Kumaun University, Nainital

B.Sc. (H) Chemistry

Faculty of Science

THREE-YEAR FULL-TIME PROGRAMME (Six-Semester Course)

COURSE CONTENTS

(Effective from the Academic Year 2020-2021)

Kumaun University
Nainital

Uttarakhand

Course Structure

Year-1 Semester-I			
Paper	Code	Name of the paper	Marks (End semester+ Internal)
Paper-1	CHE 101	Inorganic Chemistry- I	75 (55 + 20)
Paper-2	CHE 102	Organic Chemistry –I	75 (55 + 20)
Paper-3	ELC 101	Foundation of English –I	50 (35 +15)
Paper-4	MAM 101	Mathematics-I	100 (75 + 25)
Paper-5	PHY 101	Physics-I	75 (55 + 20)
Lab-I	CHE-Lab	Chemistry Practical	25 + 25
Lab-II	PHY- Lab	Physics practical	25
Year-1 Semester-II			
Paper-6	CHE 203	Physical Chemistry – I	75 (55 + 20)
Paper-7	CHE 204	Analytical Methods in Chemical Analysis	75 (55 + 20)
Paper-8	ELC 202	Foundation of English –II	50 (35 +15)
Paper-9	MAM 202	Mathematics-II	100 (75 + 25)
Paper-10	PHY 202	Physics-II	75 (55 + 20)
Lab-III	CHE-Lab	Chemistry Practical	25 + 25
Lab-IV	PHY-Lab	Physics Practical	25
In addition, there shall be one qualifying paper in self-learning mode called Environmental Studies offered in Semester-2			
Year-2 Semester-III			
Paper-11	CHE 305	Inorganic Chemistry – II	75 (55 + 20)
Paper-12	CHE 306	Organic Chemistry – II	75 (55 + 20)
Paper-13	CHE 307	Physical Chemistry – II	75 (55 + 20)
Paper-14	MAM 303	Mathematics-III	100 (75 + 25)
Paper-15	PHY-303	Physics-III	75 (55 + 20)
Paper-16	SKD-301	Skill Development-I	50 (35 + 15)
Lab-V	CHE-Lab	Chemistry Practical	25 + 25 + 25
Lab-VI	PHY-Lab	Physics Practical	25
Year-2 Semester-IV			
Paper-17	CHE 408	Inorganic Chemistry – III	75 (55 + 20)
Paper-18	CHE 409	Organic Chemistry – III	75 (55 + 20)
Paper-19	CHE 410	Physical Chemistry – III	75 (55 + 20)
Paper-20	MAM 404	Mathematics-IV	100 (75 + 25)
Paper-21	PHY 404	Physics-IV	75 (55 + 20)
Paper-22	SKD-402	Skill Development-II	50 (35 + 15)
Lab-VII	CHE-Lab	Chemistry Practical	25 + 25 + 25
Lab-VIII	PHY-Lab	Physics Practical	25
Year -3 Semester-V			
Paper-23	CHE 511	Inorganic Chemistry – IV	75 (55 + 20)

Paper-24	CHE 512	Organic Chemistry – IV	75 (55 + 20)
Paper-25	CHE 513	Physical Chemistry – IV	75 (55 + 20)
Paper-26	CHE 514	Biochemistry and Environmental Chemistry	75 (55 + 20)
Lab-IX	CHE Lab	Chemistry Practical	25 + 25 + 25
Lab-X	BCHE-Lab	Biochem practical	25
Year-3 Semester-VI			
Paper-27	CHE 615	Inorganic Chemistry – V	75 (55 + 20)
Paper-28	CHE 616	Organic Chemistry – V	75 (55 + 20)
Paper-29	CHE 617	Physical Chemistry – V	75 (55 + 20)
Paper-30	CHE 618	Applications of Computers in Chemistry	75 (55 + 20)
Lab-XI	CHE-Lab	Chemistry Practical	25 + 25 + 25
Lab-XII	COMP-Lab	Computer practical	25

NOTE:

- *For Semester I to Semester IV, there shall be core courses (subject centered), Generic courses (minor subject) for the students of B. Sc. (H) physics and Mathematics, Ability Enhancement Courses and Skill Development courses. For Semester V and VI, students will have to study only core courses.*

Pattern of examination theory papers/Laboratory Courses

Each theory paper shall consist two sections A and B.

Section A*: Section A will have eight short answer questions; the student will be asked to attempt any six question. Each question will carry five marks (6 X 5 = 30)*

Section B*: Section B will have two long answer questions with internal choice. Both the questions will be compulsory. Each question will carry 12.5 marks (2 X 12.5 =25).*

Practical examination*: Each practical subject will have laboratory course. The practical examination of each lab course will be of two hours. Each practical examination is of 25 marks.*

Internal assessment

For each theory paper, 25% marks are assigned for internal assignment of the students. The internal assessment shall be in the form of quizzes and written test of short duration and has to be conducted by the Professor In-Charge periodically during the semester. The record of the internal assessment has to be maintained by the Professor In-Charge. The professor will have to show the answer sheets to his/her students when requested for and must satisfy the students if the student/s raise any doubt regarding evaluation of the answer sheets. The internal assessment marks will be uploaded by the Professor onto the University examination portal before the commencement of theory examination.

Paper 1-CHE 101: Inorganic Chemistry - I

Marks: 75 (55+20)

Unit I: Atomic Structure:
Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrödinger's wave equation, significance of ψ and ψ2. Quantum numbers and their significance.Normal and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions. 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.
Unit 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 (van der 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-Jaffe's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.Sanderson's electron density ratio.

Recommended Texts:

1. Lee, J. D. Concise Inorganic Chemistry, Wiley India, 2012.
2. Puri, B. R., Sharma, L. R. and Kalia, K. C. Principles of Inorganic Chemistry, Milestone, Delhi, 2014.
3. Madan, R. L. Chemistry for Degree Students (B. Sc. 1st Year), S. Chand, 2013.
4. Malik, W. U., Tuli, G. D. and Madan, R. D. Selected Topics in Inorganic Chemistry, S. Chand, 2013.

Paper 2-CHE 102: Organic Chemistry - I

Marks: 75 (55+20)

Unit-I: Basics of Organic Chemistry
Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.
Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and itsapplications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes

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

Unit II: Stereochemistry

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centers, Diestereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

Unit III: Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon sigma bonds

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

B. Carbon-Carbon pi bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E_1, E_2reactions.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 (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis

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

Unit IV: Aromatic Hydrocarbons

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

Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition, 2016
2. Finar, I. L. Organic Chemistry (Volume 1), Pearson Education India, 6th Edition, 2009
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Pearson Education India, 6th Edition, 2009
4. R. L. Madan, Chemistry For Degree Students (B. Sc. 1st year), S. Chand Ltd., 2013
5. Marc Loudon G., Organic Chemistry, Oxford Univ. Press, 2011

Lab-I: CHE-Lab: Inorganic Chemistry

PRACTICAL Marks: 25 (20+05)

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

(B) Acid- Base Titrations

(i) Estimation of carbonate and hydroxide ions in a mixture.
(ii) Estimation of carbonate and bicarbonate ions 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,Longman, 1966 or any other text that covers the course.

Lab-I: CHE-Lab: Organic Chemistry

PRACTICAL Marks: 25(20+05)

1. Calibration of the thermometer.
2. Purification of organic compounds by crystallization using following solvents: a. Water b. Alcohol c. Alcohol-Water mixture.
3. Determination of the melting points of unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. 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 ascending and horizontal paper chromatography b. Separation of a mixture of two sugars by ascending paper chromatography c. Separation of a mixture of o- and p-nitrophenol or o- and p-aminophenol by thin layer chromatography (TLC).

SEMESTER II

Paper-6:CHE 203: Physical Chemistry- I

Marks:75 (55+20)

Unit-I: Gaseous state:

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

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

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

Unit -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 and comparison with that of gases.

Qualitative discussion of structure of water.

Unit -III: Solid state:

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

Unit -IV: Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Solubility and solubility product of sparingly soluble salts – applications of solubility 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.

Recommended Texts:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 9th Ed., Oxford University Press (2013).
2. Bahl, Tuli and Bahl, Essentials of Physical Chemistry, S. Chand Ltd.,
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier; (2009).
5. Madan, R. L. Chemistry for Degree Students (1st year), S. ChandLtd., 2013

Paper-7: CHE 204: Analytical Methods in Chemical Analysis

Marks: 75 (55+20)

Unit -I : Qualitative and Quantitative aspects of analysis:
Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q, and T test, rejection of data, and confidence intervals.

Unit -II: Optical methods of analysis:
Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

Basic principle of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enoltautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator& detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotope substitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, Choice of flame and Burner designs.Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Unit -III: Thermal method of analysis:
Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Unit -IV: Electro analytical methods:
Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence point. Techniques used for the determination of pKa values.

Unit -V: Separation Techniques:

Solvent extraction: Classification and 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 non aqueous media. Chromatography: Classification and principle and efficiency of the technique.
Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.
Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.
Stereo isomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of Enantiomeric composition using NMR, Chiral solvents and chiral shift reagents Chiral chromatographic techniques using chiral columns (GC and HPLC).
Role of computers in instrumental methods of analysis.

Recommended texts:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by GH Jeffery and others) 5th Ed. The English Language Book Society of Longman
2. Willard, Hobert H. et. al: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. New York- John Willy, 2004.
4. Harris, Daniel C,Quantitative Chemical Analysis, 3rd Edition, W.H. Freeman and Company, New York, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry New Age, International Publisher, 2009.
6. SKoog, West and Holler, Fundamentals of Analytical Chemistry, 6th Edition, Sauders College Publishing, New York. 1991.
7. Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Ditts, R.V. Analytical Chemistry – Methods of separation.

Lab-III: CHE-Lab: Physical Chemistry - I

PRACTICAL Marks: 25(20+05)

(I) Surface tension measurements (use of organic solvents excluded). a) Determine the surface tension by (i) drop number (ii) drop weight method. b) Study the variation of surface tension of detergent solutions with concentration

(II) Viscosity measurement using Ostwald's viscometer (use of organic solvents excluded). (a) Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature. (b) Study

the effect of variation of viscosity of an aqueous solution with the concentration of solute.

(III) pH measurements

b) Measurement of pH of different solutions using pH-meter. c) Preparation of buffer solutions (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide

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

d) pH metric titrations of (i) strong acid and strong base (ii) weak acid and strong base Any other experiment carried out in the class.

Lab-III:CHE-Lab: Analytical Methods in Chemical Analysis

PRACTICAL Marks: 25(20+05)

Separation Techniques

1. Chromatography:
   (a) Separation of mixtures
   (i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}
   (ii) Separate and identify the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography.

Report the Rf values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values. (c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.

2. Solvent Extractions: (i) To separate a mixture of Ni^{2+}& Fe^{3+} by complexing with DMG and extracting the Ni^{2+} DMG complex in chloroform, and determine its concentration with spectrophotometry. (ii) Solvent extraction of zirconium with amberliti LA-1, separation from a mixture of irons and gallium.
3. Determine the pH of given aerated drinks fruit juices, shampoos and soaps.
4. Determination of Na, Ca, Li ions in cola drinks and fruit juices using fame photometric techniques.
5. Analysis of soil:
   (i) Determination of pH of soil.
   (ii) Total soluble salt
   (iii) Estimation of calcium, magnesium, phosphate, nitrate
6. Ion exchange:
   (i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
   (ii) Separation of metal ions from their binary mixture.
   (iii)Separation of amino acids from organic acids by ion exchange chromatography.

7. Determination of pKa values of indicator using spectrophotometry.
8. Structural characterization of compounds by Infra-Red spectroscopy.
9. Determination of dissolved oxygen in water.
10. Determination of chemical oxygen demand (COD).
11. Determination of Biological oxygen demand (BOD).

SEMESTER – III

Paper-11:CHE 305: Inorganic Chemistry -II

Marks: 75 (55+20)

Unit -I: Chemical Bonding-I:

(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.

Unit-II, Chemical Bonding - II:

(ii) Covalent bond: Lewis structure, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, Valence Bond theory (Heitler-London approach). multiple bonding (σ and π bond approach), and bond lengths. 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.

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.

Unit-III,Chemical Bonding-III:

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

Recommended Texts:

1. Douglas, B. E. and Mc Daniel, D. H., Concepts & Models of Inorganic Chemistry, Oxford 1970.
2. Puri, B. R., Sharma, L. R. and Kalia, K. C. Principles of Inorganic Chemistry, Milestone, Delhi, 2014.
3. Madan, R. L., Chemistry for Degree Students (B. Sc. 2nd Year), S. Chand Ltd., 2010.
4. Malik, W. U., Tuli, G. D. and Madan, R. D. Selected Topics in Inorganic Chemistry, S. Chand, 2013.
5. Atkins, P., Overton, T., Rourke, J., Weller, M. and Armstrong, F., Shriver and Atkins' Inorganic Chemistry, Oxford Univ. Press, 2012.
6. Porterfield, H. W., Inorganic Chemistry, Second Edition, Academic Press, 2005.

Paper-12: CHE 306: Organic Chemistry -II

Marks:75 (55+20)

Unit 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; SN Ar, Benzyne mechanism
Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.
Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit II: Alchols, Phenols, Ethers and epoxide:
Alcohols: preparation, properties and relative reactivity of 1^o, 2^o, 3^o alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol- Pinacolone rearrangement;
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer – Tiemann and Kolbe's – Schmidt Reactions, Fries and Claisen rearrangements with mechanism;
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

Unit III: Carbonyl Compounds:
Structure, reactivity and preparation;
Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol, 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, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition.

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

Unit 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 substitution at acyl group - Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement

Unit V: Sulphur containing compounds:
Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition, 2016
2. Finar, I. L. Organic Chemistry (Volume 1), Pearson Education India, 6th Edition, 2009.
3. Marc Loudon, G., Organic Chemistry, Oxford Univ. Press
4. Madan, R. L., Chemistry for Degree Students (2nd Year), S. Chand Ltd, New Delhi, 2013

Paper-13: CHE 307: Physical Chemistry -II

Marks: 75 (55+20)

Unit I : Chemical thermodynamics:
Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroeth law of thermodynamics.
First law: Concept of heat, q, work, w, internal energy U and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.
Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.
Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.
Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.
Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other

thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Unit II : Systems of variable composition:
Partial molar quantities, dependence of thermodynamic parameters on composition; GibbsDuhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

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

Unit IV: Solutions and colligative properties:
Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.
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.

Recommended Texts:

1. Atkins, P. W. & Paula, J. de, Atkin's Physical Chemistry 9th Ed., Oxford University Press (2013).
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Engel, T. & Reid, P. Thermodynamics, Statistical Thermodynamics, & Kinetics Pearson Education, Inc: New Delhi (2007).
4. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
5. Puri, Sharma & Pathania, Principles of Physical Chemistry. Milestone, Delhi, 2014.
6. Bahl, Tuli and Bahl, Essentials of Physical Chemistry, S. Chand Ltd. New Delhi.

Paper-16: SKD-301: Skill Development-I

MM: 50 (35+15)

Steps in Chemical Analysis; Sampling, sample preparation, analysis, interpretation and preparation of report

Significant Figures; significant figures in Arithmatics-addition, subtraction, multiplication and division

Laboratory burner; Bunsen burner, air flow regulation, obtaining warm gentle flame with the burner, hottest flame of the burner. Cutting and bending glass tubings/glass rod, fire polishing of glass tubing or rod.

SI Units, conversion between units, problem solving

Use of measuring equipments; pipette, burette, chemical balance, least count

Chemical Concentration; normality, morality, preparation of solution of defines normality/molarity of a given compound and from a given solution of different strength, percent composition, part per million (ppm), part per billion (ppb), calculations

Types of errors; systematic errors, Random errors, precision & accuracy, absolute and relative uncertainty

Propagation of Uncertainty; addition, subtraction, multiplication, division.

Mean and Standard deviation, Standard deviation and probability

Titration; types of titration, end point, equivalence point, indicators; types and theory

Recommended Texts:

1. Nivaldo J. Tro, Ho Yu Au-Yeung, Introductory Chemistry, Fifth Edition, Pearson India Education, 2017.
2. Timberlake, K. C., Timberlake, W., Basic Chemistry, Fourth Edition, Pearson India Education, 2017.
3. Pavia, D.L., Lampman, G. M., Kriz, G. S, Engel, R.G., Microscale and Macroscale Techniques in the Organic Laboratory, Harcourt College Publishers
4. Harris, D. C., Exploring Chemical Analysis, W. H. Freeman and Company, New York.
5. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman and Company, New York.

Lab-V: CHE-Lab: Inorganic Chemistry -II

PRACTICAL Marks:25 (20+05)

(a) Iodo / Iodimetric Titrations

(i) Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).

(ii)Estimation of (a) arsenite and (b) antimony in tartar-emetic iodimetrically (c) 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.

Recommended Texts:

1. Vogel, A. I. A Textbook of Quantitative Inorganic Analysis, Longman, 1966, or any other text which covers the course.

Lab-V:CHE-Lab: Organic Chemistry -II

PRACTICAL Marks: 25 (20+05)

Organic preparations

1. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-,p- anisidine) and phenols (β-naphthol, vanillin, salicylic acid)
2. Benzolyation of one of the following compounds: amines (aniline, o-,m-,p- toluidines and o-, m-,p- anisidine) and phenols (β-naphthol, resorcinol, p-cresol) by Schotten Baumann reaction
3. Hydrolysis of amides and esters to obtain benzoic acid
4. Derivatives of the carbonyl compounds: 2,4-DNP of one the following compounds- acetone, ethyl methyl ketone, di-ethyl ketone, cyclohexanone semicarbazone of one the following compounds- acetone, ethyl methyl ketone, diethyl ketone, cyclohexanone oxime of one the following compounds- di-ethyl ketone, cyclohexanone
5. Nitration of one the following compounds: nitrobenzene, chlorobenzene, bromobenzene
6. Oxidation of the following compounds: benzaldehyde, benzyl alcohol acetophenone to benzoic acid (by iodoform reaction)

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

Lab-V:CHE-Lab: Physical Chemistry -II

PRACTICAL Marks: 25 (20+05)

(I) 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.
(g) Study of the solubility of benzoic acid in water and determination of ΔH.

(II) Indexing of given powder diffraction pattern of a cubic crystalline system.

Any other experiment carried out in the class.

SEMESTER IV

Paper 17: CHE 408: Inorganic Chemistry -III

Marks: 75 (55+20)

Unit I : 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.
Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.
Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.
Theoretical principles involved in volumetric analysis, done in the lab.

Unit II : Noble Gases :
Occurrence & uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2 and XeF_4, 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).

Unit III : 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.

Recommended Texts:
1. Lee, J. D. Concise Inorganic Chemistry, Wiley India, 2012.
2. Puri, B. R., Sharma, L. R. and Kalia, K. C. Principles of Inorganic Chemistry, Milestone, Delhi, 2014.
3. Madan, R. L., Chemistry for Degree Students (B. Sc. 2nd Year), S. Chand Ltd., 2013.

4. Malik, W. U., Tuli, G. D. and Madan, R. D. Selected Topics in Inorganic Chemistry, S. Chand, 2013.
5. Atkins, P., Overton, T., Rourke, J., Weller, M. and Armstrong, F., Shriver and Atkins' Inorganic Chemistry, Oxford Univ. Press, 2012.
6. Cotton, F.A. and Wilkinson, G, Advanced Inorganic Chemistry, Wiley.

Paper 18: CHE 409: Organic Chemistry -III

Marks: 75 (55+20)

Unit 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^o, 2^o and 3^o amines with Hinsberg reagent and nitrous acid;
Diazonium Salts: Preparation and their synthetic applications.

Unit II: Polynuclear Hydrocarbons
Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

Unit 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), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction
Derivatives of furan: Furfural and furoic acid.

Unit 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. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition, 2016
2. Finar, I. L. Organic Chemistry (Volume 1), Pearson Education India, 6th Edition, 2009.
3. Finar, I. L. Organic Chemistry (Volume 2): Pearson Education India, 6th Edition, 2009

Paper 19:CHE 410: Physical Chemistry -III

Marks: 75 (55+20)

Unit 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.

Three component systems, water-chloroform-acetic acid system, triangular plots.

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

Nernst distribution law: its derivation and applications.

Unit II: Electrochemistry

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

Chemical cells, reversible and irreversible cells with examples.Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers.Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Recommended Texts:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

Paper-22: SKD-402: Skill Development-II

MM: 50 (35+15)

Physical Constants; melting points, melting point theory, mixture melting point, packing of melting point tube, Determination of melting point ; decomposition, discoloration, softening, shrinking and sublimation. Boiling point, determination of boiling point, use of boiling chips, calibration of thermometer.

Solubility; definition, predicting solubility behaviour, water as a solvent, organic solvents

Crystallization; selection of suitable solvent/s, purification of compounds,

Filtration; gravity filtration, filter papers, vacuum filtration, aspirator, working of aspirator.

Distillation; simple distillation, distillation theory, fractional distillation, difference between simple and fractional distillation, vapour – liquid composition diagram, Raoult's Law, types of fractionating columns, column efficiency, azeotropes.

Extraction; theory, distribution coefficient, separation and drying agents

Polarimetry; Nature of polarized light, polarimeter, sample cells, operation of the polarimeter, optical purity.

Refractometry; The refractive index, Refractometer

Electromagnetic Radiation; properties, absorption of light, transmittance, absorbance and Beer's Law. Spectrophotometer; single beam and double beam instruments

Recommended Texts:

6. Nivaldo J. Tro, Ho Yu Au-Yeung, Introductory Chemistry, Fifth Edition, Pearson India Education, 2017.
7. Timberlake, K. C., Timberlake, W., Basic Chemistry, Fourth Edition, Pearson India Education, 2017.
8. Pavia, D.L., Lampman, G. M., Kriz, G. S, Engel, R.G., Microscale and Macroscale Techniques in the Organic Laboratory, Harcourt College Publishers
9. Harris, D. C., Exploring Chemical Analysis, W. H. Freeman and Company, New York.
10. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman and Company, New York.

Lab-VII: CHE-Lab: Inorganic Chemistry -III

PRACTICAL Marks: 25(20+05)

(a) Complexometric Titrations:

- (i) Complexometric estimation of (i) Mg^{2+} (ii) Zn^{2+} using EDTA
- (ii) Estimation of total hardnesss of water samples
- (iii) Estimation of Ca^{2+} in solution by (substitution method) using Erio-chrome black-T as indicator.
- (iv) Estimation of Ca/Mg in drugs and Biological samples.

(b) Argentometry Estimation of Cl^- (i) By Mohr's method, (ii) By Vohlard's method, (iii) By Fajan's method.

(c) Paper Chromatographic separation of Ni (II) and Co(II); Cu(II) and Cd (II) ions

Lab-VII: CHE-Lab: Organic Chemistry –III

PRACTICAL Marks: 25 (20+05)

Organic Preparations

1. Diels-Alder reaction between anthracene and maleic anhydride
2. Reduction: nitrobenzene to azobenzene (TLC of the mixture), m-dinitrobenzene to m-nitroaniline
3. S-benzylisothiuranum salts of any one water soluble and one water insoluble acid: acetic acid, phenyl acetic acid, oxalic acid, benzoic acid, phthalic acid
4. Photochemical reduction of benzophenone to benzopinacol
5. Benzoin condensation of benzaldehyde (using thiamine hydrochloride)
6. Condensation of p-toluidine with benzaldehyde/salicylaldehyde/2-hydroxy-3methoxy benzadehyde to get Schiff's base (solventless condensation)

Estimation of:

1. Phenol and aniline by bromination with potassium bromate-potassium bromide method
2. Glycine by formylation method
3. Saponification value of an oil/fat

Lab-VII: CHE-Lab: Physical Chemistry –III

PRACTICAL Marks: 25 (20+05)

(I) Study the equilibrium of at least one of the following reactions by the distribution method:
(i) $I_2(aq) + I^- \rightarrow I_3^-$ (aq) (ii) Cu^{2+}(aq) + $nNH_3 \rightarrow Cu(NH_3)_n^{2+}$

(II) Perform the following potentiometric titrations (at least two):
(i) Strong acid with strong base (ii) weak acid with strong base and (iii) dibasic acid with strong base

(III) Potentiometric titration of Mohr's salt with potassium dichromate.

(IV) Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

(V) Phase equilibria: Construction of the phase diagram of (i) simple eutectic and (ii) congruently melting systems, using cooling curves and ignition tube methods.
Any other experiment carried out in the class.

SEMESTER V

Paper-23: CHE 511: Inorganic Chemistry -IV

Marks: 75 (55+20)

Unit I : Coordination Chemistry

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

Unit 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 & Frost-Ebsworth 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)

Unit III: Lanthanoids and actinoids:
Occurrence, electronic configuration, atomic radii (lanthanide and actinide contraction), complex formation, oxidation states, colour, spectral and magnetic properties, separation of lanthanides (ion-exchange method only).

Recommended Texts:

1. Lee, J. D. Concise Inorganic Chemistry, Wiley India, 2012.
2. Gopalan R., Ramalingam, V., Concise Coordination Chemistry, Vikas Publishing House, 2008.
3. Puri, B. R., Sharma, L. R. and Kalia, K. C. Principles of Inorganic Chemistry, Milestone, Delhi, 2014.
4. Madan, R. L., Chemistry for Degree Students (B. Sc. 3rd Year), S. Chand Ltd. New Delhi, 2013.
5. Malik, W. U., Tuli, G. D. and Madan, R. D. Selected Topics in Inorganic Chemistry, S. Chand, 2013.
6. Atkins, P., Overton, T., Rourke, J., Weller, M. and Armstrong, F., Shriver and Atkins' Inorganic Chemistry, Oxford Univ. Press, 2012.

Paper-24:CHE 512: Organic Chemistry -IV

Marks: 75 (55+20)

Unit I: Carbohydrates
Occurrence, classification and their biological importance
Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation;

Disaccharides – Structure elucidation of maltose, lactose and sucrose
Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

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

Unit III: 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, C-protecting and C-activating groups - Solid-phase synthesis

Unit IV: Lipids
Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.
Unit V: Pharmaceutical Compounds: Structure and Importance
Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis).
An elementary treatment of Antibiotics and detailed study of chloramphenicol,
Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine)

Unit VI: Terpenes
Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α- terpineol.
Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition, 2016.
2. Finar, I. L. Organic Chemistry (Volume 1), Pearson Education India, 6th Edition, 2009.
3. Finar, I. L. Organic Chemistry (Volume 2), Pearson Education India, 6th Edition, 2009.
4. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry, Fourth Edition, W. H. Freeman.
5. Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry, Sixth Edition, W. H. Freeman.
6. Marc Loudon, Organic Chemistry, Oxford Univ. Press

Paper-25: CHE 513: Physical Chemistry -IV

Marks: 75 (55+20)

Unit 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.
Ionic velocities, mobilities and their determinations, 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.

Unit 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.
Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.
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.

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

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 9th Ed., Oxford University Press (2013).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Laidler, K. J. Chemical Kinetics Pearson Education: New Delhi (2004).
5. Bahl, Tuli and Bahl, Essentials of Physical Chemistry, S. Chand Ltd, New Delhi.
6. Bajpai, D. N., Advanced Physical Chemistry, S. Chand Ltd., New Delhi

Paper-26:CHE 514: Biochemistry and Environmental Chemistry

Marks:75 (55+20)

Unit I:

Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations,Krebs cycle
Proteins: classification, biological importance; Primary, secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Denaturation of proteins
Enzymes: Nomenclature, Characteristics (mention of Ribozymes), Classification;Active site, Mechanism of enzyme action, Stereospecificity of enzymes,Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry

Unit II:
Lipids: Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications.
Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.

Unit III:
Environment and it's segments, Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulfur
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, Controls of air pollution, Climate change, Green house effect, global warming. Techniques of measuring air pollutants.
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

Unit IV:
Energy and Enviornment: Sources of energy: Coal, petrol and Natural gas. Nuclear Fusion / Fisson, Solar energy, Hydrogen, geothermal, Tidal and Hydel etc.
Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and it's Management
Recommended Texts:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M. and Lehninger, A.L., Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W., Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/ McGraw-Hill
4. Manahan S.E., Environmental Chemistry, CRC Press
5. Miller, G.T., Environmental Science 11th edition. Brooks/Cole
6. Mishra, A., Environmental Studies. Selective and Scientific Books, New

7. vanLoon, G W and Duffy, SJ, Environmental Chemistry, A global Prospective, Oxford Univ. Press, Third Edition, 2011.

Lab-IX: CHE-Lab: Inorganic Chemistry -IV

PRACTICAL Marks: 25(20+05)

(a) Quantitative Analysis: The following quantitative estimations are to be carried out.

(i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.
(ii) Estimation of copper as CuSCN
(iii) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$ through (a) Heterogeneous and (b) Homogeneous media. (c) Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminiumoxinate).

(b) Inorganic Preparations

(i) Tetraammine copper (II) sulphate, $[Cu(NH_3)_4]SO_4\ H_2O$
(ii) Potassium trisoxalatochromate (III), $K_3[Cr(C_2O_4)_3]$
(iii) *Cis* and *trans* $K[Cr(C_2O_4)_2\ (H_2O)_2]$ Potassium dioxalatodiaquachromate (III)
(iv) Pentaamminecarbonato Cobalt (III) ion

(c) Spectrophotometric estimation of Ferrous ions by using 1,10-phenanthroline

Recommended Texts:

1. Vogel, A.I. A text book of Quantitative Analysis, Longman, 1966 or any other text which covers the course.

Lab-IX: CHE-Lab: Organic Chemistry -IV

PRACTICAL Marks: 25(20+05)

1. Systematic analysis of extra elements in the given unknown compounds
2. Tests for following functional groups and unsaturation
3. Qualitative analysis of the following types of unknown organic compounds
   Carboxylic acids, Phenols, Alcohols, Aldehydes, Ketones , Esters.

Lab-IX: CHE-Lab: Physical Chemistry –IV

PRACTICAL Marks: 25(20+05)

(I) To study changes in conductance in the following systems (i) strong acid-strong base (ii) weak acid-strong base and (iii) mixture of strong acid and weak acid-strong base

(II) 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, volumetrically or conductometrically. (b) Iodide-persulphate reaction (c) Saponification of ethyl acetate.

Any other experiment carried out in the class.

Lab-X: BCHE-Lab: Biochemistry and Environmental Chemistry

PRACTICAL Marks: 25(20+05)

1. To perform quantitative estimation of protein using Lowry's method. Determine the concentration of the unknown sample using the standard curve plotted.
2. Study of the action of salivary amylase at optimum conditions
3. Effect of pH on the action of salivary amylase
4. Effect of temperature on the action of salivary amylase
5. Effect of inhibitor on the action of salivary amylase
6. Study of the activity of Trypsin using fresh tissue extracts.
7. To study the effect of temperature, organic solvents, on semi-permeable membrane.
8. Isolation of Genomic DNA from E Coli
9. Qualitative analysis of the soil from different locations for pH and different water soluble cations and anions
10. Quantitative estimation of oxidizable organic matter in soil, carbonate and bicarbonates by volumetry and calcium and magnesium by EDTA titration.
11. Hardness of water by EDTA titration
12. Study of pH and conductivity of tap water and polluted water.

SEMESTER VI

Paper-27: CHE 615: Inorganic Chemistry -V

Marks: 75(55+20)

Unit I: Theoretical Principles:
Theoretical principles and chemistry involved in qualitative analysis of mixture of cations and anions including interfering and insolubles.

Unit II: Organometallic Compounds:
Definition and classification of organometallic compounds, EAN rule.

Unit III: Metal Carbonyls:
Preparation, properties, structure and bonding of mononuclear carbonyls. π-Acceptor behaviour of carbon monoxide, synergic effect (MO diagram of CO) Carbonylate anions, ferrocene and its reactions.

Unit IV: 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.Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine.
Iron and its application in bio-systems, Hemoglobin; Storage and transfer of iron.

Recommended Texts:

1. Crabtree, R. H., The Organometallic Chemistry of the Transition Metals, 7th Edition, JohnWiley, 2019.
2. Coates, G. E., Gree, M. L. H., Principles of Organometallic Chemistry, 2nd Edition, Chapman & Hall, UK, 1960.
3. Huheey, J. E., Keiter, E. A., Keiter, R. L., Inorganic Chemistry: Principle of Structure and Reactivity, Pearson Education of India, 1997.
4. Mehrotra, R. C., Singh, A., Organometallic Chemistry, New Age International, 2007.
5. Bertini, I., Gray, H. B., Lippard, S. J., Valentine, J. S., Bioinorganic Chemistry, University Science Books, 1994.
6. Dugas, Hermann, Penny, C., Bioinorganic Chemistry: A Chemical Approach to Enzyme Action, Springer-Verlag, 1981.
7. Kalsi, P. S., Kalsi, J.P., Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age International Publishers, 2008.

Paper-28: CHE 616: Organic Chemistry -V

Marks: 75 (55+20)

Unit I: Organic spectroscopy
General principles Introduction to absorption and emission spectroscopy.
UV Spectroscopy: Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis- and trans- isomers.
IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H- bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.
NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpetation of NMR spectra of simple compounds
Applications of IR, UV and NMR for identification of simple organic molecules.

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

Unit III: Polymers
Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.
Polymerisation reactions - Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes;
Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene);
Fabrics – natural and synthetic (acrylic, polyamido, polyester);
Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization;
Polymer additives; Introduction to liquid crystal polymers;
Biodegradable and conducting polymers with examples.

Recommended Texts:

1. Kemp, W. Organic Spectroscopy, Palgrave.
2. Kalsi, P. S. Textbook of Organic Chemistry, New Age International (P) Ltd.
3. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition, 2016.
4. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
5. Gowariker, V. R., Viswanathan, N. V. &Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
6. Sharma, Y. R., Elementary Organic Spectroscopy, S. Chand Ltd., 2013.
7. Banwell and McCash, Fundamentals of Molecular Spectroscopy, McGraw Hill India, 4th Edition, 2016.
8. Kalsi, PS, Spectroscopy for Organic Compounds, New Age International, 2007.

Paper-29: CHE 617: Physical Chemistry -V

Marks: 75 (55+20)

Unit 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; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.
Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.
Rigid rotator model of rotation of diatomic molecule.Schrödinger equation, transformation 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), radial distribution functions of 1s, 2s, 2p, 3s, 3p and 3d orbitals. Average and most probable distances of electron from nucleus.
Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).
Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAOMO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H2. Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB).Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localized and non-localized molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules. Simple Hückel Molecular Orbital (HMO) theory and its application to simple polyenes (ethene, butadiene).

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

Recommended Texts:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi.
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill.
3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA.
4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press.
5. Nakanishi & Solomon, Infrared Spectroscopy

Paper-30: CHE 618: Applications of Computers in Chemistry

Marks: 75 (55+20)

Unit I : Recapitulation of computer basics:
PC hardware, operating systems, data storage and backup, networks, information technology. Basic operations using windows.

Unit II: Computer programming:
Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.
BASIC programs for numerical differentiation and integration (Trapezoidal rule, Simpson's rule), finding roots (quadratic formula, iterative, Newton-Raphson method), numerical solution of differential equations.
Conceptual background of molecular modelling: Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Recommended Texts:

1. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co.
2. Venit, S.M. Programming in Basic: Problem solving with structure and style. Jaico Publishing House: Delhi.
3. Engel, T. & Reid, P. Physical Chemistry 2nd Ed. Pearson (2010). Chapter on Computational Chemistry.

Lab-XI: CHE-Lab: Inorganic Chemistry -V

Marks: 25(20+05)

Qualitative analysis:

Using H_2S /PTC/ Thioacetamide or any other reagent. Identification of cations and simple anions in a mixture of salts containing not more than six ions (Three cations and three anions)

interfering anions using semimicro scheme of analysis. If combination of cations or anions is given in the mixture, insoluble should be avoided. Spot tests should be carried out for final identifications wherever feasible.

Cation : $Pb^{2+,}$ Bi^{3+} $Cu^{2+,}$ $Cd^{2+,}$ As^{3+}, Sb^{3+}, Sn^{2+} or Sn^{4+}, Fe^{2+} OR Fe^{3+}, Al^{3+}, Cr^{3+},Co^{2+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^+, K^+

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

Lab-XI: CHE-Lab: Organic Chemistry -V

Marks: 25(20+05)

1. Tests for following functional groups

2. Qualitative analysis of following types of unknown organic compounds

   i. Carbohydrates, ii. Primary, secondary and tertiary amines iii. Nitro compounds, iv. Amides, v. Aryl halides, vi . Hydrocarbons

Identification of the functional groups, C-C and C-N triple bonds, sp^3, sp^2 and sp hybridized C-H bonds by IR spectroscopy (IR spectra to be provided)

Lab-XI: CHE-Lab: Physical Chemistry -V

PRACTICAL Marks: 25(20+05)

- Colourimetry
- Verification of Lambert-Beer's Law
- Determination of pK (indicator) for phenolphthalein or methyl red
- Study the formation of a complex between ferric and thiocyanate (or salicylate) ions.
- Study the kinetics of interaction of crystal violet with sodium hydroxide colourimetrically.
- Analysis of the given vibration-rotation spectrum of HCl(g)
- Record the UV spectrum of p-nitrophenol (in 1:4 ethanol: water mixture). Repeat after adding a small crystal of NaOH. Comment on the difference, if any.
- Record the U.V. spectrum of a given compound (acetone) in cyclohexane (a) Plot transmittance versus wavelength.

(b) Plot absorbance versus wavelength.

(c) Calculate the energy involved in the electronic transition in different units, i.e. cm^{-1}, kJ/mol, kcal/mol & eV.

Any other experiment carried out in the class.

Lab-XII: COMP-Lab: Application of Computers in Chemistry

PRACTICAL Marks: 25(20+05)

Word processing:

Incorporating chemical structures into word processing documents, presentation graphics, online publication (www/html), multimedia animations, etc.

Handling numeric data: spreadsheet software (Excel), simple calculations, statistical analysis, plotting graphs using a spreadsheet (radial distribution curves for hydrogenic orbitals, gas kinetic theory, spectral data, pressure-volume curves of van der Waals gas, data from phase equilibria studies), graphical solution of equations, solving equations numerically (e.g. pH of a weak acid ignoring/ not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).

Numeric modeling, numerical curve fitting, linear regression (rate constants from concentration time data, molar exinction coefficients from absorbance data), numerical differentiation (e.g. handling data from potentiometric titrations), integration (e.g. entropy/enthalpy change from heat capacity data). Numerical solution of differential equations (e.g. kinetics).

Molecular modeling:

Visualization of 3D structures, calculation of molecular structures and properties (e.g., conformational energies of butane, rotation of 1,3-butadiene, distribution of isomers, energies of orbitals and total energy as a function of bond angle for H_2O, simulation of Diels-Alder reaction, SN_2 reactions).

Chemical information on the web. Chemical abstracts. Structures and properties.

Note: 1. Software: Microsoft Office, ChemOffice (Free alternatives: OpenOffice (www.openoffice.org), ISIS Draw (http://www.mdli.com; registration required), ArgusLab (www.planaria-software.com).

2. References: Internet, documentation of software.

These are representative projects. The students must be encouraged to explore other projects and prepare a presentation/poster based on their project. Internal assessment may be based on the project.

Dr. Anand B. Melkani
Convener, Chemistry
Faculty of Science
Kumaun University, Nainital

Minor chemistry papers for B. Sc. Maths (H) and B. Sc. Physics (H) students

Semester-I

MM 75 (55 +20)

Paper-I Atomic Structure, Bonding, General Organic Chemistry and Aliphatic Hydrocarbons

Theory: 60 Lectures

Section A: Inorganic Chemistry-1 (30 Periods)

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

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and $\psi 2$, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (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. 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. (14 lectures)

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, trigonalbipyramidal and octahedral arrangements.

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

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of

orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches. (16 Lectures)

Section B: Organic Chemistry-1 (30 Periods)

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.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule. (8 Lectures)

Stereochemistry

Conformations of 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)

Aliphatic Hydrocarbons

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

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

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

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$. (12 Lectures)

Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry, Wiley India, 2012.
2. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, Milestone, Delhi, 2014.
3. Madan, RL, Chemistry for Degree Students (B. Sc. 1st Year), S. Chand, 2013.
4. Malik, Tuli and Madan, Selected Topics in Inorganic Chemistry, S. Chand. 2013
5. Solomons, TWG and Fryhle, CB, Organic Chemistry, 8th Edition, John Wiley & Sons, 2004.
6. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition,
7. Finar, I. L. Organic Chemistry (Volume 1), Pearson Education India, 6th Edition, 2009.
8. R. L. Madan, Chemistry For Degree Students (B. Sc. 1st year), S. Chand Ltd., 2013

MM 25

Lab-I: Atomic Structure, Bonding, General Organic Chemistry and Aliphatic Hydrocarbons

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.

(Any other text available in the market/library)

Semester-II

MM 75 (55 + 20)

Paper-II: Chemical Energetics, Equilibria, and Functional Organic Chemistry-I

Theory: 60 Lectures

Section A: Physical Chemistry-1 (30 Lectures)

Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics.

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

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

(10 Lectures)

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. (8 Lectures)

Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect.Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. (12 Lectures)

Section B: Organic Chemistry-2 (30 Lectures)

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

Aromatic hydrocarbons

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

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene).Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene). (8 Lectures)

Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2, and S_Ni) reactions.

Preparation: from alkenes and alcohols.

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

Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

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

(8 Lectures)

Alcohols, Phenols and Ethers (Upto 5 Carbons) Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

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

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

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

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

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

(14 Lectures)

Reference Books:

1. Marc Loudon G., Organic Chemistry, Oxford Univ. Press, 2011
2. Solomons, TWG and Fryhle, CB, Organic Chemistry, 8th Edition, John Wiley & Sons, 2004.
3. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition,
4. Finar, I. L. Organic Chemistry (Volume 1), Pearson Education India, 6th Edition, 2009.
5. R. L. Madan, Chemistry For Degree Students (B. Sc. 1st year), S. Chand Ltd., 2013.
6. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 9th Ed., Oxford University Press (2013).
7. Bahl, Tuli and Bahl, Essentials of Physical Chemistry, S. Chand Ltd.,
8. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
9. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier; (2009).

MM 25

Lab-II: Chemical Energetics, Equilibria, and Functional Organic Chemistry

Section A: Physical Chemistry Thermochemistry

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

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
b) Preparation of buffer solutions: (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide

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

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done. (a) Bromination of Phenol/Aniline (b) Benzoylation of amines/phenols (c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

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, S. Chand & Co.

(Any other text available in the market/library)

Semester-III

MM 75 (55 + 20)

Paper-III: Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II

Theory: 60 Lectures

Section A: Physical Chemistry-2 (30 Lectures)

Solutions

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

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation.Nernst distribution law and its applications, solvent extraction.

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium.Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

Conductance

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

Transference number and its experimental determination using Hittorf and Moving boundary methods.Ionic mobility. Applications of conductance measurements: determination of degree of

ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acidbase).

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.

pH determination using hydrogen electrode and quinhydrone electrode.

Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Section B: Organic Chemistry-3 (30 Lectures)

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

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic)

Preparation: Acidic and Alkaline hydrolysis of esters.

Reactions: Hell – Vohlard - Zelinsky Reaction.

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

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

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation. ` (6 Lectures)

Amines and Diazonium Salts

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

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: Preparation: from aromatic amines.

Reactions: conversion to benzene, phenol, dyes.

(6 Lectures)

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edmann degradation (Nterminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) &Cactivating groups and Merrifield solid-phase synthesis. (10 Lectures)

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation. (8 Lectures)

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw---Hill (2007).
2. Finar, I. L. Organic Chemistry (Volume 1), Pearson Education India, 6th Edition,2009.
3. Finar, I. L. Organic Chemistry (Volume 2), Pearson Education India, 6th Edition, 2009.
4. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson Education, 6th Edition, 2016.
5. R. L. Madan, Chemistry For Degree Students (B. Sc. 2nd & 3rd year), S. Chand Ltd., 2013
6. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 9th Ed., Oxford University Press (2013).
7. Bahl, Tuli and Bahl, Essentials of Physical Chemistry, S. Chand Ltd.,
8. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
9. R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
10. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
11. Berg, J. M., Tymoczko, J. L. &Stryer, L. Biochemistry 7th Ed., W. H. Freeman

Lab-III: Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$

$Cu^{2+}(aq) + xNH_2(aq) \rightleftharpoons [Cu(NH_3)x]^{2+}$

Phase equilibria

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

Conductance

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: v. Strong acid vs. strong base vi. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:
I. Strong acid vs. strong base
II. Weak acid vs. strong base
III. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

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

II

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

Reference Books:

- 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.
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

(Any other text available in the market/library)

Semester-IV

MM 75 (55 + 20)

Paper IV: Chemistry of s- and p-block Elements, States of Matter and Chemical Kinetics

Theory: 60 Lectures

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process. (4 Lectures)

s- and p-Block Elements

Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred-Rochow scales).Allotropy in C, S, and P.

Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Compounds of s- and p-Block Elements

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

Concept of multicentre bonding (diborane).

Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH)

Oxoacids of P, S and Cl.

Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2

(26 Lectures)

Section B: Physical Chemistry-3 (30 Lectures)

Kinetic Theory of Gases

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

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

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.

Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Liquids

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

Solids

Forms of solids.Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles,

Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only).Defects in crystals. Glasses and liquid crystals.

Chemical Kinetics

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

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

Reference Books:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 9th Ed., Oxford University Press (2013).
2. Bahl, Tuli and Bahl, Essentials of Physical Chemistry, S. Chand Ltd.
3. G. M. Barrow: Physical Chemistry Tata McGraw---Hill (2007).
4. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
5. Madan, R. L. Chemistry for Degree Students (2^{nd} & 3^{rd} year), S. Chand Ltd., 2013.
6. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, Milestone, Delhi, 2014.
7. Puri, Sharma and Pathania, Principles of Physical Chemistry, Milestone, Delhi, 2014.

MM 25

Lab-IV: Chemistry of s- and p-block Elements, States of Matter and Chemical Kinetics

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-}, $SO3^{2-}$, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-,SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^-

(Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

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

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

II. Initial rate method: Iodide-persulphate reaction

II. 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.
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

(Any other text available in the market/library)

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