

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

(Autonomous)

SYLLABUS

Bachelor of Science (B.Sc.)

(Three Year Under Graduate Programme)

CHEMISTRY

Syllabus & Examination Scheme (NEP 2020)

I - II Semester 2025-26

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

(Autonomous)

BACHELOR OF SCIENCE

Chemistry Semester I

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHE101	Chemical bonding, Chemistry of s - block & p - block elements, , Mathematical concepts, States of matter and Nuclear Chemistry	100	4	3	-
BCHEP 151	Chemistry Lab I	50	2	-	4
Total		150	6		

* 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. Semester I

1 credit- 25 marks

4 credit- 100 marks

Question paper: 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. The objective of this course is to explain the basic concepts of mathematics and to explain the structural differences and transformations between states of matter. In addition, the laboratory course is designed to provide students with practical experience in basic qualitative analytical techniques, the use of laboratory techniques, and the determination of physical properties of matter.

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, mathematical concepts, and states of matter. Students will also have practical experience in calibration of glassware, qualitative analysis of radicals, identification of functional groups in organic compounds, determination of various physical properties of substances, crystallization and preparation of standard solutions of different concentrations

Marks distribution in question paper:

The question paper (EoSE – End of Semester Examination) will consist of two parts: Part A and Part 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 of question no 2 to question no.5. There will be one question from each unit with internal choice. Each question will carry 14 marks.

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Chemical bonding, Chemistry of s -block & p - block elements, , Mathematical concepts, States of matter and Nuclear Chemistry

Unit-I

Ionic Solids: Ionic structures, Radius ratio rule and its effect and coordination number, Limitations of radius ratio rule, Lattice defects, Semiconductors, Lattice energy and Born-Haber cycle, Solvation energy and solubility of ionic solids, Polarizing power and polarisability of ions, Fajan's rule.

Metallic bond: Free electron theory, Valence bond theory and Band theory.

Weak Interactions: Hydrogen bonding, Van der Waals forces.

Periodicity of s and p-block elements:

Effective nuclear charge, Shielding or screening effect, Slater rules, Variation of effective nuclear charge in periodic table. Atomic radii (Van der Waals), Ionic and crystal radii, Covalent radii (octahedral and tetrahedral). Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. Electron gain enthalpy, Trends of electron gain enthalpy. Electronegativity, Pauling's/Mulliken's/Allred-Rochow's and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, Partial charge, Hybridization, Group electronegativity. Sanderson's electron density ratio.

s-Block Elements: Comparative study of properties of alkali and alkaline earth metals, Diagonal relationships, Salient features of hydrides, Solvation and complexation tendencies including their functions in biosystems, An introduction to alkyls and aryls.

Unit-II

Covalent Bond: Valence bond theory and its limitations, Directional characteristics and shapes of simple inorganic molecules and ions. Valence shell electron pair repulsion (VSEPR) theory to NH_3 , H_3O^+ , SF_4 , ClF_3 , ICl_2 , H_2O .

Molecular Orbital Theory: Homonuclear and heteronuclear (CO and NO) diatomic molecules. Multicenter bonding in electron deficient molecules, Bond strength and bond energy, Percentage ionic character from dipole moment and electronegativity difference.

Periodicity in properties of p-block elements with special reference to atomic and ionic radii, Ionization energy, Electron-affinity, Electronegativity, Diagonal relationship, Catenation.

Some Important Compounds of p-block Elements: Hydrides of boron, Diborane and higher boranes, Borazine, Borohydrides, Fullerenes, Carbides, Fluorocarbons, Silicates (structural principle), Tetrasulphur tetranitride, Basic properties of halogens, Interhalogens and polyhalides

Unit-III

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: Intermolecular forces, Structure of liquids (a qualitative description). Structural differences between solids, liquids and gases. Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of smectic, nematic and cholesteric phases. Thermography and seven segment cells.

Solid State: Definition of space lattice, 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.

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.), Band theory of solids, Defects in solids.

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Unit-IV

Gaseous States: Postulates of kinetic theory of gases, Deviation from ideal behavior, Van der Waals equation of state.

Critical Phenomenon: PV isotherms of real gases, Continuity of states, the isotherms of Van der Waals equation, Relationship between critical constants and Van der Waals constants, the law of corresponding states, Reduced equation of state.

Molecular Velocities: Root mean square, average and most probable velocities. Qualitative discussion of the Maxwell's distribution of molecular velocities, Collision number, Mean free path and collision diameter. Liquification of gases (based on Joule-Thomson effect.)

Nuclear Chemistry: Fundamental particles of nucleus (nucleons), concept of nuclides and its representation, Isotopes, Isobars and Isotones (with specific examples), forces operating between nucleons (n-n, p-p & n-p), Qualitative idea of stability of nucleus (n/p ratio).

Radiochemistry: Natural and artificial radioactivity, Radioactive disintegration series, Radioactive displacement law, Radioactivity decay rates, Half-life and average life, Nuclear binding energy, Mass defect and calculation of defect and binding energy, Nuclear reactions, Spallation, Nuclear fission and fusion. Brief discussion on atom bomb, Nuclear reactor and Hydrogen atom.

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.
Essentials of Nuclear Chemistry by H.J. Arnikar, New Age International Publishers.
7. Chemical Kinetics by Keith J. Laidler, Pearson Education.
8. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma & M. S. Pathania, Vishal Publishing Co.
9. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
10. Physical Chemistry by W. Atkins, Oxford University Press.
11. Physical Chemistry by R. J. Silby and R. A. Alberty, John Wiley & Sons.
12. Physical Chemistry by G.M. Barrow, Tata McGraw-Hill.
13. A Textbook of Physical Chemistry: (Volume I) by K. L. Kapoor, Macmillan India Ltd.

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Chemistry Lab I

1 credit- 25 marks

2credit- 50 marks

External Assessment: 30 marks

Internal Assessment: 20 marks

Inorganic Chemistry

7 marks

1. Volumetric Analysis

- Estimation of hardness of water by EDTA.
- Estimation of ferrous/ferric ions by dichromate/permanganate method.
- Estimation of copper using thiosulphate by iodometric method.
- Determination of quantity of acetic acid in commercial vinegar using standard NaOH solution.
- Determination of alkali content in antacid tablet using standard HCl solution.
- Estimation of calcium content in chalk as calcium oxalate by permanganometry.

Organic Chemistry

5 marks

2. A. Laboratory Techniques

- Determination of melting point (naphthalene, benzoic acid, urea etc.); boiling point (methanol, ethanol, cyclohexane, etc.); mixed melting point (urea- cinnamic acid) using Thiele's tube.
- Crystallization of phthalic acid and benzoic acid from hot water, acetanilide from boiling water, naphthalene from ethanol. Sublimation of naphthalene, camphor etc.

B. Qualitative Analysis

Identification of functional groups (unsaturation, phenolic, alcoholic, carboxylic, carbonyl, ester, carbohydrate, amine, amide, nitro, etc.) in simple organic compounds (solids or liquids) through element detection (N, S and halogens).

Physical Chemistry

8 marks

3. Viscosity and Surface Tension:

- To determine the viscosity/surface tension of a pure liquid (alcohol etc.) at room temperature. (Using the Ostwald Viscometer/Stalagmometer, respectively.).
- To determine the percentage composition of a given binary mixture (acetone and ethyl methyl ketone) by surface tension method.
- To determine the percentage composition of a given binary mixture (non- interacting systems) by viscosity method.
- To determine the viscosity of amyl alcohol in water at different concentrations (change in viscosity due to intermolecular interactions and calculate the excess viscosity of these solutions.)

4. Viva voce

5 marks

5. Practical Record

5 marks

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Suggested Books and References:

- 1.Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall.
- 2.Vogel's Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, ELBS.
- 3.Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd.
- 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.Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International, N
- 7.Advanced Practical Organic Chemistry J. B Yadav, Goel Publishing House.
- 8.Practical Physical Chemistry, by B. D Khosla, S. Chand & Company.

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BACHELOR OF SCIENCE

Chemistry Semester II

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHE201	Reaction mechanism, Aromatic and Aliphatic hydrocarbons, Stereochemistry, Aromaticity and Alkyl & Aryl halides	100	4	3	-
BCHEP 251	Chemistry Lab II	50	2	-	4
Total		150	6		

* EoSE = End of Semester Examination

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

Note:

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

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B.Sc. Semester II

1 credit- 25 marks

4 credit- 100 marks

Question paper: 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 aromatic hydrocarbons, and to explain the order and molecularity of the reactions, the rate law and order of reactions determination. In addition, the laboratory course is designed to provide students with practical experience in basic quantitative analytical techniques including volumetric analysis, qualitative analytical techniques, and the determination of kinetic parameters of reactions.

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 order and molecularity of reactions, rate law and methods determining order and kinetic parameters of reactions. Students will also have practical experience in quantitative analytical techniques including volumetric analysis, identification of organic compounds by determination of functional groups, 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 to question no.5.

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

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Reaction mechanism, Aromatic, Aliphatic hydrocarbons, Stereochemistry, Aromaticity, Alkyl & Aryl halides and Chemical kinetics

Unit-I

Fundamentals of Organic Chemistry: Classification and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties of organic compounds. Electronic Displacements: Inductive, Electromeric, Resonance and Mesomeric effects, Hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic bond fission with suitable examples. Curly arrow rules, Formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity.

Mechanism of Organic Reactions: Reaction intermediates: Types, shapes and relative stability; Carbocations, Carbanions, Free radicals, Carbenes, Nitrenes and Benzyne (Arynes). Types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. Markovnikov rule, Anti- Markovnikov rule, Saytzeff's rule and Hofmann elimination. Energy considerations. Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).

Aliphatic Hydrocarbon: Alkanes and Cycloalkanes; Free radical halogenation of alkanes; mechanism, orientation, reactivity and selectivity. Cycloalkanes - nomenclature, methods of formation, chemical reactions. Baeyer's strain theory and its limitations. Theory of strain less rings.

Alkenes; Relative stabilities of alkenes. Chemical reactions of alkenes - hydroboration-oxidation, oxymercuration-reduction, epoxidation, ozonolysis and oxidation with $KMnO_4$, Polymerization of alkenes, Substitution at the allylic and vinylic positions of alkenes.

Unit-II

Stereochemistry of Organic Compounds: Concept of isomerism, Types of isomerism, Difference between configuration and conformation, Flying wedge and Fischer projection formulae.

Optical Isomerism: Elements of symmetry, Molecular chirality, Enantiomers, Stereogenic centre, Optical activity. Properties of enantiomers, Chiral and achiral molecules with two stereogenic centres. Diastereomers, Threo and Erythro isomers, Meso compounds. Resolution of enantiomers. Inversion, Retention and racemization (with examples).

Relative and absolute configuration, Sequence rules, D-L and R-S systems of nomenclature.

Geometrical Isomerism: Determination of configuration of geometric isomers; cis-trans and E-Z systems of nomenclature. Geometrical isomerism in oximes and alicyclic compounds.

Conformational Isomerism: Newman projection and Sawhorse formulae, Conformational analysis of ethane, *n*-butane and cyclohexane.

Cycloalkenes, Dienes and Alkynes: Classification and nomenclature of isolated, conjugated and cumulated dienes. Structure of allenes and butadiene. Methods of formation, properties and chemical reactions - 1,2- and 1,4- additions, Diels-Alder reaction and polymerization reactions.

Structure and bonding of alkynes, Synthetic methods, Chemical reactions - acidity of alkynes, Mechanism of electrophilic and nucleophilic addition reactions: hydroboration-oxidation, metal-ammonia reduction, oxidation and polymerization.

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Unit-III

Arenes and Aromaticity: Nomenclature of benzene derivatives: The aromatic nucleus, aryl group, and side chain, Structure of benzene: molecular formula and Kekule structure, Stability and carbon-carbon bond lengths of benzene, Resonance structure, MO diagram.

Aromaticity: Huckel's rule, aromatic ions-three to eight membered.

Aromatic electrophilic substitution: General pattern of the mechanism, role of sigma and pi complexes, Mechanism of nitration, halogenation, sulphonation, mercuration, chloromethylation and Friedel crafts reactions, Energy profile diagrams, Activating and deactivating substituents, Directive influence, orientation and ortho/para ratio. Side chain reactions of benzene derivatives, Birch reduction.

Alkyl Halides: Synthetic methods of alkyl halides, Chemical reactions, Mechanisms of nucleophilic substitution reactions of alkyl halides, S_N2 and S_N1 reactions with energy profile diagrams.

Polyhalogen compounds: Chloroform, Carbon tetrachloride

Aryl Halides: Methods of formation of aryl halides, Nuclear and side chain reactions, The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions, Relative reactivities of alkyl, vinyl, allyl and aryl halides.

Unit-IV

Chemical Kinetics: Chemical kinetics and its scope, Rate of a reaction, Factors influencing the rate of a reaction: concentration, temperature, pressure, solvent, light, catalyst. Concentration dependence of rates, Mathematical characteristics of simple chemical reactions - zero order, first order, second order and pseudo-order; Half-life and mean-life. Determination of the order of reaction - differential method, Method of integration, Method of half-life period and isolation method. Radioactive decay as a first order phenomenon.

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.

Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects.

Chemistry of Noble Gases: Chemical properties of the noble gases, Chemistry of Xenon, Structure and bonding in Xenon compounds.

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Suggested Books and References:

1. Concise Inorganic Chemistry by J.D. Lee, Wiley.
2. Inorganic Chemistry: Principles of Structure and Reactivity by Ellen A. Keiter, James E. Huheey and Richard L. Keiter, Pearson.
3. Organic Chemistry by S. S. Gupta, Oxford University Press.
4. Organic Reaction Mechanisms by V. K. Ahluwalia and Rakesh Kumar Parashar, Narosa Publishing House, New Delhi.
5. Organic Chemistry – Reactions and Reagents: Covering Complete Theoretical Organic Chemistry by O. P Agarwal, Goel Publishing House, Meerut.
6. Organic Chemistry by R. T. Morrison and R. N. Boyd, Prentice Hall.
7. Organic Chemistry by I. L. Finar (Vol. I & II), ELBS.
8. Advanced Organic Chemistry by A. Bahl and B. S. Bahl, S. Chand.
9. Modern Organic Chemistry by M.K. Jain and S. C. Sharma, Vishal Publishing Co.
10. March's Advanced Organic Chemistry: Reactions,
11. Mechanisms and Structure by J. March and M. B. Smith, Wiley. Mechanism in Organic Chemistry by Peter Sykes, Pearson Education.
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. A Textbook of Physical Chemistry by K. L. Kapoor (Volume 5), Macmillan India Ltd.
15. Chemical Kinetics and Reaction Dynamics by Santosh K. Upadhyay, Springer (Anamaya Publishers, New Delhi, India).

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Chemistry Lab II

1 credit- 25 marks

2 credit- 50 marks

External Assessment: 30 marks

Internal Assessment: 20 marks

Inorganic Chemistry

7 marks

1. Qualitative Analysis

Separation and identification of six radicals (three cations and three anions) in the given inorganic mixture including special combinations of anions.

Organic Chemistry

5 marks

2. (a) Synthesis of semi carbazones of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
- (b) Synthesis of 2,4-dinitrophenylhydrazones of any aldehyde /ketone.
- (c) Synthesis of Coumarin through salicylaldehyde.
- (d) Synthesis of 3,5- dinitro benzoic acid using benzoic acid and nitrating reagent

OR

- (a) Chromatography separation of the active ingredients of plants (spinach etc.), flowers and juices by Paper/Thin layer chromatography (TLC).
- (b) Separation and identification of the monosaccharides in the given mixture by Paper/Thin layer chromatography (TLC) and reporting the R_f values.
- (c) Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.

Physical Chemistry

8 marks

3 Chemical Kinetics:

- (a) To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at room temperature.
- (b) To study the effect of acid strength on the hydrolysis of an ester.
- (c) To compare the strengths of HCl and H₂SO₄ by studying the kinetics of hydrolysis of ethyl acetate.
- (d) To study the oxidation of iodide ions by H₂O₂ as an iodine clock reaction.
- (e) To study the decomposition of H₂O₂ catalyzed by iodide ions.
- (f) To study the kinetics of reaction between acetone and iodine in presence of an acids.

4. Viva voce

5 marks

5. Practical Record

5 marks

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2. Vogel's Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, ELBS.
3. Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd.
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. Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International, N
7. Advanced Practical Organic Chemistry J. B Yadav, Goel Publishing House.
8. Practical Physical Chemistry, by B. D Khosla, S. Chand & Company.
9. Advanced Practical Organic Chemistry by Amit Arora, Discovery Publishing House, New Delhi.

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**S. S. Jain Subodh P.G. College, Jaipur
(Autonomous)**

Bachelor of Science (B.Sc.)
(Three Year Under Graduate Programme)

CHEMISTRY

Examination Scheme & Syllabus (NEP 2020)

**Semester III & IV
2026-27**

**S. S. Jain Subodh P.G. College, Jaipur
(Autonomous)**

BACHELOR OF SCIENCE (B. Sc.)

Semester III

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHE301	Chemistry of Transition elements, Lanthanides & Actinides, Chemistry of Alcohols, Phenols, Ethers, Epoxides, Aldehydes & Ketones, Basic Enolate Chemistry, Thermodynamics I, Thermochemistry and Chemical Equilibria.	100	4	3	-
BCHEP 351	Chemistry Lab III	50	2	-	4
Total		150	6		

*** 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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BACHELOR OF SCIENCE (B. Sc.)

Semester III

COURSE OUTCOMES:

Student will be able to:

CO1: explain the characteristic properties, oxidation states, coordination chemistry, magnetic behavior, and spectral properties of transition elements, lanthanides, and actinides, including their comparative chemistry and applications.

CO2: describe the classification, preparation, properties, and reaction mechanisms of alcohols, phenols, ethers, and epoxides, and apply their chemical transformations in organic synthesis.

CO3: analyze the structure, preparation, and reactions of aldehydes, ketones, and enolate compounds, and explain important organic reaction mechanisms and synthetic applications

CO4: apply the principles of thermodynamics, thermochemistry, chemical equilibrium, equilibrium to evaluate energy changes, equilibrium constants, acid–base behavior, buffer systems, and solubility phenomena.

CO5: correlate concepts from inorganic, organic, and physical chemistry to understand chemical properties, reaction mechanisms, and quantitative relationships in chemical systems.

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BACHELOR OF SCIENCE (B. Sc.)

Semester III

BCHE301

60 Hours

Chemistry of Transition Elements, Lanthanides & Actinides, Chemistry of Alcohols, Phenols, Ethers, Epoxides, Aldehydes & Ketones, Basic Enolate Chemistry, Thermodynamics I, Thermochemistry and Chemical Equilibria.

Unit I

Chemistry of Elements of First Transition Series:

Characteristic properties of d-block elements. Properties of the elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation-states, coordination number and geometry.

Chemistry of Elements of Second and Third Transition Series:

General characteristics, comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states, magnetic behaviour, spectral properties and stereochemistry.

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

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 $[Pb(OAc)_4]$ 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.

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

Unit III

Aldehydes and Ketones:

Structure of the carbonyl group. Synthesis: aldehydes from acid chlorides, ketones from nitriles and carboxylic acids and aldehydes & 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 IV

Thermodynamics I:

Definition of Thermodynamic Terms:

System & surrounding, types of systems, intensive and extensive properties. State and path functions and their differentials. Thermodynamic process, concept of heat and work.

First Law of Thermodynamics:

Statement, definition of internal energy and enthalpy, heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law, Joule-Thomson coefficient and inversion temperature. Calculation of w , q , dU & dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry:

Standard state, standard enthalpy of formation, Hess's law of heat summation and its applications. Heat of reaction at constant pressure and constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, temperature dependence of enthalpy. Kirchhoff's equation.

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.

Suggested Books and References:

- 1 Concise Inorganic Chemistry by J.D. Lee, Wiley, India.
- 2 Inorganic Chemistry by Housecroft, E. Catherine & Sharpe, G Alan, Pearson Education Ltd.
- 3 Advanced Inorganic Chemistry by G. D. Tuli, S. Chand, New Delhi.

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- 4 Advanced Inorganic Chemistry by Satya Prakash, S. Chand, New Delhi.
- 5 Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
- 6 Organic Chemistry by R. T. Morrison & R. N. Boyd, Prentice Hall
- 7 Organic Chemistry by I. L. Finar, (Vol. I & II) Elbs.
- 8 A Text Book of Physical Chemistry: A. S. Negi and S. C. Anand, New Age International Publishers.
- 9 Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
- 10 Elements of Physical Chemistry, P. Atkins and J. De Paula, Oxford Press.
- 11 A Textbook of Physical Chemistry, Application of Thermodynamics, by K. L. Kapoor, (Volume- 3) Tata Mc. Graw Hill.

Syllabus

BCHEP 351:

Chemistry Lab III

(4 Hrs./week)

Inorganic Chemistry (Any three)

10 marks

Gravimetric estimations:

- (a) Estimate Zinc as Zinc ammonium phosphate.
- (b) Estimate Lead as Lead chromate.
- (c) Estimate Copper as Cuprous thiocyanate.
- (d) Estimate Nickel as Nickel dimethyl glyoximate.

Volumetric Estimations:

- (a) Determine the strength of Potassium permagnate 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.

Organic Chemistry

15 marks

Qualitative Analysis:

- (a) Identification of organic compound (solids or liquids) through element detection (N, S and halogens) melting /boiling points, functional group analysis with the preparation of suitable derivative.
- (b) **One step organic involving: (Any two)**
 - i. **Bromination**
 - (a) P-bromacetanalide from Acetanilide

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- (b) Tribromo aniline from aniline
- (c) Tribromo phenol from phenol

ii. Reduction:

- (a) m -nitro aniline from m -dinitrobenzene.
- (b) Anthrone by anthraquinone

iii. Electrophilic substitution Reactions

m-dinitrobenzene from nitrobenzene

Physical Chemistry (Any three)

10 marks

- (a) To determine partition coefficient of iodine between water and $CCl_4/CHCl_3/CS_2$ at room temperature.
- (b) To study the distribution of benzoic acid between benzene and water.
- (c) Determine the velocity constant and order of reaction for the hydrolysis of ethyl acetate by sodium hydroxide at room temperature (saponification of an ester).
- (d) To determine heat of neutralization of given acid and base.
- (e) To determine the dissociation energy of given weak acid.
- (f) To determine the molecular mass of given non-volatile substance cryscopically.

Viva-Voce

8 marks

Practical Record

7 marks

Suggested Books and References:

1. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt. Ltd.
2. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. University Press, Hyderabad.
3. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House Pvt. Ltd.
4. Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.
5. Vogel's Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, Elbs.
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.
8. Advanced Practical Organic Chemistry J. B Yadav, Goel Publishing House.
9. Practical Physical Chemistry, by B. D Khosla, S. Chand & Company.

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BACHELOR OF SCIENCE (B. Sc.)

Semester IV

EXAMINATION SCHEME

Paper code	Paper Title	Maximum Marks	Credit	EoSE* in Hrs.	
				Theory	Practical
BCHE401	Coordination Chemistry, Metal-Ligand Bonding & Magnetic properties of Transition Metal Complexes, Carboxylic Acids & their derivatives & Organic compounds of Nitrogen, Carbohydrates, Electrochemistry I and Thermodynamics II.	100	4	3	-
BCHEP 451	Chemistry Lab IV	50	2	-	4
Total		150	6		

* 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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BACHELOR OF SCIENCE (B. Sc.)

Semester IV

COURSE OUTCOMES:

Student will be able to:

CO1: explain the principles of coordination chemistry, including Werner's theory, bonding theories, crystal field splitting, magnetic behavior, and the determination of magnetic properties of transition metal complexes.

CO2: describe the structure, preparation, properties, and reactions of carboxylic acids and their derivatives, and explain mechanisms of important organic transformations involving acyl compounds.

CO3: explain the preparation, structure, properties, and reactions of nitrogen-containing organic compounds and carbohydrates, including reaction mechanisms, stereochemistry, and structural elucidation of biomolecules.

CO4: apply the electrolytic principals to calculate specific conductance and equivalent conductance. Apply the laws of thermodynamics to analyze physical and chemical processes and predict the spontaneity, feasibility & equilibrium of chemical reactions.

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

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BACHELOR OF SCIENCE (B. Sc.)

Semester IV

BCHE401

60 Hours

Coordination Chemistry, Metal-Ligand Bonding & Magnetic properties of Transition Metal Complexes, Carboxylic Acids & their derivatives & Organic Compounds of Nitrogen, Carbohydrates, Electrochemistry I and Thermodynamics II.

Unit I

Coordination Chemistry:

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

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.

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.

Unit II

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 (including 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).

Unit III

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 and alkaline media. Picric acid.

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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 and 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.

Carbohydrates:

Introduction, classification, constitution and reaction of glucose and fructose, Mutarotation and its mechanism, cyclic structure: pyranose and furanose forms, Haworth projection formulae, Configuration of monosaccharides, Determination of ring size, Conformational analysis of monosaccharides, Epimerization, Chain lengthening and chain shortening in aldoses. Interconversion of aldoses and ketoses.

Disaccharides: Structure determinations of maltose, lactose and sucrose.

Polysaccharides: Structure of starch and cellulose, glycosidic linkages.

Unit IV

Electrochemistry – I:

Electrical 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 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 and its determination by Hittorf's method and moving boundary method. Applications of conductivity measurements: Determination of degree of dissociation, determination of K_a of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

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. Gibbs and Helmholtz functions: Gibbs 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.

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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. Concise Coordination Chemistry by R. Gopalan and V. Ramalingam, Vikas Publishing House Pvt, Ltd.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J March, & M. B Smith Wiley.
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 Publishing House.
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. Elements of Physical Chemistry, P. Atkins and J. De Paula, Oxford Press.
13. A Textbook of Physical Chemistry, Application of Thermodynamics, by K. L. Kapoor, (Volume-3) Tata McGraw Hill.
14. Physical Chemistry by G.M Barrow, Tata McGraw-Hill.
15. Solutions, Phase Equilibrium, Conductance & Electrochemistry by Puri, Sharma, Pathania and Kaur, Vishal Publishing Co.
16. Textbook of Physical Chemistry, (Volume 5) by Kapoor, K. L Macmillan India Ltd.

Syllabus

BCHEP451

Chemistry Lab IV

4 Hrs./week

Inorganic Chemistry (Any Three)

10 marks

Inorganic Preparations:

- (a) Preparation of tetraamminecopper(II) sulphate
- (b) Preparation of cis- and trans-potassium diaquadioxalatochromate(III).
- (c) Synthesis of sodium trioxalatoferrate(III).
- (d) Preparation of bis(dimethylglyoximate)nickel (II).

Organic Chemistry (Any Three)

15 marks

Organic Syntheses:

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- (a) Synthesis of iodoform from ethanol and acetone (Aliphatic Electrophilic Substitution).
- (b) Synthesis of osazones from carbohydrate.
- (c) Synthesis of 2, 4 dinitrophenylhydrazone from carbonyl compound.
- (d) Synthesis of phthalimide from phthalic anhydride.
- (e) Synthesis of succinic anhydride.

Physical Chemistry (Any Three)

10 marks

- (a) Determination of transition temperature of the given substance ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$, $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ or $\text{SrBr}_2 \cdot 6\text{H}_2\text{O}$) by thermometric method.
- (b) To construct the phase diagram of two component system like phenol- H_2O system and determine the CST (critical solution temperature) and composition of the solution at CST.
- (c) To study the effect of solute NaCl and succinic acid etc. on the CST (critical solution temperature) of two partially miscible liquids (phenol- H_2O system) and determine the concentration of that solute in the given partially miscible liquid system.
- (d) Preparation of different types of buffer solutions and determination of pH using pH meter.

Viva voce

8 marks

Practical Record

7 marks

Suggested Books and References:

1. A. I. Vogel, Vogel's Qualitative Inorganic Analysis, Prentice Hall.
2. Vogel's Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, Elbs.
3. Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd.
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. Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International, New Delhi
7. Advanced Practical Organic Chemistry J. B Yadav, Goel Publishing House.
8. Practical Physical Chemistry, by B. D Khosla, S. Chand & Company.