, and concentrations in fields like forensics, pharmacology, materials science, astronomy, and environmental monitoring*

Learning outcome: *After completion of this course the students will learn about spectroscopy and how chemical compounds are identified and separated using contemporary methods and instruments.*

Unit I:

Introduction to spectroscopic method 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.

Unit II:

Rotational Spectroscopy:

Rotational spectra of diatomic molecules – rigid rotator concept – determination of bond length – effect of isotopic substitution – spectra of non-rigid rotator.

Unit III:

Vibrational and Raman Spectroscopy:

Vibrational spectra of diatomic molecules – harmonic and anharmonic oscillator model – Morse potential - calculation of force constants – effect of isotope - vibrations of polyatomic molecules, fundamental modes of vibration of H_2O & CO_2 molecules. Diatomic vibrating rotor – vibration rotation spectrum of CO. Basic principles of IR spectroscopy. Principle of Raman spectroscopy – rotational and vibrational Raman spectra of linear molecules, stokes and anti-stokes lines, rule of mutual exclusion. Symmetry and IR/Raman activity of normal modes of vibration. Interpretation of IR and Raman spectra of simple inorganic and coordination compounds.

Unit IV:

Electronic spectroscopy:

Basic principles. Electronic transitions and selection rule - spectrum of atomic hydrogen – fine structure, spectra of H-like atoms. Electronic transitions in diatomic molecules – Selection rule - Born Oppenheimer approximation – vibrational coarse structure - Frank Condon principle – electronic transitions in polyatomic molecules. chromophore, auxochrome – absorption due to ethylenic chromophore. Effect of solvents on electronic transition, quantitative estimation by spectrophotometry.

Unit V:

ESR spectroscopy: Electron spin resonance and hyperfine splitting. g value and hyperfine constant, Bohr magneton, electron Zeeman splitting, electron nuclear hyperfine splitting, illustration using simple examples like H atom, methyl radical.

Recommended books :

1. Organic Spectroscopy, 3rd Edition, William Kemp.
2. NMR Spectroscopy, 2nd Edition, Harald Günther
3. Physical Methods in Inorganic Chemistry, Russel S. Drago.
4. Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, 4th Edition.
5. Electroanalytical methods, Bard and Faulkner.
6. Atkins Physical Chemistry, Atkins, de Paula and Keeler, 11th Edition.
7. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012.
8. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press.
9. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition

Course Title: SPECTROSCOPY (PRACTICAL)

Course Code: CHEM-C-17

Credit: 01

Full Marks: 25

Class: 15 Nos.

1. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
2. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
3. IR Absorption Spectra (Study of Aldehydes and Ketones)
4. Nuclear Magnetic Resonance

5. Use of fluorescence to do “presumptive tests” to identify blood or other body fluids.
6. Collection, preservation, and control of blood evidence being used for DNA testing
7. 12.Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Ychromosome only or multiple chromosome)

Recommended Books:

5. Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. JamesHoller and Stanley Crouch (ISBN 0-495-01201-7).
6. Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

SEMESTER VIII

Course title: SPECTROSCOPY-II
Course code: CHEM-C-21

Credit:03
Full Marks: 75
(Theory: 60, IA: 15)

Course objective: *This is an introductory level course in spectroscopic chemistry. The aim of the course is to introduce the theory and applications of spectroscopic chemistry to the students. They will learn about determining chemical composition, molecular structures, and concentrations in fields like forensics, pharmacology, materials science, astronomy, and environmental monitoring*

Learning outcome: *After completion of this course the students will learn about spectroscopy and how chemical compounds are identified and separated using contemporary methods and instruments*.

UNIT I:

IR spectroscopy:

IR spectroscopy – Characteristic bands for different functional groups, change in band frequency due to FGI. Effects of hydrogen bonding on band frequency. Structure elucidation by IR spectroscopy – finger print region and group frequencies – effect of hydrogen bonding (alcohol, keto-enol) and coordination to metal. Problem solving.

Unit II:

NMR spectroscopy:

Chemical shifts and splitting patterns of signals, coupling constant and its distinction from chemical shift - use of coupling constant in structural elucidation. Simplification of spectra by use of shift reagents and high magnetic fields, integration and its use in proton count and molecular ratios - determination of enantiomeric excess. Deuterium exchange technique in the determination of labile hydrogen, spin-decoupling and NOE, 13C NMR (DEPT), Complexity of 13C NMR spectra and use of spin decoupling in its simplification, CINDP and its applications. Worked out examples using application of NMR. Introduction to Magnetic Resonance Imaging (MRI).

UNIT III:

Mass spectrometry:

Mass spectrometry: ionization techniques, isotope abundance, molecular ion, fragmentation processes of different organic molecules, McLafferty rearrangement, deduction of structure through mass spectral fragmentation. Applications of ESI-MS and MALDI-MS. Problem solving.

UNIT IV:

Mössbauer spectroscopy:

Mössbauer: Basic principles, isomer shift, quadruple splitting, and effect of magnetic field. Application to the study of high-spin and low-spin iron compounds and Sn compounds in various oxidation states and coordination geometries.

Recommended Books:

1. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 27th Edison, 2008.

2. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Prakashan, 6th Edition, 2014.

3. M. Halpern, Experimental Physical Chemistry, 2nd Edition, Prentice Hall, Upper Saddle River, NJ 07458 75

4. Other Sources: Journal of Chemical Education, ACS Publications.

5. Baruah, S. Practical Chemistry. Kalyani Publishers.

Course Title: SPECTROSCOPY (PRACTICAL)

Course Code: CHEM-C-21

Credit: 01

Full Marks: 25

Class: 15 Nos.

Spectroscopy LAB

1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of a Mixture of Cobalt and Nickel by UV/Vis spectrophotometer.
4. Determination of concentration of Na and K in water by Flame Photometer.

Course title: PROJECT DESERTATION
Course code: CHEM-C-22

Credit:12

Full Marks: 300

(Internal Assessment: 30%)

Course Outcomes: *The students would be able to demonstrate and plan scientific research, and implement it within a reasonable time-frame. It is expected that after completing this*

project/dissertation, students will learn to work independently and how to keep accurate/readable record of their experimental works. In addition, students will be able to handle laboratory equipment and chemicals, and utilize sophisticated instruments for analysis, data collection and interpretation. Moreover, students will learn how to perform literature review and will be able to critically examine research articles, find out research gap and improve their scientific writing/communication and be able to disseminate their work by attending conferences

Course title: SPECTROSCOPY-II
Course code: CHEM-M-08

Credit:03
Full Marks: 75
(Theory: 60, IA: 15)
Theory: (45 Lectures)

Course objective: *This is an introductory level course in spectroscopic chemistry. The aim of the course is to introduce the theory and applications of spectroscopic chemistry to the students. They will learn about determining chemical composition, molecular structures, and concentrations in fields like forensics, pharmacology, materials science, astronomy, and environmental monitoring*

Learning outcome: *After completion of this course the students will learn about spectroscopy and how chemical compounds are identified and separated using contemporary methods and instruments.*

UNIT I:

IR spectroscopy:

IR spectroscopy – Characteristic bands for different functional groups, change in band frequency due to FGI. Effects of hydrogen bonding on band frequency. Structure elucidation by IR spectroscopy – finger print region and group frequencies – effect of hydrogen bonding (alcohol, keto-enol) and coordination to metal. Problem solving.

Unit II:

NMR spectroscopy:

Chemical shifts and splitting patterns of signals, coupling constant and its distinction from chemical shift - use of coupling constant in structural elucidation. Simplification of spectra by use of shift reagents and high magnetic fields, integration and its use in proton count and molecular ratios - determination of enantiomeric excess. Deuterium exchange technique in the determination of labile hydrogen, spin-decoupling and NOE, 13C NMR (DEPT), Complexity of 13C NMR spectra and use of spin decoupling in its simplification, CINDP and its applications. Worked out examples using application of NMR. Introduction to Magnetic

Resonance Imaging (MRI).

UNIT III:
Mass spectrometry:
Mass spectrometry: ionization techniques, isotope abundance, molecular ion, fragmentation processes of different organic molecules, McLafferty rearrangement, deduction of structure through mass spectral fragmentation. Applications of ESI-MS and MALDI-MS. Problem solving.

UNIT IV:
Mössbauer spectroscopy:
Mössbauer: Basic principles, isomer shift, quadruple splitting, and effect of magnetic field. Application to the study of high-spin and low-spin iron compounds and Sn compounds in various oxidation states and coordination geometries.

Recommended Books:
1. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 27th Edison, 2008.
2. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Prakashan, 6th Edition, 2014.
3. M. Halpern, Experimental Physical Chemistry, 2nd Edition, Prentice Hall, Upper Saddle River, NJ 07458 75
4. Other Sources: Journal of Chemical Education, ACS Publications.
5. Baruah, S. Practical Chemistry. Kalyani Publishers.

Course Title: SPECTROSCOPY (PRACTICAL)

Course Code: CHEM-C-21

Credit: 01
Full Marks: 25
Class: 15 Nos.

Spectroscopy LAB
1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of a Mixture of Cobalt and Nickel by UV/Vis spectrophotometer.
4. Determination of concentration of Na and K in water by Flame Photometer.
