DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI

UNIVERSITY DEPARTMENT OF CHEMISTRY

B.Sc. Programme in Chemistry
(Based on CBCS Pattern)

Guideline and syllabus for three years B.Sc. Programme in Chemistry

2018-21 onwards

APPROVED BY

THE BOARD OF STUDIES,

UNIVERSITY DEPARTMENT OF CHEMISTRY

DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI

UNIVERSITY DEPARTMENT OF CHEMISTRY

BOARD OF STUDIES

FOREWORD

A meeting of the BOARD OF STUDIES was held in the UNIVERSITY DEPARTMENT OF CHEMISTRY, DSPM UNIVERSITY, RANCHI on 24.04.2018. All members were participated in the syllabus approval meeting. The Draft Syllabus was then approved by the BOARD OF STUDIES in the meeting held on 24.04.2018 and finally placed before the ACADEMIC COUNCIL of DSPM UNIVERSITY for approval.

1. **Prof. R. R. Jha** — **External Subject Expert**
   Former Head
   University Department of Chemistry,
   RU, Ranchi

2. **Prof. Sanjoy Misra** — **External Subject Expert**
   Former Head
   University Department of Chemistry,
   RU, Ranchi

3. **Dr. N. K. Roy** — **Faculty Member**
   Assistant Professor
   University Department of Chemistry,
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4. **Dr. A. K. Acharya** — **Faculty Member**
   Assistant Professor
   University Department of Chemistry,
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5. **Dr. Rajeev Ranjan** — **Faculty Member**
   Assistant Professor
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6. **Dr. Poonam Bhardwaj** — **Faculty Member**
   Assistant Professor
   University Department of Chemistry,
   DSPMU, Ranchi

7. **Dr. Khurshid Akhtar** — **Chairperson & HOD**
   Assistant Professor
   University Department of Chemistry,
   DSPMU, Ranchi

UNIVERSITY DEPARTMENT OF CHEMISTRY

DEPARTMENT COUNCIL

FOREWORD

In the UNIVERSITY DEPARTMENT OF CHEMISTRY, DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, the faculty members participated in the syllabus preparation meetings held on 15.02.2018, 17.02.2018, 19.02.2018, 21.02.2018, 24.02.2028, 26.02.2028 and 28.02.2018. Keeping in view the aims of the UGC Model Curriculum in developing interdisciplinary skills in students and linking chemistry studies with professional development of students, the teachers of different branches of chemistry, namely Inorganic, Organic and Physical chemistry had joint brainstorming sessions and arrived at a Draft Syllabus in Chemistry for Six semesters B.Sc. course. The Draft Syllabus was then approved by the Department Council in a meeting held on 07.03.2018 and finally placed before the ACADEMIC COUNCIL of DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY for approval.

1. **Dr. N. K. Roy** — **Faculty Member**
   Assistant Professor
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   University Department of Chemistry,
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DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY, RANCHI

UNIVERSITY DEPARTMENT OF CHEMISTRY

B.Sc. (H) Programme in Chemistry
(Based on CBCS Pattern)

SEM	COURSE OPTED	COURSE NAME	Distribution of Marks			
			END SEM	MID SEM	PRACTICAL	TOTAL
I	Ability Enhancement Compulsory Course-I	English Communications-I/ Environmental Science-I	-	-	-	100
	Core Course-I	Inorganic Chemistry-I	60	15	25	100
	Core Course-II	Physical Chemistry-I	60	15	25	100
	Generic Elective-1	GE-1	As per concerned Department's syllabus			100
II	Ability Enhancement Compulsory Course-II	English Communications-II/ Environmental Science-II	-	-	-	100
	Core Course-III	Organic Chemistry-I	60	15	25	100
	Core Course-IV	Physical Chemistry-II	60	15	25	100
	Generic Elective-2	GE-2	As per concerned Department's syllabus			100
III	Core Course-V	Inorganic Chemistry-II	60	15	25	100
	Core Course-VI	Organic Chemistry-II	60	15	25	100
	Core Course-VII	Physical Chemistry-III	60	15	25	100
	Skill Enhancement Course-1	SEC-1	-	-	-	-
	Generic Elective-3	GE-3	As per concerned Department's syllabus			100
IV	Core Course-VIII	Inorganic Chemistry-III	60	15	25	100
	Core Course-IX	Organic Chemistry-III	60	15	25	100
	Core Course-X	Physical Chemistry-IV	60	15	25	100
	Skill Enhancement Course-2	SEC-2	-	-	-	-
	Generic Elective-4	GE-4	As per concerned Department's syllabus			100
V	Core Course-XI	Organic Chemistry-IV	60	15	25	100
	Core Course-XII	Physical Chemistry-V	60	15	25	100
	Discipline Specific Elective-1	DSE-1	60	15	25	100
	Discipline Specific Elective-2	DSE-2	60	15	25	100
VI	Core Course-XIII	Inorganic Chemistry-IV	60	15	25	100
	Core Course-XIV	Organic Chemistry-V	60	15	25	100
	Discipline Specific Elective-3	DSE-3	60	15	25	100
	Discipline Specific Elective-4	DSE-4	60	15	25	100

Core Papers (C): (Credit: 06 each) (1 period/week for tutorials or 4 periods/week for practical)

1. Inorganic Chemistry I: Atomic Structure & Chemical Bonding (4 + 4)
2. Physical Chemistry I: States of Matter & Ionic Equilibrium (4 + 4)
3. Organic Chemistry I: Basics and Hydrocarbons (4 + 4)
4. Physical Chemistry II: Chemical Thermodynamics and its Applications (4 + 4)
5. Inorganic Chemistry II: s- and p-Block Elements (4 + 4)
6. Organic Chemistry II: Oxygen Containing Functional Groups (4 + 4)
7. Physical Chemistry III: Phase Equilibria and Chemical Kinetics (4 + 4)
8. Inorganic Chemistry III: Coordination Chemistry (4 + 4)
9. Organic Chemistry III: Heterocyclic Chemistry (4 + 4)
10. Physical Chemistry IV: Electrochemistry (4 + 4)
11. Organic Chemistry IV: Biomolecules (4 + 4)
12. Physical Chemistry V: Quantum Chemistry & Spectroscopy (4 + 4)
13. Inorganic Chemistry IV: Organometallic Chemistry (4 + 4)
14. Organic Chemistry V: Spectroscopy (4 + 4)

Discipline Specific Elective Papers: (Credit: 06 each) (4 papers to be selected: DSE 1-4

1. Novel Inorganic Solids (4) + Lab (4)
2. Polymer Chemistry (4) + Lab (4)
3. Inorganic Materials of Industrial Importance (4) + Lab (4)
4. Medicinal Chemistry (4) + Lab (4)
5. Industrial Chemicals & Environmental Chemistry (4) + Lab (4)
6. Organic Synthesis (4) + Lab (4)
7. Industrial Chemicals & Environmental Chemistry (4) + Lab (4)
8. Green Chemistry (4) + Lab (4)

Note: Universities may include more options or delete some from this list.

Any one group from below mentioned Group-A and Group-B :

Semester-V

GROUP-A

DSE-1: Novel Inorganic Solids (4) + Lab (4)

DSE-2: Polymer Chemistry (4) + Lab (4)

OR

GROUP-B

DSE-1: Inorganic Materials of Industrial Importance (4) + Lab (4)

DSE-2: Medicinal Chemistry (4) + Lab (4)

Semester-VI

GROUP-A

DSE-3: Industrial Chemicals & Environmental Chemistry (4) + Lab (4)

DSE-4: Organic Synthesis (4) + Lab (4)

OR

GROUP-B

DSE-3: Analytical Methods in Chemistry (4) + Lab (4)

DSE-4: Green Chemistry (4) + Lab (4)

Skill Enhancement Courses (02 papers) (Credit: 02 each) - SEC1 to SEC2

1. Pesticide Chemistry
2. Fuel Chemistry

Note: Universities may include more options or delete some from this list

SEC-1 : Pesticide Chemistry

SEC-2 : Fuel Chemistry

Other Discipline (Four papers of any one discipline) - GE 1 to GE 4

1. Mathematics (5) + Tut (1)

2. Physics (4) + Lab (4)

3. Botany (4) + Lab (4)

4. Zoology (4) + Lab (4)

Any other discipline of importance

Generic Elective Papers (GE) (Minor-Chemistry) (any four) for other Departments / Disciplines: (Credit: 06 each)

1. Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons
   (4) + Lab (4)

2. Chemical Energetics, Equilibria, Quantum Chemistry & Functional Group Organic Chemistry-I
   (4) + Lab (4)

3. Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry-II
   (4) + Lab (4)

4. Chemistry of s-, p- and d-block block elements, States of matter and Chemical Kinetics
   (4) + Lab (4)

Note: Universities may include more options or delete some from this list

Important:

1. ***University can add/delete some experiments of similar nature in the Laboratory papers.***

2. ***University can add to the list of reference books given at the end of each paper.***

Course Structure (Chemistry-Major)
Details of courses under B.Sc. (Honours)

Course	*Credits	
	Theory+ Practical	Theory + Tutorial
I. Core Course		
(14 Papers)	14×4= 56	14×5=70
Core Course Practical / Tutorial*		
(14 Papers)	14×2=28	14×1=14
II. Elective Course		
(8 Papers)		
A.1. Discipline Specific Elective	4×4=16	4×5=20
(4 Papers)		
A.2. Discipline Specific Elective		
Practical/Tutorial*	4×2=8	4×1=4
(4 Papers)		
B.1. Generic Elective/ Interdisciplinary	4×4=16	4×5=20
(4 Papers)		
B.2. Generic Elective		
Practical/ Tutorial*	4×2=8	4×1=4
(4 Papers)		
III. Ability Enhancement Courses		
1. Ability Enhancement Compulsory		
(2 Papers of 2 credit each)	2×2=4	2×2=4
Environmental Science		
English/MIL Communication		
2. Ability Enhancement Elective		
(Skill Based) (Minimum 2)	2×2=4	2×2=4
(2 Papers of 2 credit each)		
Total credit	**140**	**140**

***wherever there is a practical there will be no tutorial and vice-versa.**

GENERAL GUIDELINES

1. B.Sc. (H) Course in Chemistry shall be of three years duration.

2. There shall be semester wise examination.

3. There shall be six semester (06) in two years, Semester-I and Semester-II in first year (1st year), Semester-III and Semester-IV in the second year (2nd year) and Semester-V and Semester-VI in the second year (3rd year).

4. There shall be FOURTEEN (14) Compulsory Core Papers and FOUR (04) Discipline Specific Elective Papers.

5. There shall be TWO (02) Ability Enhancement Compulsory Papers and TWO (02) Skill Enhancement Compulsory Papers.

6. For both Semester-V and Semester-VI, there shall be TWO GROUP of DSE PAPERS, out of which student has to elect ONE GROUP.

   GROUP OF OPTIONAL DSE PAPERS:
   Semester-V
   GROUP-A
   DSE-1: Novel Inorganic Solids (4) + Lab (4)
   DSE-2: Polymer Chemistry (4) + Lab (4)

   OR
   GROUP-B
   DSE-1: Inorganic Materials of Industrial Importance (4) + Lab (4)
   DSE-2: Medicinal Chemistry (4) + Lab (4)

   Semester-VI
   GROUP-A
   DSE-3: Industrial Chemicals & Environmental Chemistry (4) + Lab (4)
   DSE-4: Organic Synthesis (4) + Lab (4)

   OR
   GROUP-B
   DSE-3: Analytical Methods in Chemistry (4) + Lab (4)
   DSE-4: Green Chemistry (4) + Lab (4)

7. Each theory paper in each END SEMESTER EXAMINATION shall carry SIXTY (60) as FULL MARKS.

8. There shall be MID SEMESTER EXAMINATION/ INTERNAL EVALUATION in the middle of each Semester carrying FIFTEEN (15) as FULL MARKS.

9. There shall be total EIGHT (08) questions in each End-Semester Theory Examinations. Examinees are required to answer any FIVE (05) questions out of EIGHT (08).

10. The duration of End-Semester Examination shall be of THREE (03) HOURS in each Theory Paper of each Semester.

11. The duration of End-Semester Examination shall be of THREE (03) HOURS in each Combined Practical Paper.

INSTRUCTION FOR GE-CHEMISTRY

12. There shall be ONE Theory Paper and ONE Practical Paper in each GE-CHEMISTRY Paper.

13. Each theory paper in each END SEMESTER EXAMINATION shall carry SEVENTY FIVE (75) as FULL MARKS.

14. Each practical paper in each END SEMESTER EXAMINATION shall carry TWENTY FIVE (25) as FULL MARKS.

15. There shall be no MID SEMESTER EXAMINATION/ INTERNAL EVALUATION in GE-CHEMISTRY papers.

16. There shall be TWO section (Section-A & Section-B) in each theory papers. There shall be FOUR questions from each section and Examinees are required to answer FIVE (05) questions selecting at least TWO questions from each section.

CORE COURSE (HONOURS IN CHEMISTRY)

Semester - I

Core Course - I (CC-I)
Inorganic Chemistry - I
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Atomic Structure:

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

(14 Lectures)

II Periodicity of Elements:

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

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

(b) Atomic radii (vander Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

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

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

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

(16 Lectures)

III Chemical Bonding:

(i) lonic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion

theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.
Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.
Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.
(iii) Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.
(iv) Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

(26 Lectures)

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

(4 Lectures)

Reference Books:

• Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
• Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
• Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
• Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

Core Course - I (Practical)
CC – I (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

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

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

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

Reference text:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - II (CC-II)
Physical Chemistry - I
(Credits: Theory-04, Practical-02)

Theory: 60 Lectures
Full Marks: 60+15

Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Gaseous state:

(A) Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. **(8 Lectures)**

(B) Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. vander Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and vander Waals constants, law of corresponding states.

(10 Lectures)

II Liquid state:

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

(10 Lectures)

III Solid state:

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

(12 Lectures)

IV Ionic equilibria:

(A) 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, p^H scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers. **(10 Lectures)**

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

(10 Lectures)

Reference Books:

• Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
• Ball, D. W. Physical Chemistry Thomson Press, India (2007).
• Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
• Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

Core Course - II (Practical)
CC - II (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Surface tension measurements.
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
2. Viscosity measurement using Ostwald's viscometer.
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
3. Indexing of a given powder diffraction pattern of a cubic crystalline system.
4. p^H metry

a. Study the effect on p^H of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b. Preparation of buffer solutions of different p^H
   i. Sodium acetate-acetic acid
   ii. Ammonium chloride-ammonium hydroxide

c. p^H metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d. Determination of dissociation constant of a weak acid.
Any other experiment carried out in the class.

Reference Books :

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester - II

Core Course - III (CC-III)
Organic Chemistry - I
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
Full Marks: 15+60
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Basics of Organic Chemistry

Organic Compounds: Classification, Hybridization, Shapes of molecules.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications, Dipole moment, Organic acids and bases, their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

(08 Lectures)

II Stereochemistry:

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions. Geometrical isomerism: cis–trans and syn-anti isomerism, E/Z notations with Cahn Ingold and Prelog (CIP) rules for determining absolute configuration.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, Meso structures, Racemic mixture. Resolution of Racemic mixtures. Relative and absolute configuration: D/L and R/S designations.

(14 Lectures)

III Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Classification of carbon atoms in alkanes, Isomerism in alkanes, Methods of formation of alkanes- Wurtz Reaction, Wurtz-Fittig Reaction, Kolbe Reaction, Corey-House Reaction and Decarboxylation of carboxylic acids. Free radical substitutions: Halogenation – orientation, reactivity and selectivity. **(8 Lectures)**

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti-Markownikoff addition), Mechanism of Oxymercuration-demercuration, Hydroboration-oxidation, Ozonolysis, Reduction (catalytic and chemical), syn and anti-hydroxylation. 1,2-and 1,4-addition reactions in conjugated dienes. Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

(10 Lectures)

C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Bayer's strain theory, Methods of formation of cycloalkanes : Diel's Alder Reaction, Simmons-Smith Reaction, Demjanov Rearrangement-reduction, and addition of carbenes to olefins. Conformation analysis of cycloakanes, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms - Relative stability with energy diagrams. **(10 Lectures)**

IV Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromatic/anti-aromatic/non-aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples.

Electrophilic aromatic substitution: Halogenation, Nitration, Sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of mono-functional groups.

(10 Lectures)

Reference Books:

• Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.

• Kalsi, P. S. Stereochemistry, Conformation and Mechanism; New Age International, 2005.

Core Course - III (Practical)
CC - III (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
   a. Water
   b. Alcohol
   c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
4. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
   a. Separation of a mixture of two amino acids by paper chromatography
   b. Separation of a mixture of o-and p-nitrophenol by thin layer chromatography (TLC)

Reference Books :

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

• Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - IV (CC-IV)
Physical Chemistry - II
(Credits: Theory-04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15

Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Chemical Thermodynamics:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and vander Waals) under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics. Calculation of entropy change for reversible and irreversible processes.

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

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; Gibbs-Helmholtz equation; Maxwell relations.

(36 Lectures)

II Systems of Variable Composition:

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

(8 Lectures)

III Chemical Equilibrium:

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment).

(8 Lectures)

IV Solutions and Colligative Properties:

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

(8 Lectures)

Reference Books :

• Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
• Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
• Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
• McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
• Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
• Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
• Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006)

Core Course - IV (Practical)
CC - IV (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
(c) Calculation of the enthalpy of ionization of ethanoic acid.
(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
(f) Determination of enthalpy of hydration of copper sulphate.
Any other experiment carried out in the class.

Reference Books :

• Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
• Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester - III

Core Course - V (CC-V)
Inorganic Chemistry - II
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

(8 Lectures)

II Acids and Bases

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

(8 Lectures)

III Chemistry of s- and p- Block Elements

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements.

Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

(14 Lectures)

IV Study of the inorganic compounds

Study of the inorganic compounds with emphasis on structure, bonding, preparation, properties and uses : Boric acid and borates, boron nitrides, borohydrides, carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

(14 Lectures)

V Noble Gases:

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

(8 Lectures)

VI Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates. **(8 Lectures)**

Reference Books:

• Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
• Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
• Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth- Heinemann. 1997.
• Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
• Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
• Shriver & Atkins, Inorganic Chemistry 5th Ed.

Core Course - V (Practical)
CC - V (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

(A) Iodo / Iodimetric Titrations

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

(B) Inorganic preparations

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

Reference Books:

• Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - VI (CC-VI)
Organic Chemistry - II
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15

Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism.

Organometallic compounds of Mg and Li –Use in synthesis of organic compounds.

(10 Lectures)

II Alcohols, Phenols, Ethers and Epoxides:

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

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann Reactions, Kolbe's–Schmidt Reactions, Fries rearrangement, Claisen Rearrangement, Houben-Hoesch reaction, Leaderer-Manasse Reaction, Gatterman Reaction.

Ethers and Epoxides: Preparation and reactions. Acid and base catalysed ring opening of epoxides, Orientation and stereochemistry of epoxide ring opening, Reactions with Grignard reagents and Organolithium compounds, Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

(20 Lectures)

III Carbonyl Compounds:

Structure, reactivity and preparation;

Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, and MPV)

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

(15 Lectures)

IV Carboxylic Acids and their Derivatives:

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group-Mechanism of acidic and alkaline hydrolysis of esters,

Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

(10 Lectures)

V Sulphur containing compounds:
Preparation and reactions of thiols and thioethers.

(5 Lectures)

Reference Books:

• Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.

Core Course - VI (Practical)
CC - VI (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

2. Organic preparations:
   (i) Acetylation of any one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine)
   a. Using conventional method
   b. Using green approach

   (ii). Acetylation of any one of the following compounds: phenols (β-naphthol, vanillin, salicylic acid) by any one method:
   a. Using conventional method
   b. Using green approach

   (iii). Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) or any one of the following phenols (β-naphthol, resorcinol, p- cresol)

   (iv). Oxidation of ethanol/ isopropanol (Iodoform reaction).
   (v). Bromination of any one of the following:
   a. Acetanilide by conventional methods
   b. Acetanilide using green approach (Bromate-bromide method)

Reference Books :

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - VII (CC-VII)
Physical Chemistry - III
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15

Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Phase Equilibria:

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, steam distillation.

Nernst distribution law: its derivation and applications.

(28 Lectures)

II Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

(18 Lectures)

III Catalysis:

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

(8 Lectures)

IV Surface chemistry:

Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

(6 Lectures)

Reference Books:

- Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
- Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).

• Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
• Ball, D. W. Physical Chemistry Cengage India (2012).
• Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
• Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
• Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

Core Course - VII (Practical)
CC - VII (P)

60 Lectures
Full Marks: 25
One question is to be set. **Time: $1^1/_2$ Hrs**

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems.
3. Distribution of acetic/ benzoic acid between water and cyclohexane.
4. Study the equilibrium of at least one of the following reactions by the distribution method:
   (i) $I_2(aq) + I^- \rightarrow I_3^-(aq)^{2+}$
   (ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)n$
5. Study the kinetics of the following reactions.
   1. Initial rate method: Iodide-persulphate reaction
   2. Integrated rate method:
      a. Acid hydrolysis of methyl acetate with hydrochloric acid.
      b. Saponification of ethyl acetate.
   3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Reference Books:

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester - IV

Core Course - VIII (CC-VIII)
Inorganic Chemistry - III
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

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

(20 Lectures)

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

(12 Lectures)

III Ionic Crystals:
Ionic crystals and their structures, radius ratio rule, effect of polarization on crystals. Covalent structure type- Sphalerite & Wurtzite, Geometry of simple crystal AB type: NaCl, CsCl & NiAs, reasons for preference for a particular structure in above AB type of compounds. AB_2 type: Fluorite, antifluorites, Rutile structures. Li_2O, Na_2O, $CdCl_2$, CdI_2 structures. Defects in Solids: Point defects, Line defects and Plane defects.

(12 Lectures)

IV Lanthanoids and Actinoids:
Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

(6 Lectures)

V Bioinorganic Chemistry:
Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. $Na^{+/}K^{+}$-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine.
Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

(10 Lectures)

Reference Books:

• Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
• Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
• Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
• Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. Wiley-VCH, 1999 • Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
• Greenwood, N.N. & Earnshaw A., Chemistry of the Elements, Butterworth- Heinemann,1997.

Core Course - VIII (Practical)
CC - VIII (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Gravimetric Analysis:

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

Inorganic Preparations:

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

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

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

Reference Book:

• 1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - IX (CC-IX)
Organic Chemistry - III
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15

Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

(10 Lectures)

II Macrocyclic Polyethers

Weak interactions:Ion-dipole interactions, dipole-dipole interactions, induced dipole interactions, Hydrogen bonding. Crown ethers : Introduction, features and ring size, nature of donor site. General method for synthesis of Crown ethers.

(10 Lectures)

III Heterocyclic Compounds

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

(20 Lectures)

IV Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Basic concept of medicinal importance of alkaloids.

(10 Lectures)

V Terpenes

Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral and α-terpineol.

(10 Lectures)

Reference Books:

• Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).

Core Course - IX (Practical)
CC - IX (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

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

Reference Books :

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - X (CC-X)
Physical Chemistry - IV
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 15+60
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Conductance

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

(18 Lectures)

II Electrochemistry

(A) Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass. Concentration cells with and without transference, liquid junction potential. Qualitative discussion of potentiometric titrations.

(24 Lectures)

(B) Electrical & Magnetic Properties of Atoms and Molecules Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

(10 Lectures)

III Symmetry and Group Theory

Symmetry elements and symmetry operations, Group and Subgroup, Point group, Classification and representation of groups (H_2O, NH_3, BF_3, CH_4, PCl_5, XeF_4 and SF_6), The defining property of a group, Sub group and Class, Group multiplication table for C_{2V} and C_{2h}, Generators and Cyclic groups.

(8 Lectures)

Reference Books:

• Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
• Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
• Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
• Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
• Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).

• Rogers, D. W. Concise Physical Chemistry Wiley (2010).
• F.A. Cotton, Chemical Application of Group Theory , John wiley and Sons Inc.,Newyork, 1971.

Core Course - X (Practical)
CC - X (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Conductometry :

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

Potentiometry :

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

Reference Books:

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester - V

Core Course - XI (CC-XI)
Organic Chemistry - IV
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

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

(10 Lectures)

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

(15 Lectures)

III Enzymes
Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action, enzyme inhibitors and their importance, phenomenon of inhibition.

(10 Lectures)

IV Lipids
Introduction to oils and fats, common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, Acid value, Iodine number. Reversion and rancidity.

(10 Lectures)

V Concept of Energy in Biosystems
Energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism.
ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems (structure): NAD^+, FAD.
Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle.
Overview of catabolic pathways of fat and protein. Interrelationship in the metabolic pathways of protein, fat and carbohydrate.

(15 Lectures)

Reference Books:
• Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
• Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.

• Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.

Core Course - XI (Practical)
CC - XI (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Estimation of glycine by Sorenson's formalin method.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.

Reference Books:

• Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
• Arthur, I. V. Quantitative Organic Analysis, Pearson.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - XII (CC-XII)
Physical Chemistry - V
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 15+60
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Quantum Chemistry:
Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and particle-in-a-box (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.
Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.
Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.
Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.
Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

(24 Lectures)

II Molecular Spectroscopy:
Interaction of electromagnetic radiation with molecules and various types of spectra, Born-Oppenheimer approximation.
Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.
Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential energy diagram, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.
Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, Mutual exclusion principle.
Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, electronic transitions of polyenes.
Basic Principles of NMR and ESR spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift, spin-spin coupling, ESR: Its principle, hyperfine structure.

(24 Lectures)

III Photochemistry:
Characteristics of electromagnetic radiation, Lambert-Beer's law, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low

and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. photostationary states.

(12 Lectures)

Reference Books:

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

Core Course - XII (Practical)
CC - XII (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Colourimetry :

I. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/KMnO4/$K_2Cr_2O_7$ in a solution of unknown concentration
II. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
III. Study the kinetics of iodination of propanone in acidic medium.
IV. Determine the amount of iron present in a sample using 1,10-phenathroline.
V. Determine the dissociation constant of an indicator (phenolphthalein).
VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

Reference Books :

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Semester -VI

Core Course - XIII (CC-XIII)
Inorganic Chemistry - IV
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 15+60
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Theoretical Principles in Qualitative Analysis (H_2S Scheme)

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

(10 Lectures)

II Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type.

Concept of hapticity of organic ligands.

Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler–Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

(22 Lectures)

III Reaction Kinetics and Mechanism

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

(18 Lectures)

IV Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)

3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis of gas by metal carbonyl complexes

(10 Lectures)

Reference Books:

• Vogel, A.I. Qualitative Inorganic Analysis, Longman, 1972
• Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996-03-07.
• Cotton, F.A. G.; Wilkinson & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
• Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
• Collman, James P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
• Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.

Core Course - XIII (Practical)
CC - XIII (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
   CO_3^{2-}, NO^{2-}, S^{2-}, SO_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH^{4+}, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, Mg^{2+}
   Mixtures should preferably contain one interfering anion, **or** insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3)

Spot tests should be done whenever possible.

i. Controlled synthesis of two copper oxalate hydrate complexes.
ii. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}.
iii. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Reference Books :

• Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
• Marr & Rockett Inorganic Preparations.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Core Course - XIV (CC-XIV)
Organic Chemistry - V
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15

Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Organic Spectroscopy

General principles Introduction to absorption and emission spectroscopy.

UV Spectroscopy: Types of electronic transitions, Effect of solvent polarity on electronic transitions, Chromophores and Auxochromes, Absorption and Intensity shift; Bathochromic and Hypsochromic shifts, Hyperchromic and Hypochromic shifts. Application of Fieser-Woodward Rules for calculation of λ_{max} for Conjugated dienes and α, β – unsaturated carbonyls, Distinction between cis and trans isomers. **(10 Lectures)**

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations, IR absorption positions of O, N and S containing functional groups, Effect of H-bonding, conjugation, resonance and ring size on IR absorptions, Fingerprint region and its significance, application in functional group analysis. **(8 Lectures)**

NMR Spectroscopy: Basic principles of PMR Spectroscopy, nuclear shielding and deshielding phenomenon, chemical shift and factors influencing it, Spin-Spin coupling and coupling constant, Anisotropic effect. Interpretation of PMR spectra of simple organic compounds such as ethyl bromide, ethanol, acetaldehyde, ethyl acetate, toluene, and acetophenone. Applications of IR, UV and NMR for identification of simple organic molecules. **(10 Lectures)**

II Carbohydrates

Occurrence, classification and their biological importance.

Monosaccharides – Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Inter-conversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation;

Disaccharides – Structure elucidation of maltose, lactose and sucrose.

(12 Lectures)

III Dyes

Classification, Colour and Constitution, Mordant and Vat Dyes, Chemistry of dyeing, Synthesis and applications of (i) Azo dyes-Methyl Orange and Congo Red, Mechanism of Diazo Coupling reaction, (ii) Triphenyl Methane Dyes-Malachite Green, Rosaniline and Crystal Violet, (iii) Phthalein Dyes-Phenolphthalein and Fluorescein. Structure elucidation and synthesis of natural dyes : Indigotin.

(10 Lectures)

IV Polymers

Introduction and classification, Polymerisation reactions-Addition and condensation, Mechanism of cationic, anionic and free radical addition polymerization, Metallocene based Ziegler-Natta

polymerisation of alkenes, Preparation and applications of plastics : Thermosetting (phenol-formaldehyde, Polyurethanes) and Thermosoftening (PVC, polythene).
Fabrics-Natural and synthetic (acrylic, polyamido and polyester), Rubbers-Natural and synthetic: Buna-S, Buna-N, Chloroprene and Neoprene, Vulcanization, Polymer additives, Biodegradable polymers.

(10 Lectures)

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Kemp, W. Organic Spectroscopy, Palgrave

Core Course - XIV (Practical)
CC - XIV (P)

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

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

Reference Books:

- Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

ELECTIVES
GROUP-A
DSE 1-4

DSE-1
Novel Inorganic Solids
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Synthesis and modification of inorganic solids:
Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods.

(10 Lectures)

II Inorganic solids of technological importance:
Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, Molecular material and fullerides, one-dimensional metals, molecular magnets, inorganic liquid crystals.

(10 Lectures)

III 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. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisical nanomaterials, nano-composites.

(10 Lectures)

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

(10 Lectures)

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

(10 Lectures)

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

(10 Lectures)

Reference Books:

• Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)

• Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry.
• Frank J. Ovens, Introduction to Nanotechnology

GROUP-A
DSE-1 Practical
Novel Inorganic Solids

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

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

Reference Book:
• Fahan, Materials Chemistry, Springer (2004).

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-A
DSE-2
Polymer Chemistry
(Credits: Theory - 06, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Introduction of polymeric materials:
Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers.

(10 lectures)

II 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.

(10 lectures)

III Molecular weight of polymers:
Determination of molecular weight of polymers (Mn, Mw, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods, Molecular weight distribution and its significance, Polydispersity index.

(10 lectures)

IV Polymer Solution:
Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory.

(10 lectures)

V Preparation and Properties of Polymers:
Brief introduction to preparation, structure, properties and application of the following polymers: Polyolefins, Polystyrene, Polyvinyl chloride, Polyvinyl acetate, Acrylic polymers, Fluoro polymers, Polyamides. Phenol-formaldehyde resins (Bakelite, Novalac), Urea-formaldehyde resins, Polyurethanes, Polydienes, Polycarbonates, Conducting Polymers (polyacetylene, polyaniline, polypyrrole, polythiophene).

(20 lectures)

Reference Books:
• Seymour's Polymer Chemistry, Marcel Dekker, Inc.
• G. Odian, Principles of Polymerization, John Wiley.
• F.W. Billmeyer, Text Book of Polymer Science, John Wiley.

GROUP-A
DSE-2 Practical
Polymer Chemistry

60 Lectures
Full Marks: 25
One question is to be set. **Time: $1^1/_2$ Hrs**

I.1. Polymer synthesis

1. Free radical solution polymerization of styrene (St)/ Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
2. Preparation of nylon 66/6
3. Interfacial polymerization : preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
4. Redox polymerization of acrylamide
5. Precipitation polymerization of acrylonitrile
6. Preparation of urea-formaldehyde resin
7. Preparations of novalac resin/resold resin.

Polymer characterization

1. Determination of molecular weight by viscometry:
   (a) Polyacrylamide-aq.$NaNO_2$ solution
   (b) (Poly vinyl proplylidine (PVP) in water

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Preparation of polyacrylamide and its electrophoresis

Reference Books:

• Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
• Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
• Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
• L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
• Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-A
DSE-3
Industrial Chemicals & Environmental Chemistry
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Industrial Gases and Inorganic Chemicals

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

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

(15 Lectures)

II Ecosystems

Ecosystems: Biogeochemical cycles of carbon, nitrogen and sulphur.

(5 Lectures)

III Air Pollution

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. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal. Control of particulates.

(15 Lectures)

IV Water Pollution

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.

Water purification methods: Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the industries and their treatment (Basic idea only)

Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

(15 Lectures)

V Energy & Environment

Sources of energy: Coal, petrol and natural gas. Nuclear fusion/fission, Solar energy, Hydrogen, Geothermal, Tidal and Hydel.

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

(10 Lectures)

Reference Books:

• E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.

• R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
• A. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
• S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
• S.E. Manahan, Environmental Chemistry, CRC Press (2005).
• G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).

GROUP-A
DSE-3 Practical
Industrial Chemicals & Environmental Chemistry

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

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 titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Reference Books:

• E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
• R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
• J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
• A. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
• S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-A
DSE-4
Organic Synthesis
(Credits: Theory - 06, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Retro-synthesis **10 Lecture**

Retro synthetic analysis : Definition, Synthon approach, Synthetic equivalent, Linear and convergent method in organic synthesis, Disconnection approach : One group disconnection, Retro synthesis of alcohols, Retro Diels-Alder reaction, Retro synthesis of olefins.

II Pericyclic Reactions **10 Lecture**

Orbital symmetry, Pericyclic reactions: Classification. Electrocyclic, cycloaddition and sigmatropic reactions: selection rules and stereochemistry of electrocyclic, cycloaddition and sigmatropic reactions, analysis by Frontier molecular orbital method, Claisen rearrangement.

III Organic Photochemistry **10 Lecture**

Photochemical reactions of saturated ketones : Norrish Type I and Norrish Type II reaction, Photoreduction of ketone, Photoaddition reactions, Paterno Buchi reaction. Photochemistry of simple olefins: cis-trans isomerization. Oxidative couplings: Barton reaction. Photo rearrangements: Photo-Fries rearrangement.

IV Reagents in Organic Synthesis **10 Lecture**

Reagents and their uses in organic synthesis : MCPBA, R_2CuLi, Bu_3SnH, LDA, 1,3-dithiane, $KMnO_4$, OsO_4, Wilkinson's Catalyst, Phase transfer Catalysts.

V Oxidation Reactions **10 Lecture**

Study of the following oxidation reactions with mechanism: Oxidation of alcohols by CrO_3, DMSO, DCC, oxidation of arylmethane, allylic oxidation of olefins, oxidative cleavage of glycols, oxidative cleavage of double bonds by ozonolysis, Lead tetra acetate, Periodic acid, MnO_2, Oppenauer oxidation.

VI Reduction Reactions **10 Lecture**

Study of the following reactions with mechanism : Reduction of carbonyl compounds by hydrides, Birch reduction, MPV reduction, Homogeneous and heterogeneous hydrogenation (Reduction of alkenes and alkynes), Use of complex metal hydrides as reagent: $NaBH_4$, $LiAlH_4$.

Reference Books:

• R.W. Lenz, Organic Chemistry of Synthetic High Polymers.
• W. Carruthers, Some modern methods of organic synthesis , OUP, 1982.
• R.O.C. Norman, Principles of Organic Synthesis , Second Edition, Chapman and Hall, 1978.
• R.K. Mackie and Smith, Organic Synthesis , II Ed., Longman Group UK Ltd, 1990.
• H.O. House, Modern synthetic reactions, Allied Publishers.

DSE-4 Practical
Organic Synthesis

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

I. Preparation of Organic Compounds:

1. Beta naphthyl methyl ether from beta naphthol
2. Methyl orange from sulphanilic acid
3. ortho-Benzoyl benzoic acid from phthalic anhydride
4. Resacetophenone from resorcinol
5. para-Nitrobenzoic acid from para nitrotoluene
6. meta-Nitroaniline from meta dinitrobenzene
7. Anthraquinone from anthracene

Reference Books:

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-B
DSE-1
Inorganic Materials of Industrial Importance
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Silicate Industries

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

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

(15 Lectures)

II Fertilizers

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

(8 Lectures)

III Surface Coatings

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, vehicle, modified oils, pigments, toners and lakes pigments, fillers, thinners, enamels, emulsifying agents. special paints (heat retardant, fire retardant, eco-friendly paint, plastic paint), dyes, wax polishing, water and oil paints, metallic coatings (electrolytic and electroless).

(12 Lectures)

IV Batteries

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, solar cell and polymer cell.

(5 Lectures)

V Alloys

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

(10 Lectures)

VI Catalysis

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

Phase transfer catalysts, application of zeolites as catalysts.

(5 Lectures)

VII Chemical explosives:

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

(5 Lectures)

Reference Books:

• E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
• R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
• W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
• J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
• R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.

GROUP-B
DSE-1 Practical
Inorganic Materials of Industrial Importance

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

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

Reference Books:

• E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
• R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
• W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
• J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
• R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-B
DSE-2
Medicinal Chemistry
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Structure Prediction and Drug Design:
Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by 'Threading', Molecular docking. Structure based de novo ligand design,
Drug Discovery – Chemoinformatics – QSAR.

(10 Lectures)

II 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.

(10 Lectures)

III Drugs & Pharmaceuticals
Drug discovery, design and development; Basic Retrosynthetic approach. Classification, structure and therapeutic uses.

(10 Lectures)

IV Pharmaceutical Compounds: Structure and Importance
Structure, Synthesis and therapeutic uses of the representative drugs of the following classes:
(i) Analgesics agents: : Ibuprofen (with synthesis)
(ii) Antipyretic agents: Paracetamol (with synthesis)
(iii) Anti-inflammatory agents: Aspirin (with synthesis)
(iv) Antibiotics: Chloramphenicol (with synthesis)
(v) Antibacterial and antifungal agents : Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim);
(vi) Antiviral agents: Acyclovir
(vii) Central Nervous System agents: Phenobarbital, Diazepam
(viii) Cardiovascular: Glyceryl trinitrate
(ix) antilaprosy: Dapsone
(x) HIV-AIDS related drugs : AZT- Zidovudine

(30 Lectures)

Reference Books:
• G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
• Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
• William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.

GROUP-B
DSE-2 Practical
Medicinal Chemistry

60 Lectures
Full Marks: 25
One question is to be set. **Time: $1^1/_2$ Hrs**

Practicals:
1. Preparation of Cinnamic acid
2. Preparation of Acetanilide
3. Preparation of Aspirin and its analysis.
4. Preparation of Magnesium bisilicate (Antacid).

Reference Books:
• G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
• Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
• William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-B
DSE-3
Analytical Methods in Chemistry
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 60+15
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Qualitative and quantitative aspects of analysis:
Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals. **(5 Lectures)**

II Optical methods of analysis:
Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.
Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.
Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.
Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples. **(25 Lectures)**

III Thermal methods of analysis:
Theory of thermogravimetry (TG), basic principle of instrumentation.
Techniques for quantitative estimation of Ca and Mg from their mixture. **(5 Lectures)**

IV Electroanalytical methods:
Classification of electroanalytical methods, basic principle of p^H metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values. **(10 Lectures)**

V Separation techniques:
Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction

of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents.

(15 Lectures)

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
- Ditts, R.V. Analytical Chemistry – Methods of separation.

GROUP-B
DSE-3 Practical
Analytical Methods in Chemistry

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

I. Determine the p^H of the given aerated drinks fruit juices, shampoos and soaps.

II. Analysis of water:

(i) Determination of p^H of water.
(ii) Total soluble salt
(iii) Estimation of calcium and magnesium

III. Analysis of soil:

(i) Determination of p^H of soil.
(ii) Total soluble salt
(iii) Estimation of calcium and magnesium

IV. Separation Techniques

Chromatography: Separation of mixtures

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
(ii) Separation and identification of the monosaccharides present in the given mixture

(glucose & fructose) by paper chromatography. Reporting the Rf values.

V. (i) Determination of dissolved oxygen (DO) in water.
(ii) Determination of chemical oxygen demand (COD).
(iii) Determination of Biological oxygen demand (BOD).

Reference Books:

- Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
- Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

GROUP-B
DSE-4
Green Chemistry
(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures
Full Marks: 15+60
Eight questions are to be set out of which five are to be answered. **Time: 03 Hrs**

I Introduction to Green Chemistry

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

(5 Lectures)

II Principles of Green Chemistry and Designing a Chemical synthesis

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

(25 Lectures)

III Examples of Green Synthesis/ Reactions

1. Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis, Oxidation. Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation.
3. Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes, anhydrides from dicarboxylic acid.
4. Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.
5. Selective methylation of active methylene group, Solid-state polymerization of amorphous polymers, Use of “Clayan”, a nonmetallic oxidative reagent for various reactions, Free Radical Bromination, Biocatalysis in organic syntheses.

(25 Lectures)

IV Future Trends in Green Chemistry

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

(5 Lectures)

Reference Books:

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

GROUP-B
DSE-4 Practical
Green Chemistry

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

1. Safer starting materials

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

Effect of concentration 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 economy can illustrate Green Chemistry.

Preparation of propene by two methods can be studied

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

(II) 1-propanol H_2SO_4/Δ → 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 in benzene and reflux.

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

7. Mechanochemical solvent free synthesis of azomethines

8. Co-crystal controlled solid state synthesis (C_2S_3) of N-organophthalimide using phthalic anhydride and 3-aminobenzoic acid.

9. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
10. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Skill Enhancement Course
(Credit: 02 each) : SEC 1-2

SEC-1
Pesticide Chemistry
(Credits: 02)

Theory: 30 Lectures

Eight questions are to be set out of which five are to be answered.

I General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship. **10 Lectures**

II Synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor). **20 Lectures**

Reference Book:

• R. Cremlyn: Pesticides, John Wiley.

SEC-2
Fuel Chemistry
(Credits: 02)

Theory: 30 Lectures

Eight questions are to be set out of which five are to be answered.

I Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

05 Lectures

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

10 Lectures

III Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications.
Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

10 Lectures

IV Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants.

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

05 Lectures

Reference Books:

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

Generic Elective Papers (GE) For Other Departments/Disciplines
(Minor - Chemistry) (Credit: 06 each)

Generic Elective -1

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures

There shall be FOUR questions from each section. Answer any FIVE questions selecting at least TWO questions from each section.

Section A: Inorganic Chemistry-1

(30 Periods)

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

Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(15 Lectures)

II Chemical Bonding and Molecular Structure

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

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

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

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO. Comparison of VB and MO approaches.

(15 Lectures)

Section B: Organic Chemistry-1

(30 Periods)

I Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.
Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.
values. Aromaticity: Hückel's rule.

(5 Lectures)

II Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro, D and L, cis-trans nomenclature, CIP Rules: R-S (for upto 2 chiral carbon atoms) and E-Z Nomenclature (for upto two C=C systems).

(10 Lectures)

III Aliphatic Hydrocarbons

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

Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: 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. $KMnO_4$.

(15 Lectures)

Reference Books:

• J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
• F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
• James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
• T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
• Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
• R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.

Generic Elective -1 Lab

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Section A: Inorganic Chemistry - Volumetric Analysis

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

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)

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

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

Reference Books:

• Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
• Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
• Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
• Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Generic Elective -2

CHEMICAL ENERGETICS, EQUILIBRIA, QUANTUM CHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-I

(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures

There shall be FOUR questions from each section. Answer any FIVE questions selecting at least TWO questions from each section.

Section A: Physical Chemistry-1

(30 Lectures)

I 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, 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.

(10 Lectures)

II 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.

(5 Lectures)

III 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.

(10 Lectures)

IV Quantum Chemistry

Born-Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.

Postulates of quantum mechanics, quantum mechanical operators.

Free particle. quantization, normalization of wave functions, concept of zero-point energy.

(5 Lectures)

Section B: Organic Chemistry - 2

(30 Lectures)

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

I Aromatic hydrocarbons

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

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation). Side chain oxidation of alkyl benzenes.

(8 Lectures)

II Alkyl and Aryl Halides

Alkyl Halides 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: 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.

(8 Lectures)

III Alcohols, Phenols and Ethers)

Alcohols: Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO4, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: oxidation of diols. Pinacol-Pinacolone rearrangement.

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

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

(8 Lectures)

IV 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.

(6 Lectures)

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw---Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd., New Delhi (2009).
- I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

Generic Elective -2 Lab

CHEMICAL ENERGETICS, EQUILIBRIA, QUANTUM CHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-I

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

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

p^H measurements

a) Measurement of p^H 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 p^H-meter.

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the p^H 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

Reference Books :

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Generic Elective -3

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

(Credits: Theory - 04, Practicals - 02)

Theory: 60 Lectures

There shall be FOUR questions from each section. Answer any FIVE questions selecting at least TWO questions from each section.

Section A: Physical Chemistry - 2

(30 Lectures)

I Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law–non-ideal solutions. Vapour pressure-composition and temperature- composition curves of ideal and non-ideal solutions. Lever rule. Azeotropes.

Partial miscibility of liquids, Immiscibility of liquids, Nernst distribution law and its applications.

(6 Lectures)

II Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule. Phase diagrams of one-component systems (water and sulphur).

(8 Lectures)

III Conductance

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

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.

(8 Lectures)

IV Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. p^H determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

(8 Lectures)

Section B: Organic Chemistry - 3

(30 Lectures)

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

I 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):
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)

II Amines and Diazonium Salts
Amines (Aliphatic and Aromatic): 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(only aniline): nitration, bromination, sulphonation.

(6 Lectures)

III Amino Acids, Peptides and Proteins:
Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.
Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.
Overview of structure of proteins.
Determination of Primary structure of Peptides by degradation: Edmann degradation (N-terminal).

(10 Lectures)

IV Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides.

(8 Lectures)

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Generic Elective -3 Lab

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Section A : Physical Chemistry

Conductometry

I Determination of cell constant

II Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

III Perform the following conductometric titrations:

iv. Strong acid vs. strong base

v. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

I Strong acid vs. strong base

II Weak acid vs. strong base vii. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

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

II

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. Determination of the saponification value of an oil/fat.
4. Determination of the iodine value of an oil/fat

Reference Books:

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

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.

Generic Elective - 4

CHEMISTRY OF S-, P- AND D-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

(Credits: Theory - 04, Practical - 02)

Theory: 60 Lectures

There shall be FOUR questions from each section. Answer any FIVE questions selecting at least TWO questions from each section.

Section A: Inorganic Chemistry-1

(30 Lectures)

I General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Hydrometallurgy, Methods of purification of metals (Al, Pb, Fe, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process.

(5 Lectures)

II s- and p-Block Elements

Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity, Allotropy in C and S.

Oxidation states, inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

(5 Lectures)

III Compounds of s- and p-Block Elements

Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements. Concept of multicentre bonding (diborane).

Structure, bonding and their important properties of the following compounds and their applications: NH_3, N_2H_4, PCl_3, PCl_5 and $SOCl_2$.

(10 Lectures)

IV 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 for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction.

(10 Lectures)

Section B: Physical Chemistry - 3

(30 Lectures)

I Kinetic Theory of Gases

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

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2.

(6 Lectures)

(B) Most probable, average and root mean square velocities (no derivation). Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(6 Lectures)

II Liquids

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

(6 Lectures)

III Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography-Law of constancy of interfacial angles, Law of rational indices. Miller indices. Bragg's law. Structures of NaCl, KCl and CsCl.

(6 Lectures)

IV Chemical Kinetics

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

(6 Lectures)

Reference Books:

• J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
• F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
• G. M. Barrow: Physical Chemistry Tata McGraw Hill (2007).
• G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).

Generic Elective – 4 Lab

CHEMISTRY OF S-, P- AND D-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

60 Lectures
Full Marks: 25
Time: $1^1/_2$ Hrs

One question is to be set.

Section A: Inorganic Chemistry

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

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

Anions : CO_3^{2-}, S^{2-}, SO_2^{-}, $S_2O_3^{2-}$, CH_3COO^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3^{-},SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^{-}

(Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

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

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

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

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

a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.
(III) Chemical Kinetics
Study the kinetics of the following reactions.
3. Initial rate method: Iodide-persulphate reaction
4. Integrated rate method:
c. Acid hydrolysis of methyl acetate with hydrochloric acid.
d. Saponification of ethyl acetate.
e. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Reference Books:
• A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
• A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.

Practical-1: 20 Marks, Note Book: $2^1/_2$ Marks, Viva: $2^1/_2$ Marks.