

S. S. Jain Subodh P.G. College, Jaipur

(Autonomous)

Bachelor of Science (Chemistry)

B.Sc. Chemistry

(Three/Four Year Under Graduate Programme)

Syllabus & Examination Scheme (NEP 2020)

I -II Semester

2025-26

S. S. Jain Subodh P.G. College, Jaipur

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BACHELOR OF SCIENCE (Chemistry)

Semester I

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHEH101	Chemical bonding and Chemistry of representative and transition Elements	100	4	3	-
BCHEH102	States of matter, Chemical kinetics, Thermodynamics and Thermochemistry	100	4	3	-
BCHEHP 151	Chemistry Lab I	50	2	-	4
BCHEHP 152	Chemistry Lab II	50	2	-	4
Total		300	12	-	-

* EoSE = End of Semester Examination

S. No.	PAPER	EoSE	CIA	TOTAL
1.	Theory	70%	30%	100
2.	Practical	60%	40%	100

Note:

- It will be necessary for a candidate to pass in theory part as well as practical part of a subject separately.

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B.Sc. (Chemistry) Semester I

1 credit- 25 marks

4 credit- 100 marks

External Assessment: 70 marks

Internal Assessment: 30 marks

Objectives:

The aim of this course is to provide students with a theoretical understanding of the basic constituents of matter, atoms, ions and molecules in terms of their electronic structure and chemical bonding of these are to be explained by applying basic quantum chemistry, and to explain periodicity in the physical and chemical properties of s-block, p-block and d-block elements and also to explain chemistry of their compounds. The objective of this course is also to explain the basic concepts of thermodynamics in addition to heat capacity, Joule's law, different types of enthalpies and bond enthalpies and their applications, and to explain the structural differences and transformations between states of matter and structural determination of solids. In addition, the laboratory courses are designed to provide students with practical experience in basic qualitative analytical techniques related to radicals, quantitative analytical techniques related to volumetric analysis, and the determination of physical properties of matter, pK_a of an acid and kinetic parameter for various reactions.

Course Outcomes:

By the end of this course, students will have a clear understanding of various concepts related to atomic and molecular structure, chemical bonding, periodicity in the physical and chemical properties of s, p and d block elements and chemistry of their compounds. Students will also have practical experience in calibration of glassware, qualitative analysis of radicals, quantitative analytical techniques including volumetric analysis, determination of various physical properties of substances, crystallization and preparation of standard solutions of different concentrations and determination of order and rate constant of various reactions.

Marks distribution in question paper:

The question paper (EoSE – End of Semester Examination) will consist of two parts A and B

Part-A- 14 marks

Part-A will be compulsory having 10 very short answer type questions (with a limit of 20 words) of two marks each and candidate can attempt any 7 questions.

Part-B- 56 marks

Part-B of the question paper shall be divided into 4 units comprising question no 2-5.

There will be one question from each unit with internal choice. Each question will carry 14 marks.

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Paper I: Chemical Bonding and Chemistry of Representative and Transition Elements

Unit-I

Ionic Bond: General characteristics, types of ions, size effects, Radius ratio and coordination number, Lattice energy, Born-Landé equation with derivation, Madelung constant, Born-Haber cycle and its application, energy. Polarizing power, Polarizability, Fajan's rules, Solvation energy, Solubility of ionic compounds. Defects in solids, Frankel and Schottky defects, non-stoichiometric compounds.

Metallic bond: Qualitative idea of free electron theory, valence bond theory and band theory, Semiconductors and insulators, Conduction in solids, Electrical and magnetic properties of solids, Introduction to superconductors and super-conductivity.

Unit-II

Covalent bond: General characteristics, Valence bond theory and its limitations. Directional characteristics of covalent bond, Resonance and resonance energy, Hybridization involving s, p and d-orbitals.

Valence Shell Electron Pair Repulsion (VSEPR) Theory to NH_3 , H_2O , H_3O^+ , SF_4 , ClF_3 , ICl_2 Shapes of simple inorganic molecules and ions. Dipole moment, percentage ionic-character from dipole moment and electronegativity difference.

Molecular Orbital Theory: Detailed description of linear combination of atomic orbitals (LCAO), MOT of Homonuclear and heteronuclear diatomic molecules (CO , NO) and their ions, Comparison of valence bond and molecular orbital approaches, Multicenter bonding in electron deficient molecules, bond strength and bond energy.

Weak Interactions: Hydrogen bond, theories of hydrogen bonding. Weak intermolecular forces of attraction, Vander Waals forces.

Unit-III

s-Block Elements: Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their functions in biosystems, an introduction to alkyls and aryls.

p-Block Elements: Comparative study of the p-block elements and group trends: electronic configuration, Physical and chemical properties, Diagonal relationship, Atomic and ionic radii, Ionization enthalpy, Electron gain enthalpy, Electronegativity and oxidation states, Oxidation state diagrams on the basis of redox potentials, Inert pair effect, Catenation.

Compounds of p-Block Elements: Hydrides of boron; diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates, silicones, oxygen fluorides, peracids of sulphur, tetrasulphur tetranitride, basic properties of halogens, interhalogen compounds and polyhalides.

Chemistry of Noble Gases: Position in the periodic table, discovery, isolation, important compounds of noble gases with special references to xenon compounds: Synthesis, bonding and their stereochemistry.

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Unit-IV

Chemistry of d-Block elements: Chemistry of the elements of first transition series; Electronic configuration and comparative study with respect to atomic and ionic radii, oxidation states and ionization enthalpy. Redox potentials, oxidation state diagrams on the basis of redox potentials, binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry, metallic nature, magnetic properties, catalytic activity, colour and spectral properties of transition metal ions.

Chemistry of the elements of second and third transition series; Electronic configuration, general characteristics, comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states, magnetic behaviour, spectral properties and stereochemistry.

Suggested Books and References:

1. Concise Inorganic Chemistry by J.D. Lee, Wiley.
2. Inorganic Chemistry by Catherine E. Housecroft and Alan G. Sharpe, Pearson.
3. Selected Topics in Inorganic Chemistry by Wahid U. Malik, G. D. Tuli and R. D. Madan, S. Chand, New Delhi.
4. Organic Chemistry by R.T Morrison. & R. N Boyed, Prentice Hall.
5. Organic Chemistry by S. S. Gupta, Oxford University Press.
6. Organic Reaction Mechanisms by V. K. Ahluwalia, Narosa Publishing House, New Delhi.
7. Organic Chemistry – Reactions and Reagents: Covering Complete Theoretical Organic Chemistry by O. P. Agarwal, Goel Publishing House, Meerut.
8. Organic Chemistry (Vol. I & II) by I. L Finar, ELBS.
9. Advanced Organic Chemistry by A Bahl. & B. S Bahl, S. Chand.
10. Organic Chemistry by C. N Pillai, Oxford University Press.
11. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J March, & M. B Smith, Wiley.
12. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
13. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
14. Physical Chemistry by W. Atkins, Oxford University Press.
15. Physical Chemistry by R. J. Silby and R. A. Alberty, John Wiley & Sons.
16. Physical Chemistry by G.M. Barrow, Tata McGraw-Hill.
17. A Textbook of Physical Chemistry (Volume 1) by K. L. Kapoor, Macmillan India Ltd.
18. Instrumental Methods of Chemical analysis by Gurdeep R. Chatwal & Sham K. Anand, Himalaya Publishing House.
19. Instrumental Methods of Chemical Analysis by V.K. Ahluwalia, Springer.
20. Instrumental Methods of Chemical analysis by B. K. Sharma, Goel Publishing House, Meerut.
21. Analytical Chemistry by Gary D. Christian, Purnendu K. Dasgupta & Kevin A. Schug, Wiley.
22. Fundamentals of Analytical Chemistry by F. James Holler, Stanley R Crouch, Donald M. West & Douglas A. Skoog, Cengage Learning India Pvt. Ltd.

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Paper II: States of matter, Chemical kinetics, Thermodynamics and Thermochemistry

Unit I

Ideal gases: Kinetic Theory of Gases, Concept of molar mass and molar volume. Determination of molar mass of a gas and volatile substances. The barometric distribution laws. Maxwell distribution law of molecular velocities. The Maxwell energy distribution. The Maxwell Boltzmann distribution law and its experimental verification, Derivation of average, root mean square velocities and most probable velocities. Collision properties: Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules.

Real gases: Deviations of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waal's equations and its implications. *PV* isotherms of van der Waals gas equation. Critical phenomenon and critical constants. Reduced equation of state and law of corresponding states.

Unit II

Mathematical Concepts: Logarithmic relations, curve sketching, linear graphs and calculations of slopes, differentiation of functions like kx , e^x , x^n , $\sin x$ and $\log x$; maxima and minima, partial differentiation and Euler's reciprocity relations, integration of some useful/relevant functions; permutations and combinations, factorials, probability. Matrices and Determinant.

Liquid State: Thermal expansion and compressibility, Heat of vaporization. Determination of vapour pressure and heat of vaporization. Disorder in liquid state and structure of liquid water. Intermolecular forces. Cohesion of liquids. Eyring theory of liquids, seven segment cell.

Solid state: Crystalline and amorphous states. Isotropy and anisotropy. Definition of space lattice and unit cell. Laws of crystallography- (i) Law of constancy of interfacial angles (ii) Law of rationality of indices (iii) Law of symmetry. Symmetry elements in crystals. Weiss and Miller indices. Basic concept of X-ray diffraction by crystals. Derivation of Bragg's equation. Determination of crystal structure of NaCl and CsCl (Laue's method and Powder method.). Defects in solids.

Unit III

Chemical Kinetics: Chemical kinetics and its scope, Rate of reaction; Instant rate, Specific rate, factors influencing the rate of a reaction: concentration, temperature, pressure, solvent, light, catalyst, Rate constant and their units. Rate laws in terms of the advancement of a reaction. Experimental methods of the determination of rate laws, Order, molecularity and stoichiometry of a reaction. Methods of determination of order of reaction.

Derivation of integrated rate equations- zero order, first order, second order and third order. Graphical applications of these equations for the determinations of rate constant.

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Experimental Methods of Chemical Kinetics: Conductometric, potentiometric, optical methods (polarimetry) and spectrophotometric method. Theories of chemical kinetics. Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy.

Temperature dependence of reaction rates; Arrhenius equation, Energy of activation. Collision theory of reaction rates. Complex reactions and their nature. Derivation of rate equation for the opposing or reversible reactions ($A + B \rightleftharpoons C$), parallel reactions and consecutive reactions ($A \rightarrow B \rightarrow C$), characteristics of consecutive reactions.

Unit IV

Thermodynamics: Definitions of thermodynamic terms: system, surroundings, thermodynamic process. Concept of work and heat, Internal energy, Enthalpy. State and path functions and their exact and inexact differential, Calculation of work for reversible and irreversible expansion and compression of gases under isothermal and adiabatic conditions. Zeroth law of thermodynamics, first law of thermodynamics. Heat capacity at constant pressure (C_p) and constant volume (C_v) and their thermodynamic relationship. Application of first law of thermodynamics.

Thermochemistry: Standard states, Heat of reaction at constant pressure and constant volume and their thermodynamic relationship, Enthalpy of formation and enthalpy of combustion and its applications. Changes in enthalpy at constant temperature and pressure. Hess's Law. Heat of reaction at constant pressure and volume. Variation of heat of reaction with temperature. Bond enthalpies and bond energies, Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data.

Suggested Books and References:

1. Concise Inorganic Chemistry by J.D. Lee, Wiley.
2. Inorganic Chemistry by Catherine E. Housecraft and Alan G. Sharpe, Pearson.
3. Selected Topics in Inorganic Chemistry by Wahid U. Malik, G. D. Tuli and R. D. Madan, S. Chand, New Delhi.
4. Advanced Inorganic Chemistry: Volume I & II by Satya Prakash, G. D. Tuli, S. K. Basu and R. D. Madan, S. Chand, New Delhi.
5. Inorganic Solids – Introduction to Concepts in Solid-state Structural Chemistry by D. M. Adams, John Wiley, London.
6. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
7. Organic Chemistry by R. T. Morrison & R. N. Boyd, Prentice Hall.
8. Stereochemistry of Organic Compounds by V. K. Ahluwalia, Springer.
9. Stereochemistry conformation and Mechanism by P.S. Kalsi, New Age International Publishers.
10. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
11. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
12. Physical Chemistry by W. Atkins, Oxford University Press.
13. Physical Chemistry by R. J. Silby and R. A. Alberty, John Wiley & Sons.
14. Physical Chemistry by G.M. Barrow, Tata McGraw-Hill.
15. A Textbook of Physical Chemistry (Volume 1) by K. L. Kapoor, Macmillan India Ltd.

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16. A Text Book of Physical Chemistry by A. S. Negi and S. C. Anand, New Age International Publishers.
17. Elements of Physical Chemistry, P. Atkins and J. De Paula, Oxford.
18. Instrumental Methods of Chemical analysis by Gurdeep R. Chatwal & Sham K. Anand, Himalaya Publishing House.
19. Instrumental Methods of Chemical Analysis by V.K. Ahluwalia, Springer.
20. Instrumental Methods of Chemical analysis by B. K. Sharma, Goel Publishing House, Meerut.
21. Analytical Chemistry by Gary D. Christian, Purnendu K. Dasgupta & Kevin A. Schug, Wiley.
22. Fundamentals of Analytical Chemistry by F. James Holler, Stanley R Crouch, Donald M. West & Douglas A. Skoog, Cengage Learning India

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Chemistry Lab I

1 credit - 25 marks

2 credit - 50 marks

External Assessment: 30 marks

Internal Assessment: 20 marks

Inorganic Chemistry

A. Qualitative analysis:

10 marks

Analysis of the given inorganic mixture containing **six** radicals (three acidic and three basic) including interfering acid radicals – fluoride (F^-), borate (BO_3^{3-}), oxalate ($C_2O_4^{2-}$), and phosphate (PO_4^{3-}), excluding insoluble.

B. Quantitative analysis: Volumetric analysis

10 marks

1. Estimation of Ca^{2+} & Mg^{2+} using EDTA solution.
2. Estimation of Cu (II) ions iodometrically, using sodium thiosulphate solution.
3. Determination of total hardness of water.
4. Determination of number of molecules of water of crystallization in oxalic acid crystals.
5. Estimation of sodium carbonate and bicarbonate in mixed solution.
6. Estimation of sodium carbonate and sodium hydroxide in a mixed solution.
7. Estimation of Ferrous and Ferric sulphates in a mixed solution.

Viva voce

5 marks

Practical Record

5 marks

Suggested Books and References:

1. Vogel's textbook of quantitative chemical analysis by Arthur Israel Vogel, Harlow: Prentice Hall.
2. Vogel's Qualitative Inorganic Analysis by A. I. Vogel, Prentice Hall.
3. Vogel's Qualitative Inorganic Analysis, 7/e by G. Svehla, Pearson Education.
4. Vogel's textbook of quantitative inorganic analysis: including elementary instrumental analysis by Arthur Israel Vogel, Longman Scientific & Technical.
5. Vogel's Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, ELBS.
6. Vogel's Textbook of Quantitative Chemical Analysis by G. H. Jeffery, J. Bassett, J. Mendham and R B Denney, Longman Scientific & Technical.
7. Advance Practical Inorganic Chemistry by Gurdeep Raj, Goel Publishing House.

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Chemistry Lab II

1 credit- 25 marks

2 credit- 50 marks

External Assessment: 30 marks

Internal Assessment: 20 marks

Physical Chemistry

A. Solubility and Distribution Law:

1. To study the solubility curve of salts such as potassium nitrate, etc.
2. To study the solubility curve of phenol in water and hence study the effect of separate addition of substances such as naphthalene, potassium chloride and acetic acid.
3. Determine the molecular complexity of benzoic acid in benzene by Distribution Law.

B. *pH* metry:

1. Preparation of buffer solutions of different *pH*; (i) sodium acetate-acetic acid and (ii) ammonium chloride-ammonium hydroxide.
2. Study the effect on *pH* of the solutions of acetic acid, sodium acetate and their mixture by adding *HCl/NaOH*.
3. Determination of *pH* of different buffer solutions and evaluate the *pK_a* of an acid by Handerson equation.

C. Viscosity/surface tension measurements:

1. Determine the relative viscosity of a liquid by using viscometer.
2. Determination of viscosity of aqueous solutions of (i) ethanol and (ii) sugar at room temperature.
3. Study the variation of viscosity of sucrose solution with the concentration of solute.
4. Determine the relative surface tension of a liquid by using stalagmometer.
5. Study the variation of surface tension of detergent solutions with concentration.

D. Thermochemistry:

1. Determine the heat capacity of the calorimeter and enthalpy of neutralization of an acid and base.
2. Study of the solubility of benzoic acid in water and determination of ΔH .
3. Determine the enthalpy of reaction and verify Hess's law.

Any two of the above exercises under different headings, $2 \times 10 = 20$ marks.

Viva voce

5 marks

Practical Record

5 marks

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Suggested Books and References:

1. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
2. Practical Physical Chemistry by B. D. Khosla, S. Chand & Company.
3. Senior Practical Physical Chemistry by B. D. Khosla, V. C. Garg and A. Gulati, R. Chand & Co.: New Delhi.
4. Experiments in Physical Chemistry 8th Ed. by C. W. Garland, J. W. Nibler and D. P. Shoemaker, McGraw-Hill: New York.
5. Experimental Physical Chemistry 3rd Ed. by A. M. Halpern by G. C. McBane, W.H. Freeman & Co.: New York.

Suggested E-resources:

All the above suggested books are available as e- books.

Online Lecture Notes and Course Materials:

All prescribed courses are available in the form of e-books, Adobe Acrobat documents (PDF), web pages etc.

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BACHELOR OF SCIENCE (Chemistry)

Semester II

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHEH201	Reaction mechanism, Stereochemistry, Hydrocarbons, Aliphatic and aromatic halides	100	4	3	-
BCHEH202	Principles and Methods of Analytical Techniques	100	4	3	-
BCHEHP 251	Chemistry Lab I	50	2	-	4
BCHEHP 251	Chemistry Lab II	50	2	-	4
Total		300	12	-	-

* EoSE = End of Semester Examination

S. No.	PAPER	EoSE	CIA	TOTAL
1.	Theory	70%	30%	100
2.	Practical	60%	40%	100

Note:

- It will be necessary for a candidate to pass in theory part as well as practical part of a subject separately .

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B.Sc.(Chemistry) Semester II

1 credit- 25 marks

4 credit- 100 marks

External Assessment: 70 marks

Internal Assessment: 30 marks

Objectives:

The objective of this course is to provide students with a theoretical understanding of the types of organic reactions and their mechanisms, generation and stability of various intermediates, determination of reaction mechanism, stereochemistry of organic compounds with an understanding of the enantiomers, diastereomers, D/L and R/S nomenclature. The aim of this course is to explain the structure and reactivity of aliphatic and aromatic hydrocarbons, alkyl and aryl halides, and to explain principles and methods of different analytical techniques viz. quantitative analysis including volumetric and gravimetric analysis, solvent extraction, distillation. In addition, the laboratory course is designed to provide students with practical experience in basic quantitative analytical techniques including volumetric and gravimetric analysis, qualitative analytical techniques, and the laboratory techniques.

Course Outcomes :

By the end of this course, students will have a clear understanding of drawing logical and detailed reaction mechanisms for various fundamental reactions of aliphatic and aromatic hydrocarbons, methods of determining the reaction mechanisms, classifying the molecules as chiral or achiral, determining the D/L and R/S nomenclature of stereoisomers and identifying the formation of racemic mixture or optically active compounds during the reactions. Students will also have an understanding about principles and methods of analytical techniques. Students will also have practical experience in quantitative analytical techniques including volumetric and gravimetric analysis, identification of organic compounds by determination of functional groups, thin layer and paper chromatography.

Marks distribution in question paper:

The question paper (EoSE – End of Semester Examination) will consist of two parts A and B

Part-A- 14 marks

Part-A will be compulsory having 10 very short answer type questions(with a limit of 20 words) of two marks each and candidate can attempt any 7 questions.

Part-B- 56 marks

Part-B of the question paper shall be divided into 4 units comprising question no 2-5.

There will be one question from each unit with internal choice. Each question will carry 14 marks.

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PAPER-I :-Reaction mechanism, Stereochemistry, Hydrocarbons, Aliphatic and Aromatic halides

Unit-I

Structure and Bonding: Hybridization, inductive effect, hyperconjugation, resonance, Van der Waals interactions, inclusion compounds, clathrates, charge transfer complexes, hydrogen bonding.

Mechanism of Organic Reactions: Homolytic and heterolytic bond breaking, electrophiles and nucleophiles, types of organic reactions, energy considerations, transition state, reactive intermediates- carbocations, carbanions, free radicals, carbenes, arynes and nitrenes. Methods of determination of reaction mechanism.

Alkanes: Nomenclature of branched and unbranched alkanes. Classification of carbon atoms in alkanes. Isomerism in alkanes, methods of formation (with special reference to Wurtz reaction, Kolbe reaction, Corey House reaction and decarboxylation of carboxylic acids) physical properties and chemical reactions of alkanes. Halogenation of alkanes; mechanism, orientation, reactivity and selectivity.

Unit-II

Stereochemistry of Organic Compounds: Concept of isomerism. Types of isomerism.

Optical Isomerism: Elements of symmetry, molecular chirality, enantiomers, chiral and achiral molecules with two stereogenic centres, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization, Asymmetric synthesis. Relative and absolute configuration, Fischer projection and flying wedge formula. sequence rule, D, L and R, S systems of nomenclature.

Geometric isomerism: Determination of configuration of geometrical isomers, E, Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.

Conformational isomerism: Conformational analysis of ethane and n-butane. Newman projection and Sawhorse formula. Difference between configuration and conformation.

Unit-III

Cycloalkanes: Nomenclature, methods of formation, chemical reactions. Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane). Theory of strain less rings. Cyclopropane ring: banana bonds.

Alkenes: Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration. The Saytzeff 's rule, Hofmann elimination, physical properties and relative stabilities of alkenes. Chemical reactions of alkenes, Mechanisms involved in hydrogenation, electrophilic and free radical addition reactions. Markovnikov's rule, hydroboration-oxidation, oxymercuration- demercuration, epoxidation, ozonolysis, hydration, hydroxylation and oxidation with KMnO_4 , polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Industrial applications of ethylene and propene.

Cycloalkenes: Methods of formation, conformations and chemical reactions.

Dienes: Nomenclature and classification, isolated, conjugated and cumulated dienes, Structure of allenes and butadiene, methods of formation, polymerization, Chemical reaction-1,2 and 1,4 additions. Diels-Alder reaction.

Alkynes: Nomenclature, structure and bonding, Methods of formation. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal ammonia reduction, oxidation and polymerization.

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Unit-IV

Arenes and Aromaticity: Nomenclature of benzene derivatives. Aromatic nucleus, aryl group and side chain. Structure of benzene: molecular formula and Kekule structure. Stability and carbon-carbon bond lengths of benzene, resonating structures, MO picture.

Aromaticity: The Hückel's rule and its applications. Energy level, molecular orbital diagram; ethene, 1,3 butadiene, benzene. Aromatic electrophilic substitution (SEAr): General pattern of the mechanism, role of sigma and π -complexes, mechanism of nitration, halogenation, sulphonation, and Friedel-Crafts reaction. Effect of substituent groups (inductive, mesomeric and hyperconjugative effect), activating and deactivating groups, directive influence of groups, determination of orientation to disubstituted derivatives; ortho/para ratio, Birch Reduction. Method of formation and chemical reactions of benzene, alkyl benzenes and biphenyl.

Alkyl and Aryl Halides: Nomenclature and classification of alkyl halides, methods of formation, chemical reactions. Mechanisms of nucleophilic substitution, reactions of alkyl halides SN2 and SN1 reactions with energy profile diagrams. Methods of formation of aryl halides, nuclear and side chain reactions. The addition-elimination and elimination-addition mechanisms of nucleophilic aromatic substitution reactions. Relative reactivities of alkyl halides v/s vinyl, allyl and aryl halides. Preparation and properties of vinyl, allyl and benzyl halides. Synthesis and uses of DDT and BHC.

Suggested Books and References:

1. Concise Inorganic Chemistry by J.D. Lee, Wiley, India.
2. Inorganic Chemistry by Catherine E. Housecroft, & Alan G Sharpe, Pearson Education Ltd.
3. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
4. Concepts and Models of Inorganic Chemistry, B.E. Douglas, D. McDaniel, & J. Alexander, Wiley.
5. Selected Topics in Inorganic Chemistry by Wahid U. Malik, G. D. Tuli and R. D. Madan, S. Chand, New Delhi.
6. Advanced Inorganic Chemistry (Volume I) by Satya Prakash, S. Chand, New Delhi.
7. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, & P.L Gaus, Willey.
8. Principles of Inorganic Chemistry by Brian W. Pfennig, Wiley.
9. Organic Chemistry by I. L. Finar, Pearson.
10. Organic Chemistry by R.T. Morrison, R.N. Boyd & S.K. Bhattacharjee, Pearson.
11. Chemical Kinetics by Keith J. Laidler, Pearson Education.
12. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma & M. S. Pathania, Vishal Publishing Co.
13. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
14. Physical Chemistry by W. Atkins, Oxford University Press.
15. Physical Chemistry by R. J. Silby and R. A. Alberty, John Wiley & Sons.
16. Physical Chemistry by G.M. Barrow, Tata McGraw-Hill.
17. A Textbook of Physical Chemistry: (Volume V) by K. L. Kapoor, Macmillan India Ltd.
18. Instrumental Methods of Chemical analysis by Gurdeep R. Chatwal & Sham K. Anand, Himalaya Publishing House.
19. Instrumental Methods of Chemical Analysis by V.K. Ahluwalia, Springer.
20. Instrumental Methods of Chemical analysis by B. K. Sharma, Goel Publishing House, Meerut.
21. Analytical Chemistry by Gary D. Christian, Purnendu K. Dasgupta & Kevin A. Schug, Wiley.
22. Fundamentals of Analytical Chemistry by F. James Holler, Stanley R Crouch, Donald M. West & Douglas A. Skoog, Cengage Learning India Pvt. Ltd.

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PAPER -II: - Principles and Methods of Analytical Techniques

Unit-I

Gravimetric analysis: Principle of Gravimetric analysis, precipitation methods, super saturation and precipitate formation, the purity of the precipitate, coprecipitation, post-precipitation, conditions of precipitation, precipitation from homogeneous solution, washing of the precipitate. Drying and ignition of the precipitate, masking and demasking agents.

Unit-II

Solvent extraction: Principles and process of solvent extraction, the distribution law and the partition coefficient, liquid-liquid extraction, factors favouring solvent extraction, choice of solvent for solvent extraction, stripping, solid liquid extraction, organic reagents used in solvent extraction. Organic reagents in quantitative inorganic analysis. Application of the organic reagents-DMG, Cupferron, 8 hydroxyquinoline, cupron, salicylaldehyde oxime, 1-nitroso-2-naphthol, 4-bromomandelic acid, nitron, tannic acid, arsonic acids, pyridine, anthranilic acid, pyrogallol and ethylenediamine.

Unit-III

Data analysis and comparison of results: Completion of gravimetric results, compilation of results, reliability of results-accuracy and precision, cleaning and calibration of glassware, standard deviation, t, q and f tests, correction, significant figures, errors in analysis.

Volumetric analysis: Principle and applications of redox titrations, iodometry and iodimetry. Theory of complexation titrations. Methods of end point detection, EDTA as Titrant, types of EDTA titration of mixtures, metal indicators.

Unit-IV

Distillation: Distillation methods of organic solvents; steam, fractional, vacuum and molecular distillations, manometers, monostates distillation. Analysis of oils and fats, saponification value, iodine value, RM value, acid value.

Quantitative estimation of functional groups; alcoholic phenolic, carboxylic acids and unsaturated groups (olefinic & acetylenic).

Polarimetry: Basic principle, instrumentation, experimental techniques, determination of specific rotation and concentration of the substances, applications of polarimetry. An elementary idea of Refractometry, Interferometry; circular dichroism and optical rotatory dispersion.

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Suggested Books and References: (Autonomous)

1. Concise Inorganic Chemistry by J.D. Lee, Wiley.
2. Inorganic Chemistry by Catherine E. Housecraft and Alan G. Sharpe, Pearson.
3. Selected Topics in Inorganic Chemistry by Wahid U. Malik, G. D. Tuli and R. D. Madan, S.Chand, New delhi
4. Organic Chemistry by I. L. Finar, Pearson
5. Organic Chemistry by R.T. Morrison, R.N. Boyd & S.K. Bhattacharjee, Pearson.
6. Reaction Mechanism in Organic Chemistry by S. M. Mukherji & S. P. Singh, TRINITY Press
7. Physical Chemistry by R. J. Silbey, R. A. Alberty & M. G. Bawendi, John Wiley & Sons.
8. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
9. An Introduction to Chemical Thermodynamics by R. P. Rastogi & R. R. Mishra, Vikas House. Publishing
10. A Text Book of Physical Chemistry: A. S. Negi and S. C. Anand, New Age International Publishers.
11. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
12. Instrumental Methods of Chemical analysis by Gurdeep R. Chatwal & Sham K. Anand, Himalaya Publishing House.
13. Instrumental Methods of Chemical Analysis by V.K. Ahluwalia, Springer.
14. Instrumental Methods of Chemical analysis by B. K. Sharma, Goel Publishing House, Meerut.
15. Analytical Chemistry by Gary D. Christian, Purnendu K. Dasgupta & Kevin A. Schug, Wiley.
16. Fundamentals of Analytical Chemistry by F. James Holler, Stanley R Crouch, Donald M. West & Douglas A. Skoog, Cengage Learning India Pvt. Ltd.
17. Analytical Chemistry: Theory and Practice 3rd edition by R.M. Verma, CBS.
18. Principles and Practice of Analytical Chemistry 5Th Edition by F.W. Fifield & D. Kealey, Wiley India.
19. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler & Stanley R. Crouch, Cengage Learning.
20. Analytical Chemistry I by Ulf Ritgen, Springer.

S. S. Jain Subodh P.G. College, Jaipur

(Autonomous)

B.Sc. (Chemistry) Semester II

Chemistry Lab I

1 credit- 25 marks

2 credit- 50 marks

External Assessment: 30 marks

Internal Assessment: 20 marks

Organic Chemistry:

A. Organic compound Identification:

1. Identification of organic compounds through functional groups analysis, determination of melting point/boiling point, specific test and preparation of a suitable derivative.

B. Laboratory Techniques:

1. Purification of organic solid compounds by crystallization using water/alcohol/acetone solvents.
2. Separation of two miscible liquids by fractional distillation.
3. Determination of melting point and mixed melting point of two unknown organic compounds.

C. Organic Preparations:

1. Preparation of acetanilide from aniline.
2. Preparation of an azo-dye.

Any two of the above exercises under different headings, $2 \times 10 = 20$ marks.

Viva voce

5 marks

Practical Record

5 marks

Suggested Books and References:

1. Ahluwalia, V. K. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press, Hyderabad.
2. Ahluwalia, V. K. Laboratory Techniques in Organic Chemistry, I K International, New Delhi.
3. Arora Amit Advanced Practical Organic Chemistry, Discovery Publishing House, New Delhi.
4. Furniss, Brian S., Hannaford, Antony J. et al, Vogel's Textbook of Practical Organic Chemistry, Pearson.

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(Autonomous)

Chemistry Lab II

1 credit- 25 marks

2 credit- 50 marks

External Assessment: 30 marks

Internal Assessment: 20 marks

Gravimetric Analysis

- a) Estimation of Cu as CuSCN.
- b) Estimation of Ni as Ni (dimethylglyoxime)

Laboratory Techniques

A. Thin Layer Chromatography: Determination of R_f values and identification of organic compounds.

- a) Separation of green leaf pigments (spinach leaves may be used).
- b) Preparation and separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2-one and hexan-3-one using toluene and light petroleum (40 – 60) solvent system.
- c) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5: 1.5)

B. Paper Chromatography (Ascending and Circular): Determination of R_f values and identification of organic compounds.

- a) Separation of mixture of phenylalanine and glycine. Alanine and aspartic acid, leucine and glutamic acid. Spray reagent – ninhydrin.
- b) Separation of a mixture of D, L – alanine, glycine and L-Leucine using n-butanol: acetic acid: water (4:1:5), Spray reagent-ninhydrin.
- c) Separation of monosaccharides from a mixture of D- galactose and D-Fructose Using n-butanol: acetone: water (4:5:1) Spray reagent -aniline hydrogen phthalate.

Any two of the above exercises under different headings, $2 \times 10 = 20$ marks.

Viva voce

5 marks

Practical Record

5 marks

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(Autonomous)

Suggested Books and References:

1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis by V. K. Ahluwalia, Universities Press, Hyderabad.
2. Laboratory Techniques in Organic Chemistry by V. K. Ahluwalia, I K International, New Delhi.
3. Advanced Practical Organic Chemistry by Amit Arora, Discovery Publishing House, New Delhi.
4. Vogel's Textbook of Practical Organic Chemistry Furniss, S.Brian, Hannaford, J. Antony et al., Pearson.

S. S. Jain Subodh P.G. College, Jaipur
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Bachelor of Science (Chemistry)
(Three/Four Year Under Graduate Programme)

B. Sc. Chemistry

Examination Scheme & Syllabus (NEP 2020)

Semester III & IV

2026-2027

S. S. Jain Subodh P.G. College, Jaipur
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B. Sc. Chemistry

Semester III

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHEH301	Coordination Compounds, Metal-Ligand Bonding in Transition Metal Complexes, Alcohols, Phenols, Ethers and Epoxides, Chemical Equilibrium & Thermodynamics –II, Chromatography and Ion Exchange Methods.	100	4	3	-
BCHEH302	Magnetic Properties of Transition Metal Complexes, Lanthanides and Actinides , Aldehydes and Ketones, Basic Enolate Chemistry , Electrochemistry I, Nanochemistry, Conductometric & Potentiometric Titrations and Air & Water Pollutants..	100	4	3	-
BCHEHP 351	Chemistry Lab I	50	2	-	4
BCHEHP 352	Chemistry Lab II	50	2	-	4
Total		300	12	-	-

* EoSE = End of Semester Examination

S. No.	PAPER	EoSE	CIA	TOTAL
1.	Theory	70%	30%	100
2.	Practical	60%	40%	100

Note: It is mandatory for a candidate to pass in theory part as well as practical part of a subject separately.

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B. Sc. Chemistry

Semester III

COURSE OUTCOME: PAPER I

Students will be able to:

CO1: explain the fundamental concepts of coordination chemistry, including Werner's theory, nomenclature, isomerism, bonding theories, and crystal field splitting in transition metal complexes.

CO2: describe the preparation, properties, and chemical reactions of alcohols, phenols, ethers, and epoxides, including important reaction mechanisms and synthetic transformations.

CO3: apply the principles of chemical equilibrium and thermodynamics to analyze equilibrium constants, phase changes, entropy, and spontaneity of chemical processes.

CO4: explain the principles and techniques of chromatographic and ion-exchange methods, and apply these analytical techniques for the separation and identification of chemical substances, including amino acids and metal ions.

CO5: develop the ability to correlate theoretical concepts of inorganic, organic, physical, and analytical chemistry for understanding chemical structures, reactions, equilibria, and separation processes.

B. Sc. Chemistry

Semester III

PAPER I

BCHEH 301

60

Hours

Coordination Compounds, Metal-Ligand Bonding in Transition Metal Complexes, Alcohols, Phenols, Ethers and Epoxides, Chemical Equilibrium & Thermodynamics –II, Chromatography and Ion Exchange Methods.

Unit I

Coordination Compounds:

Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complex.

Metal-ligand bonding in Transition Metal complexes:

Limitations of valence bond theory, an elementary idea of crystal-field theory, crystal-field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters.

Unit II

Alcohols:

Classification and nomenclature, Monohydric alcohols - Methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters. Hydrogen bonding, Acidic nature. Reactions of alcohol with mechanism.

Dihydric alcohols - methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$\text{Pb}(\text{OAc})_4$ and HIO_4] and pinacol-pinacolone rearrangement. Trihydric alcohols - methods of formation, chemical reactions of glycerol.

Phenols:

Nomenclature, structure and bonding. Preparation of Phenols, Physical properties and acidic character. Comparative acidic strength of alcohols and phenols, Reactions of phenols- electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gattermann synthesis, Hauben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.

Ethers and Epoxides:

Methods of formation, physical properties. Chemical reactions - cleavage and autooxidation. Ziesel's method. Synthesis of epoxides. Acid and base-catalyzed ring opening of epoxides,

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orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

Unit III

Chemical Equilibrium:

Equilibrium constant and free energy. Thermodynamic derivation of law of mass action. Le Chatelier's principle. Reaction isotherm and reaction isochore. Clapeyron equation and Clausius-Clapeyron equation, applications.

Thermodynamics –II :

Second Law of Thermodynamics: Need for the law, different statements of the law. Carnot cycle and its efficiency, Carnot-Theorem. Thermodynamic scale of temperature.

Concept of Entropy: Entropy as a state function, entropy as a function of V&T, entropy as a function of P&T, entropy change in physical change, Clausius inequality and entropy as a criteria of spontaneity and equilibrium. Entropy changes in ideal gases and mixing of gases.

Third Law of Thermodynamics:

Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data. Gibb's and Helmholtz functions: Gibb's function (G) and Helmholtz function (A) as thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change. Variation of G and A with P, V and T.

Unit IV

Chromatography:

Principles of absorption and partition chromatography, techniques and applications of column, paper and thin layer chromatography. Electrophoresis and its applications in separation of amino acids.

Ion exchange methods:

General discussion, action of ion exchange resins, column operation, experimental techniques, types of ion exchange resins, determination of the following pairs by ion exchange techniques: (a) chloride and bromide (b) nickel and cobalt.

Suggested Books and References:

1. Concise Coordination Chemistry by R. Gopalan and V. Ramalingam, Vikas Publishing House Pvt, Ltd.
2. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, & P.L Gaus, Willey.
3. Concise Inorganic Chemistry by J. D. Lee, Wiley-India.
4. Inorganic Chemistry by Catherine E. Housecroft, & Alan G Sharpe, Pearson Education Ltd.
5. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
6. Concepts and Models of Inorganic Chemistry, B.E. Douglas, D. McDaniel, & J. Alexander, Wiley.
7. Organic Chemistry by R. T. Morrison & R. N. Boyd, Prentice Hall.
8. Reaction Mechanism in Organic Chemistry by S. M. Mukherji & S. P. Singh, Trinity Press.
9. Organic Chemistry by I. L. Finar, (Vol. I & II) Elbs.
10. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
11. A Text Book of Physical Chemistry: A. S. Negi and S. C. Anand, New Age International

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Publishers.

12. Elements of Physical Chemistry, P. Atkins and J. De Paula, Oxford.
13. Analytical Chemistry Chatwal, R. Gurdeep, Himalaya Publishing House.
14. Skoog and West's Fundamentals of Analytical Chemistry by M. Donald, A Douglas, F. Holler James, F. West et al, 2022, Cengage Learning India Pvt. Ltd.

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B. Sc. Chemistry

Semester III

COURSE OUTCOME: PAPER II

Students will be able to:

CO1: explain the magnetic behavior of transition metal complexes using magnetic susceptibility measurements, spin-only formula, and electronic structure concepts, and describe the chemistry of lanthanides and actinides including their separation and complex formation.

CO2: describe the structure, synthesis, properties, and reactions of aldehydes, ketones, and enolate compounds, and apply reaction mechanisms for organic transformations and synthetic strategies.

CO3: apply the principles of electrochemistry, electrolyte behavior, conductivity measurements, ionic transport to analyse chemical systems and also understand the importance of nanomaterials in today's world.

CO4: explain the principles and applications of conductometric and potentiometric titrations, and apply analytical methods for water and air pollution monitoring, assessment, and control.

CO5: develop an understanding of chemical analysis and reaction processes by integrating concepts of inorganic chemistry, organic chemistry, physical chemistry, and environmental chemistry for practical applications.

B. Sc. Chemistry

Semester III

PAPER II

BCHEH 302

Magnetic Properties of Transition Metal Complexes, Lanthanides and Actinides , Aldehydes and Ketones, Basic Enolate Chemistry, Electrochemistry I, Nanochemistry, Conductometric & Potentiometric Titrations and Air & Water Pollutants.

Unit I

Magnetic properties of Transition Metal Complexes:

Types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes

Chemistry of Lanthanides and Actinides:

Electronic structure, oxidation states, ionic radii and lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds.

General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, similarities between the later actinides and the later lanthanides

Unit II

Aldehydes and Ketones:

Structure of the carbonyl group. Synthesis of aldehydes from acid chlorides, ketones from nitriles and carboxylic acids, aldehydes and ketones using 1,3-dithianes,. Physical properties.

Mechanism of nucleophilic additions to carbonyl group with particular emphasis on Benzoin, Aldol, Perkin and Knoevenagel condensations. Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction. Oxidation of aldehydes, Baeyer-Villiger oxidation of ketones, Cannizzaro reaction, MPV (Meerwein-Ponndorf-Verley), Clemmensen, Wolff-Kishner, LiAlH_4 and NaBH_4 reductions, Halogenation of enolizable ketones. Use of acetals and 1,3-dithiane as protecting group.

Organic Synthesis via Enolates:

Acidity of α -hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Claisen condensation, Keto-enol tautomerism in ethyl acetoacetate. Synthetic applications of ethyl acetoacetate and malonic ester.

Unit III

Electrochemistry – I:

Electrical transport-conduction in metals and electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance. Variation of equivalent and specific conductance with dilution. Migration of ions and Kohlrausch law, Arrhenius theory of

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electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations. Debye- Huckel-Onsager's equation for strong electrolytes (elementary treatment only). Transport number, definition and determination by Hittorf's method and moving boundary method. Applications of conductivity measurements: Determination of degree of dissociation, K_a of acids and solubility product. (sparingly soluble salt)

Introduction to Nano Chemistry:

Introduction, synthesis, characterization and properties of nanomaterials, role of size and shape in nanomaterials, electronic properties, magnetic properties, optical properties and applications of nanomaterials. Health, safety and environmental aspects of nano science.

Unit IV

Conductometric Titrations:

The basis of conductometric titrations. Apparatus and measurement, applications of conductometric titrations. High frequency titrations and its advantages & applications.

Potentiometric Titrations:

Introduction, electrodes, instrumentation, potentiometric titrations, differential potentiometric titrations, automatic potentiometric titrations, location of end points, determination of some metals through potentiometric titrations.

Air and Water pollutants

Water analysis: analysis of water for dissolved oxygen, BOD. and COD. Biological treatment methods. Prevention of water pollution by treatment of industrial wastes with special reference to cement, fertilizer and dyeing industries.

Air pollution: General consideration types of air pollutants, unit of measurement, sampling monitoring and analysis of CO and SO₂ in atmosphere, effect of air pollutants on plants and human health, methods for pollution control, especially for pollution by automobiles.

Suggested Books and References:

1. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, & P.L Gaus, Wiley.
2. Concise Inorganic Chemistry by J. D. Lee, Wiley-India.
3. Inorganic Chemistry by Catherine E. Housecroft, & Alan G Sharpe, Pearson Education Ltd.
4. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
5. Concepts and Models of Inorganic Chemistry, B.E. Douglas, D. McDaniel, & J. Alexander, Wiley.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J March, & M. B Smith Wiley.
7. Organic Chemistry by R. T. Morrison & R. N. Boyd, Prentice Hall
8. Reaction Mechanism in Organic Chemistry by S. M. Mukherji & S. P. Singh, Trinity Press.
9. Organic Chemistry by I. L. Finar, (Vol. I & II) Elbs.
10. Physical Chemistry by R. J. Silbey, R. A. Alberty & M. G. Bawendi, John Wiley & Sons.
11. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.

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12. An Introduction to Chemical Thermodynamics by R. P. Rastogi & R. R. Mishra, Vikas Publishing House.
13. A Text Book of Physical Chemistry: A. S. Negi and S. C. Anand, New Age International Publishers.
14. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
15. Elements of Physical Chemistry, P. Atkins and J. De Paula, Oxford.
16. A Textbook of Physical Chemistry, Application of Thermodynamics, by K. L. Kapoor, (Volume-3) McGraw Hill.
17. An Introduction to Electrochemistry by Samuel Glasstone, BSC Publishers.
18. Electrochemistry and its Applications by G. Whitmore, Sarup & Sons.
19. Instrumental Methods of Chemical analysis (Analytical Chemistry), Chatwal, R Gurdeep, S Anand, Himalaya Publishing House.
20. Basic Concepts of Analytical Chemistry – Fourth Edition by S. M. Khopkar, New Age International Publisher. Physical Chemistry by G.M Barrow, Tata McGraw-Hill.
21. Fundamentals of Electrochemistry by Morris Sylvain, Sarup & Sons.
22. Solutions, Phase Equilibrium, Conductance & Electrochemistry by Puri, Sharma, Pathania and Kaur, Vishal Publishing Co.
23. Phase Equilibria, Phase Diagrams and Phase Transformations by Mats Hillert, Cambridge University Press.
24. Nanomaterials Chemistry by C. N. R. Rao, A. Müller & A. K. Cheetham (Eds.) –.
25. Textbook of Nanoscience and Nanotechnology by B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath & James Murday –(University Press).
26. A Textbook of Nanoscience and Nanotechnology by T. Pradeep. (Tata Mc. Graw-Hill).

Syllabus

BCHEHP: 351

Practical I

4 Hrs./week

Inorganic Chemistry

10 marks

Quantitative

Gravimetric Analysis (*any three*)

- a) Estimation of Barium (as sulphate)
- b) Estimation of Lead (as chromate)
- c) Estimation of Zinc (as Zinc ammonium phosphate)
- d) Estimation of Magnesium (as Magnesium hydrogen phosphate, MgHPO_4)

Or

Volumetric Estimations:

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- (a) Determine the strength of Potassium permanganate using standard solution of Oxalic Acid/ Mohr's salt.
- (b) Estimate the amount of Ferrous ions present in the solution using standard Potassium Dichromate solution.
- (c) Estimation of hydrogen per oxide by iodometric method

Organic Chemistry

15 marks

Identification of simple organic compound and prepare its suitable derivative.

Physical Chemistry:

10 marks

- (a) To find the velocity constant of the hydrolysis of methyl acetate catalyzed by an acid. To determine the order of saponification of ethyl acetate by NaOH.
- (b) To find out the rate constant and order of reaction between potassium persulphate and potassium iodide,
- (c) To study the reaction between acetone and iodine.

Viva voce

8 marks

Practical Record

7 marks

Suggested Books and References:

1. Vogel's textbook of Practical Organic Chemistry including Qualitative Organic Analysis, by A.I. Vogel Longman, London and New York. Prentice Hall.
2. A.I. Vogel, Vogel's Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, Elbs.
3. Advance Practical Inorganic Chemistry by Gurdeep Raj, Goel Publishing House.
4. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
5. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
6. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt. Ltd.
7. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. Universities Press, Hyderabad.
8. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House

Syllabus

BCHEHP:352

Practical II

4 Hrs./week

Inorganic Chemistry

10 Marks

Inorganic Preparations (*any four*) of Coordination Compounds and their characterization:

- (a) Chloropentamminecobalt(III) chloride.
- (b) Pyridine complex of copper.
- (c) Tetramminecopper(II) sulphate.
- (d) Mercury tetrathiocyanatocobaltate.
- (e) Prussian blue.
- (f) Hexaamminenickel(II) chloride.

Organic Chemistry

15 Marks

Simple one step organic preparation: (Any Five)

- (a) Preparation of m-dinitrobenzene from nitrobenzene.
- (b) Preparation of acetanilide from aniline.
- (c) Preparation of aspirin from salicylic acid.
- (d) Preparation of o-and p-bromo acetanilide from acetanilide.
- (e) Preparation of o-and p-bromo aniline from o-and p-bromoacetanilide.
- (f) Partial reduction of m-dinitrobenzene into m-nitro aniline.
- (g) Preparation of methyl orange from sulphanilic acid

Physical Chemistry

10 Marks

- a) Determination of transition temperature by thermometric/dialometric method.
- b) Determination of molecular weight of non-volatile solute by cryoscopic method & application of technique for determination of the Van't Hoff factor or degree of dissociation of an electrolyte.

Viva voce

8 marks

Practical Record

7 marks

Suggested Books and References:

1. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
2. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
3. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt Ltd.
4. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. Universities Press, Hyderabad.
5. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt Ltd.
6. Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.
7. Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd.
8. Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International.

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B. Sc. Chemistry

Semester IV

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHEH401	Metal-ligand Bonding, Oxidation-Reduction, Absorption Spectroscopy, Carboxylic Acids & Derivatives, Phase Equilibrium, Spectrophotometric Titrations, Nephelometry & Turbidimetry, Flame and Atomic Emission Spectrography.	100	4	3	-
BCHEH402	Acids and Bases, Hard and Soft Acids and Bases, Nuclear Chemistry, Radioactivity, Organic Compounds of Nitrogen, Synthetic Dyes, Sulpha Drugs, Polymers and Polymerization, Electrochemistry-II, Electrogravimetry and Coulometry.	100	4	3	-
BCHEHP 451	Chemistry Lab I	50	2	-	4
BCHEHP 452	Chemistry Lab II	50	2	-	4
Total		300	12	-	-

***EoSE = End of Semester Examination**

S. No.	PAPER	EoSE	CIA	TOTAL
1.	Theory	70%	30%	100
2.	Practical	60%	40%	100

Note: It is mandatory for a candidate to pass in theory part as well as practical part of a subject separately.

B. Sc. Chemistry

Semester IV

COURSE OUTCOME: PAPER I

Students will be able to:

CO1: explain the fundamental concepts of metal–ligand bonding and critically evaluate the limitations of Crystal Field Theory (CFT) in describing the electronic structure and properties of coordination compounds.

CO2: construct and interpret Frost, Latimer, and Pourbaix diagrams to assess oxidation-state stability, redox transformations, and the influence of pH and electrode potential on chemical equilibria.

CO3: explain the principles of the electromagnetic spectrum to predict and analyze the UV. IR and electromagnetic spectra

CO4: explain the structure, bonding, physical properties, and acidic nature of carboxylic acids and their derivatives, and evaluate the effect of substituents on their acid strength.

CO6: analyze phase equilibrium data to solve numerical & conceptual problems related to chemical & industrial process.

CO6: explain the principles, instrumentation, and experimental procedures of spectrophotometric titrations, nephelometry, turbidimetry, Flame Emission Spectrometry (FES) and Atomic Absorption Spectrometry (AAS), including nebulization, flame characteristics, and analytical interferences.

B. Sc. Chemistry

Semester IV

PAPER I

BCHEH 401

60 Hours

Metal-ligand Bonding, Oxidation-Reduction, Absorption Spectroscopy, Carboxylic Acids & Derivatives, Phase Equilibrium, Spectrophotometric Titrations, Nephelometry & Turbidimetry, Flame and Atomic Emission Spectrography.

Unit I

Metal-Ligand Bonding:

Limitations of crystal field theory, molecular orbital theory of octahedral, tetrahedral and square planar complexes, π -bonding and molecular orbital theory.

Oxidation-Reduction:

Use of redox potential data, analysis of redox cycle, redox stability in water, disproportionation, the diagrammatic representation of redox potential data- Frost, Latimer and Pourbaix diagrams.

Unit II

Absorption Spectroscopy:

Ultraviolet (UV) Spectroscopy: Absorption laws (Beer-Lambert Law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of solvents on transitions, effect of conjugation. Concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones.

Infrared (IR) Spectroscopy: Molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristics absorption of various functional groups and interpretation of IR spectra of simple organic compounds.

Carboxylic Acids:

Structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength. Preparation of carboxylic acids. Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction. Reduction of carboxylic acids, mechanism of decarboxylation.

Methods of formation and chemical reactions of halo acids. Hydroxy acids - malic, tartaric and citric acids.

Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents (succinic, glutaric and adipic acids).

Carboxylic Acid Derivatives:

Structure, nomenclature and synthesis of acid chlorides, esters, amides (urea) and acid anhydrides. Relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution.

Preparation of carboxylic acid derivatives, chemical reactions, mechanisms of esterification and hydrolysis (acidic and basic).

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Unit III

Phase Equilibrium:

Statement and meaning of the terms: phase, component and degree of freedom, derivation of Gibb's phase rule, phase equilibria of one component system - water, CO₂ and Sulphur systems.

Phase Equilibria of two component system: solid-liquid equilibria simple eutectic Bi-Cd, Pb-Ag systems, desilverization of Lead. Solid Solutions: Compound formation with congruent melting point (Mg-Zn) and benzophenone – dimethylamine, incongruent melting point NaCl-H₂O, picric acid and benzene, FeCl₃ – H₂O and CuSO₄·H₂O system. Liquid-Liquid Mixtures: Ideal liquid mixtures, Raoult's law and Henry's law, non-ideal system, azeotropes HCl-H₂O and ethanol-water system. Partial Miscible Liquids: Phenol-water, trimethylamine- water, nicotine- water system, lower and upper consolute temperature, effect of impurities on consolute temperature.

Immiscible liquids: Steam distillation

Unit IV

Spectrophotometric Titrations:

Basic principle. instrumentation experimental techniques, spectrophotometric analysis of Fe (III), Co(I), Ni (II), Fe (II) in presence of Al (III) with EDTA.

Nephelometry & Turbidimetry:

General discussion, instrumentation, some nephelometry determination (a) sulphate (b) phosphate

Flame Emission and Atomic Absorption Spectrometry:

Basic principle, instrumentation. Nebulization, flames and flame temperatures, interferences, flame spectrometric techniques.

Atomic Emission Spectrography:

Spectroscopic sources, instruments for emission spectrographic analysis, qualitative and quantitative spectrographic analysis. Qualitative spectrographic analysis of a non-ferrous alloy and complex organic mixture.

Suggested Books and References:

1. Organic Chemistry by S. S. Gupta, Oxford University Press.
2. Organic Reaction Mechanisms by V. K. Ahluwalia, Narosa Publishing House, New Delhi.
3. Organic Chemistry – Reactions and Reagents Complete Theoretical Organic Chemistry, by O. P. Agarwal, Covering Goel Publishing House, Meerut.
4. Organic Chemistry by R.T Morrison. & R. N. Boyd., Prentice Hall.
5. Organic Chemistry by I. L. Finar, (Vol. I & II) ELBS.
6. Advanced Organic Chemistry by A. Bahl. & B. S. Bahl., S. Chand.
7. Organic Chemistry by C. N. Pillai., Oxford University Press.
8. Modern Organic Chemistry by M. K. Jain & S.C. Sharma, Vishal Publishing Co.
9. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J. March, & M. B. Smith Wiley.
10. Inorganic Chemistry by Catherine E. Housecroft, & Alan G. Sharpe, Pearson Education Ltd.
11. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
12. Stereochemistry of Organic Compounds by V. K. Ahluwalia, Springer.
13. Heterocyclic Chemistry – Third Edition by Thomas L. Gilchrist, Pearson.
14. Fundamentals of Molecular Spectroscopy by C. N. Banwell, Campus Book House.
15. Spectrometric Identification of Organic Compounds by Robert Silverstein, Wiley.
16. Fundamentals of Molecular Spectroscopy by P. S. Sindhu, New Age International.
17. Introduction to Spectroscopy – Fifth Edition by Pavia, Lampman, Kriz & Vyvyan Cengage India Private Limited.

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18. Modern Spectroscopy – Fourth Edition by J. Michael Hollas, John Wiley & Sons.\
19. Spectroscopy by B. K. Sharma, Goel Publishing House.
20. Solutions, Phase Equilibrium, Conductance & Electrochemistry by Puri, Sharma, Pathania and Kaur, Vishal Publishing Co.

B. Sc. Chemistry

Semester IV

COURSE OUTCOME: PAPER II

Students will be able to:

CO1: explain the theories of acids and bases, apply the HSAB concept to predict acid–base interactions, and interpret the principles of nuclear chemistry, radioactivity, and nuclear reactions.

CO2: describe the preparation, properties, and reactions of nitrogen-containing organic compounds, dyes, sulphur drugs, and polymers, and correlate their structures with their chemical reactivity and practical applications.

CO3: apply electrochemical principles to calculate electrode and cell potentials, analyze galvanic and electrolytic cells, determine thermodynamic parameters, and perform potentiometric measurements including pH determination.

CO4: explain the principles of electrogravimetry and coulometry, and apply electroanalytical techniques for the quantitative determination and separation of metal ions using controlled current and controlled potential methods.

B. Sc. Chemistry

Semester IV

PAPER II

BCHEH 402

60 Hours

Acids and Bases, Hard and Soft Acids and Bases, Nuclear Chemistry, Radioactivity, Organic Compounds of Nitrogen, Synthetic Dyes, Sulpha Drugs, Polymers and Polymerization, Electrochemistry-II, Electrogravimetry and Coulometry.

Unit I

Acids and Bases:

Theories: Arrhenius, Bronsted-Lowry, Lux-Flood. Solvent system concept and Lewis's concept of acids and bases.

Hard and Soft Acids and Bases (HSAB):

Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness.

Nuclear Chemistry:

Fundamental particles of nucleus (nucleon), concept of nuclides, representation of nuclides, isotopes, isobars and isotones with specific examples. Applications of radioisotopes, size concept in nucleus and atom. Qualitative idea of the stability of nucleus (n/p ratio). Shell and liquid drop model.

Radioactivity:

Natural and artificial radioactivity, disintegration series, disintegration rates, half-life, average life, nuclear binding energy, mass defects, Einstein's mass energy relations, artificial transmutation, nuclear reactions, spallation, nuclear fission and fusion, nuclear reactors, hazards of radioactive emanations.

Unit II

Organic Compounds of Nitrogen:

Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral, alkaline and electrolytic media. Picric acid.

Amines:

Structure, nomenclature and preparation of alkyl, and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds. Physical properties, stereochemistry of amines. Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts. Gabriel-phthalimide reaction and Hoffmann bromamide reaction & its mechanism.

Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. diazotisation and mechanism. Synthetic transformations of aryl diazonium salts, azo coupling and its applications.

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Synthetic Dyes:

Colour and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of Methyl orange, Congo red, Malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and Indigo.

Sulpha Drugs:

Mechanism of action, Synthesis of sulphadiazine, sulphapyridine, sulphathiazole, sulphaguanidine and sulphamethazole.

Polymers and Polymerization:

Addition and condensation polymerization, their mechanism, copolymerization, coordination polymerization, Ziegler-Natta catalyst, plastics, thermoplastic and thermosetting resins, plasticizers, polystyrene, PVC, polyacrylates, polyacrylonitrile, dacron, terylene, nylon-66, bakelite, melamine and polyurethanes. Synthetic and natural rubber.

Unit III

Electrochemistry –II

Types of Reversible Electrodes: Gas-metal- ion, metal-metal ion, metal-insoluble salt anion and redox electrodes, electrode reactions, Nernst equation, derivation of cell E.M.F. and single electrode potential, standard hydrogen electrode, reference electrodes, standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells-reversible and irreversible cells, conventional representation of electrochemical cells.

EMF of a cell and its measurements, Computation of cells EMF. Calculation of thermodynamic quantities of cell reactions (ΔG , ΔH and K), polarization, over potential and hydrogen overvoltage. Concentration cell with and without transport, liquid junction potential, application of concentration cells. Valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pK_a , determination of pH using hydrogen - quinhydrone and glass electrodes by potentiometric methods.

Unit IV

Electrogravimetry:

Theory, electrode reactions, overpotential, deposition, electrolytic separation of metals, character of the deposit and electrolytic separation of metals with controlled cathode potential. Electrolytic determinations at constant current—Copper and Lead. Electrolytic determinations with controlled cathode potential—Antimony, Copper, Lead and Tin in an alloy.

Coulometry:

Coulometry at controlled potential, separation of Ni and Co by coulometric analysis at controlled potential, coulometry at constant current, coulometry titrations.

Suggested Books and References:

1. Instrumental Methods of Chemical analysis (Analytical Chemistry), Chatwal, R Gurdeep, S Anand, Himalaya Publishing House.
2. Analytical Chemistry Chatwal, R. Gurdeep, Himalaya Publishing House.
3. Skoog and West's Fundamentals of Analytical Chemistry by M. Donald, A Douglas, F. Holler James,
4. F. West et al, 2022, Cengage Learning India Pvt. Ltd.
5. Basic Concepts of Analytical Chemistry – Fourth Edition by S. M. Khopkar, New Age International Publisher.
6. Instrumental Methods of Chemical Analysis (Analytical Chemistry) by B. K. Sharma, Goel Publishing House.
7. An Introduction to Electrochemistry by Samuel Glasstone, East West Pvt. Ltd.
8. Electrochemistry and its Applications by G. Whitmore, Sarup & Sons.
9. Physical Chemistry by G.M Barrow, Tata McGraw-Hill.
10. Fundamentals of Electrochemistry by Morris Sylvain, Sarup & Sons.

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11. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, & P.L Gaus, Wiley.
12. Concise Inorganic Chemistry by J. D. Lee, Wiley-India.
13. Inorganic Chemistry by Catherine E. Housecroft, & Alan G Sharpe, Pearson Education Ltd.
14. Organic Chemistry by R. T. Morrison & R. N. Boyd, Prentice Hall.
15. Reaction Mechanism in Organic Chemistry by S. M. Mukherji & S. P. Singh, Trinity Press.
16. Organic Chemistry by I. L. Finar, (Vol. I & II) Elbs.

Syllabus

BCHEHP:451

Practical I

4 Hrs./week

Inorganic Chemistry

Qualitative Analysis:

10 marks

Identification of six radicals in a mixture, one of which should be a rare earth metal ion. The mixture may contain radicals of any combination including interfering acid radicals and insoluble.

Quantitative Analysis:

15 marks

Estimation of any two of the following mixtures by volumetric and gravimetric methods.

- (a) Copper-Zinc
- (b) Zinc-Nickel
- (c) Copper-Nickel

Organic Chemistry

10 marks

Quantitative Estimations:

- (a) Determination of neutralization equivalent of an organic acid.
- (b) Determination of Saponification value of an ester/oil.
- (c) Determination of iodine value of oil to measure unsaturation.
- (d) Estimation of glucose by titration with Fehling's solution/ Benedict solution.

Viva voce

8 marks

Practical Record

7 marks

Suggested Books and References:

1. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
2. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
3. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt. Ltd.
4. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. Universities Press, Hyderabad.
5. Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.
6. Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd.
7. Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International, New Delhi.

Syllabus

BCHEHP:452

Practical II

4 Hrs./week

A) Conductometry:

10 Marks

- a) To find out the strength of strong acid by titrating it against strong base.
- b) To find out the strength of weak acid by titrating it against a strong base.
- c) To find out the strength of hydrochloric acid and acetic acid in a mixture of both, by titrating it against sodium hydroxide.
- d) Determination of equivalent conductivity of an electrolyte at different dilutions.

B) Spectrophotometry or Colourimetry:

15 Marks

- a) Verify Lambert Beer Law & determine the concentration of the given aqueous solution of unknown concentration of salt (KMnO_4 , CuSO_4 , $\text{K}_2\text{Cr}_2\text{O}_7$)

C) pH metric titrations:

10 marks

- a) To find out the strength of strong acid by titrating it against strong base.
- b) To find out the strength of strong acid by titrating it against weak base.
- c) To find out the strength of weak acid by titrating it against strong base.
- d) Find out the strength of HCl and CH_3COOH in a mixture of both by titrating it against NaOH .

D) Determination of Dissolved Oxygen, Chemical Oxygen Demand & Biological Oxygen Demand of different water samples.

Viva voce

8 marks

Practical Record

7 marks

Suggested Books and References:

1. Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.
2. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
3. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
4. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt. Ltd.
5. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. Universities Press, Hyderabad.
6. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt. Ltd.
7. Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd
8. Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International, New Delhi.