

B. Sc. (Hons.) Courses

Students admitted to 3-year B. Sc. (Hons.) course of the Banaras Hindu University have to choose any one combination of 3-subjects. The subject-combinations, which have Chemistry as one of the subjects, are

(A) In the Faculty of Science (Male and Female both)

- (i) Physics, Mathematics, Chemistry,
- (ii) Botany, Zoology, Chemistry,
- (iii) Botany, Geology, Chemistry, and
- (iv) Geology, Geography, Chemistry

(B) In Mahila Maha Vidyalaya (MMV) (Female only)

- (i) Physics, Mathematics, Chemistry
- (ii) Botany, Zoology, Chemistry
- (iii) Zoology, Chemistry, Psychology
- (iv) Botany, Home Science, Chemistry

B.Sc. (Hons.) CHEMISTRY Syllabi

(Effective from Session 2000-2001)

(A) Theory Papers:

B.Sc. Part I	Marks
BCH-101 : Inorganic Chemistry	50
BCH-102 : Organic Chemistry	50
BCH-103 : Physical Chemistry	<u>50</u>
	<u>150</u>
B.Sc. Part II	
BCH-201 : Inorganic Chemistry	50
BCH-202 : Organic Chemistry	50
BCH-203 : Physical Chemistry	<u>50</u>
	<u>150</u>
B.Sc. Part III	
BCH-301 : Analytical Chemistry	75
BCH-302 : Inorganic Chemistry	75
BCH-303 : Organic Chemistry	75
BCH-304 : Biomolecules, Polymers, and Drugs	75
BCH-305 : Physical Chemistry	75
BCH-306 : Physical Chemistry - A Molecular Approach	<u>75</u>
	<u>450</u>

(B) Practicals

B. Sc. Part I

<u>Section A (Quantitative)</u>	<u>Marks</u>	<u>Section B (Qualitative)</u>	<u>Marks</u>
Physical	8	Inorganic Mixtures	10
Volumetric	7	Organic	5
Viva	5	Viva	5
Sessional	5	Sessional	5
	<u>25</u>		<u>25</u>

B. Sc. Part II

<u>Section A (Quantitative)</u>	<u>Marks</u>	<u>Section A (Qualitative)</u>	<u>Marks</u>
Physical	8	Inorganic Mixtures	10
Volumetric	7	Organic	5
Viva	5	Viva	5
Sessional	5	Sessional	5
	<u>25</u>		<u>25</u>

B. Sc. Part III

<i>Section A</i> :	Physical	50
<i>Section B</i> :	Inorganic	50
<i>Section C</i> :	Organic	<u>50</u>
		<u>150</u>

Note : Separate examinations will be held for each section of practical.

B.Sc. (Hons.) Part I

BCH-101 : Inorganic Chemistry

Marks : 50

1. **Atomic Structure** : Idea of de Broglie matter waves. Heisenberg uncertainty principle. Schrödinger wave equation, significance of wave functions, Atomic orbitals. Quantum numbers. Aufbau and Pauli exclusion principles. Hund's multiplicity rule. Variation of orbital energies with atomic number and energy level diagram, electronic configuration of elements, effective nuclear charge and shielding; radial and angular wave functions and distribution curves, shape of s,p,d orbitals and their characteristics. 10
2. **Periodic Properties** : Atomic and ionic radii, ionization energy, electrode potential (use of redox potential-reaction feasibility), electron affinity and electronegativity – definition, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour. 10
3. **Chemical Bonding** : (i) **Ionic Bond** – Types of ionic solids, radius ratio effect and coordination number, limitations of radius ratio, lattice defects, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarizability, Fajan's rules. 6
(ii) **Covalent Bond** : Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions such as NH₃, H₃O⁺, SF₄, ClF₃, ICl₂⁻, and H₂O by valence shell electron pair repulsion (VSEPR) theory, linear combination of atomic orbitals (LCAO), bonding, nonbonding and antibonding molecular orbitals. Applications of MO theory to explain the stability of homo and hetero dinuclear diatomic molecules, multi-centre bonding in electron-deficient molecules. 12
(iii) **Bond Energy** : Dissociation and average bond energies – determination, periodic trends and applications. Metallic Bond : Free electron, valence bond and band theories. Weak Interactions: Hydrogen Bond – experimental evidence, van der Waal's forces. 4
4. **s-Block Elements** : Hydride (classification, general methods of preparation and salient features), hydration energies, solvation and complexation tendencies of alkali and alkaline-earth metals, principle of metallurgical extraction, Chemistry of Li and Be, their anomalous behaviour and diagonal relationships, alkyls and aryls; role in biology. 8
5. **p-Block Elements** : Comparative study (group-wise) of group 13 & 14 elements with respect to periodic properties. Compounds such as hydrides, halides, oxides and oxyacids; diagonal relationship; preparation, properties, bonding and structure of diborane, borazine and alkalimetal borohydrides. Preparation, properties and technical applications of carbides and fluorocarbons. Silicones and structural principles of silicates. 10

Books Recommended

1. "A New Concise Inorganic Chemistry", **J. D. Lee**, 5th Edition (1996), Chapman & Hall, London.
2. "Modern Inorganic Chemistry", **R. C. Aggarwal**, 1st Edition (1987), Kitab Mahal, Allahabad.
3. "Basic Inorganic Chemistry", **F. A. Cotton, G. Wilkinson, and Paul L. Gaus**, 3rd Edition (1995), John Wiley & Sons, New York.

1. **Structure and Reactivity** : Atomic orbitals, hybridization, orbital representation of methane, ethane, ethene, ethyne and benzene; polarity of bonds – inductive, resonance and steric effects and their influence on acidity and basicity of organic compounds. 6
2. **Organic reaction mechanisms** : Heterolytic and homolytic cleavage, nucleophiles, electrophiles and free-radicals; substitution, addition and elimination reactions; energy profile diagrams-transition states (general considerations). 5
3. **Alkanes** : Conformations of ethane and n-butane; mechanism of chlorination of methane. 3
4. **Alkyl halides** : Preparation and reactions, SN1 and SN2 mechanisms. Grignard reagents- preparation and synthetic applications. 5
5. **Alkenes** : E1 and E2 mechanisms, Elimination versus substitution reactions, Addition reactions (electrophilic and free radical), Hydration, hydroxylation, hydroboration, epoxidation and ozonolysis. 6
6. **Dienes** : Conjugated and isolated dienes, resonance stabilization, 1,2-versus 1,4-addition, Diels-Alder reaction. 3
7. **Alkynes** : Reduction, electrophilic addition, acidity and metal acetylides. 2
8. **Alcohols** : Comparative study of dehydration, oxidation, substitution and esterification of primary, secondary and tertiary alcohols. 4
9. **Aldehydes and Ketones** : Nucleophilic addition reactions, aldol condensation, Cannizzaro reaction, oxidation and reduction, Haloform reaction. 6
10. **Aliphatic Carboxylic Acids** : General preparation and reactions of mono- and di-carboxylic acids. 3
11. **Polymers and Polymerization** : Elementary treatment - Alkene polymerization and condensation polymers – polyethylenes, nylons and terylene. 4
12. **Active methylene compounds** : Preparation and synthetic applications of ethyl acetoacetate and diethyl malonate, Tautomerism. 6
13. **Stereochemistry** : Fischer, saw-horse and Newman projection formulae. Chirality-optical activity, enantiomerism and diastereoisomerism involving one and two chiral centers, configuration, geometrical isomerism, D/L, R/S and E/Z nomenclatures. 7

Books Recommended

1. “Organic Chemistry”, **R. T. Morrison and R. N. Boyd**, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
2. “Organic Chemistry”, **S. M. Mukherjee, S. P. Singh, and R. P. Kapoor**, 1st Edition (1985), New Age International (P) Ltd. Publishers, New Delhi.
3. “Organic Chemistry – Structure and Reactivity”, **Seyhan N. Ege**, 3rd Edition (1998), AITBS Publishers and Distributors, Delhi.
4. “Organic Chemistry”, **Paula Y. Bruice**, 2nd Edition, Prentice-Hall, International Edition (1998).

1. **Gaseous State** : Kinetic theory of gases, ideal gas laws and kinetic theory. Collision in a gas- mean free path, collision diameter, collision number. Behaviour of real gases - the van der Waal's equation, brief mention of other equations of state. Critical phenomena - critical constants of a gas and their determination, continuity of state, the van der Waals equation and critical state, Principle of corresponding states, liquefaction of gases. 8

2. **Liquid State** : Surface tension of liquids, capillary action, surface tension and temperature, interfacial tension, surface active agents, the Parachor and chemical constitution (atomic and structural parachors). Viscosity of liquids, experimental determination of viscosity coefficient, its variation with temperature. 6

3. **Thermodynamics** : Introduction of different terms and processes in thermodynamics : [systems (isolated, closed, open) and surrounding, macroscopic properties (extensive and intensive), kinds of processes], First Law of thermodynamics and internal energy, state and state functions (exact differential), sign convention for heat and work, nature of work, path dependence of work and heat. Enthalpy, heat changes at constant volume and constant pressure, heat capacities (C_v , C_p) and relation between them for ideal gases.

Reversible and irreversible processes, maximum work, thermodynamic quantities (w , q , ΔU , ΔH) for isothermal and adiabatic reversible expansion of ideal gases. Ideal gas law for adiabatic reversible expansion, comparison of adiabatic and isothermal reversible expansion. Joule-Thomson effect, Joule-Thomson coefficient in ideal and real (van der Waal) gases, inversion temperature.

Change in internal energy (ΔU) and enthalpy (ΔH) of chemical reactions, relation between ΔU and ΔH , variation of heat of reaction with temperature (Kirchhoff's equation). 15

4. **Electrochemistry** : Arrhenius theory of electrolytic dissociation, classification of electrolytes; Hydrolysis of salts, hydrolysis constant, buffer solutions, indicators and theory of acid-base indicators.

Migration of ions : transference number and its determination (Hittorf and Moving Boundary methods). Conductance of solutions, variation of molar conductance with concentration (Kohlrausch square root law), Kohlrausch law of independent migration of ions, ionic mobility, hydration of ions, application of conductance measurements (degree of dissociation of weak electrolytes, dissociation constant of weak acids, determination of solubility of sparingly soluble salts, degree of dissociation of water, conductometric titrations). 15

5. **Chemical Kinetics** : Order and molecularity of a chemical reaction, basic kinetic laws of first and second order reactions, analysis of kinetic data for the determination of the rate constant and order, effect of temperature on reaction rates (Arrhenius equation), collision theory of rates of bimolecular reactions. 6

6. **Nuclear Chemistry** : Isotopes : their separation and applications. Nuclear forces, nuclear binding energy, stability of nucleus, energy changes in nuclear reactions, Bethe notation, nuclear fission and fusion. Uses of nuclear radiations (radiation, sterilization, radiation energy for chemical synthesis). Radio isotopes as a source of electricity. 10

Books Recommended

1. "Physical Chemistry", **P. C. Rakshit**, 5th Edition (1988), 4th Reprint (1997), Sarat Book House, Calcutta.
2. "Principles of Physical Chemistry", **B. R. Puri, L. R. Sharma, and M. S. Pathania**, 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.
3. "Physical Chemistry", **K. J. Laidler and J. M. Meiser**, 3rd Edition, Houghton Mifflin Comp., New York, International Edition(1999).

B.Sc.(Hons.) Part II

BCH-201 : Inorganic Chemistry

Marks : 50

1. **Acids and Bases** : Arrhenius, Brønsted-Lowry, Luxflood, Solvent System and Lewis concepts of acids and bases. Factors affecting strengths of Lewis acids and bases. 7
2. **Non-aqueous Solvents** : Physical properties of a solvent for functioning as an effective reaction medium. Types of solvents and their general characteristics. Reactions in liquid ammonia and liquid sulfur dioxide. 7
3. **Chemistry of p-block elements (Groups 15, 16, 17 and 18)** : Group trend in periodic properties, hydrides, oxides, oxyacids and halides. Structures of oxides and oxyacids of nitrogen, phosphorus, sulphur, selenium, tellurium and halogens. Chemistry of cyclophosphazines and tetrasulphur tetranitride. Basic properties of iodine, structure and bonding of interhalogens and polyhalides, compounds of xenon. 16
4. **Transition Metals** : Characteristic properties of 3d elements – ionic radii, oxidation states, complexation tendency, magnetic behaviour and electronic spectral properties. Spectrophotometric estimation of metal ions. 8
5. **Lanthanides** : Comparative study of lanthanide elements with respect to electronic configuration, atomic and ionic radii, oxidation state and complex formation. Lanthanide contraction. Occurrence and principles of separation of lanthanides. 8
6. **Coordination Compounds** : Werner's theory, nomenclature, chelates, stereo-chemistry of coordination numbers 4, 5 and 6. Various types of isomerism in coordination complexes. Important applications of coordination compounds. Theories of metal-ligand bonding in transition metal complexes- Sidgwick effective atomic number concept, valence bond theory of coordination compounds. 14

Books Recommended

1. "Concise Inorganic Chemistry", **J. D. Lee**, 5th Edition (1996), Chapman & Hall, London.
2. "Modern Inorganic Chemistry", **R. C. Aggarwal**, 1st Edition (1987), Kitab Mahal, Allahabad.
3. "Basic Inorganic Chemistry", **F. A. Cotton, G. Wilkinson, and Paul L. Gaus**, 3rd Edition (1995), John Wiley & Sons, New York.

BCH-202 : Organic Chemistry

Marks : 50

1. **Petroleum and Petrochemicals** : Origin of petroleum, composition, refining, reforming, fractionation, cracking, knocking. Octane number, Cetane number, kerosene, naphtha, LPG, synthetic petrol, petrochemicals. 5
2. **Benzene** : Structure, aromaticity, Huckel rule. 4
3. **Electrophilic Aromatic Substitutions** : Mechanisms of nitration, halogenation, sulphonation and Friedel-Crafts (alkylation and acylation) reactions. Effects of substituents on reactivity and orientation. 6
4. **Aryl Halogen Compounds** : Chlorobenzene, comparative reactivity of aryl, benzyl, vinyl and allyl halides. Side chain chlorination of toluene. DDT and BHC. Nucleophilic aromatic substitution in aryl halides. 5
5. **Aromatic Aldehydes and Ketones** : Preparation and important reactions of benzaldehyde and acetophenone. 4
6. **Carboxylic Acids and their Derivatives** : Carboxylic acids, general preparation and reactions. Comparative acidity of carboxylic and sulphonic acids. Benzoic, phthalic and cinnamic acid. General chemistry of acid chlorides, acid anhydrides, amides and esters 6
7. **Penols** : Phenol, catechol and resorcinol; general methods of preparation and reactions. Relative acidity of phenol, alcohol and carboxylic acid. Reimer-Tiemann and Kolbe reactions. 4
8. **Nitrogen Containing Compounds** : Nitrobenzene and its reduction products. Comparative basicity of aliphatic and aromatic amines. Hinsberg test for amines. Diazonium salts : preparation and synthetic applications. 8
9. **Carbohydrates** : Classification, characteristic reactions of aldoses and ketoses. Glucose-structure (including cyclic structure), mutarotation. Fructose (reactions only). 6
10. **Heterocyclic Compounds** : Synthesis and reactions, aromatic character of furan, pyrrole, thiophene and pyridine. 6
11. Problems based on chemical reactions and structure covering the above topics. 6

Books Recommended :

1. "Organic Chemistry", **R. T. Morrison and R. N. Boyd**, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
2. "Organic Chemistry", **S. M. Mukherji , S. P. Singh, and R. P. Kapoor**, 1st Edition (1985), 5th Reprint (1999), New Age International (P) Ltd. Publishers, New Delhi.
3. "Organic Chemistry – Structure and Reactivity", **Seyhan N. Ege**, AITBS publishers, Delhi (1998).
4. "Organic Chemistry", **Paula Y. Bruice**, 2nd Edition , Prentice-Hall Internattional Inc, New Jersey, International Edition (1998).

- 1. Thermodynamics** : Limitation of First Law, spontaneous processes and Second Law of Thermodynamics, Carnot cycle, entropy, entropy changes in reversible and irreversible processes and of universe, physical concept of entropy, entropy changes of an ideal gas in different processes, entropy of an ideal gas, entropy changes in mixture of gases. Third Law of thermodynamics, variation of entropy with temperature, determination of absolute entropies of liquid and gases. The concept of residual entropy. Applications of Third Law.
Free energy and its concept, Gibbs and Helmholtz free energies and their relationship, variation of free energy with temperature and pressure. Maxwell's relations, Gibbs-Helmholtz equations, its application for the determination of ΔG , ΔH , ΔS of a reversible cell reaction. Criteria for reversible and irreversible processes based on entropy and free energy concept. Thermodynamics of phase transition-Claapeyron-Clausius equation and its applications. 15
- 2. Phase Equilibria** : Phase rule, phase, component, degree of freedom, thermodynamic derivation of phase rule, phase diagrams of one component systems (water and sulfur), two component systems (phenol-water, lead-silver, tin-magnesium). The distribution law, applications to cases of dissociation and association of solutes in one of the phases, solvent extraction, equilibrium constant from distribution coefficient ($KI + I_2 = KI_3$). 10
- 3. Electrochemical Cells** : Galvanic cells, reversible and irreversible cells, cell *emf* and its measurement.. Reactions in reversible cells, free energy and *emf* of reversible cell. Single electrode potential (Nernst equation), its measurement and sign convention. Standard electrode potential. *Emf* of reversible cell from electrode potentials. Types of reversible electrode, reference electrodes. Applications of *emf* measurements : determination of ionic activities, pH, potentiometric titrations (acid-base, redox, precipitation type reactions), equilibrium constant. Concentration cells with and without transference. Liquid junction potential and its elimination. Overvoltage, experimental determination of hydrogen overvoltage, application of overvoltage. Fuel cells (hydrogen-oxygen, hydrocarbon-oxygen), Commercial cells (primary and secondary cells), dry cell, acid and alkali storage cells. 15
- 4. Surface and Colloids Chemistry** : Adsorption- Langmuir and Freundlich isotherms. Multi layer adsorption-BET equation (no derivation) and its application to surface area measurement. Sols (reversible and irreversible), emulsions and emulsifiers, association colloids (micelles), gels. Applications of colloids. 6
- 5. Solid State** : Structural distinction between liquid and solid, crystalline state, crystal systems, crystal lattices, space lattice, unit cell, law of rational indices, Miller indices, crystals and x-rays (the Bragg's equation). 6
- 6. Kinetics of Complex Reactions** : reversible (first order in both directions), concurrent, consecutive reactions. Unimolecular gas reactions (Lindmann theory), steady-state approximations, theory of absolute reaction rate and its thermodynamical formulation, temperature dependence of frequency factor, numerical problems. 8

Books Recommended

1. "Physical Chemistry", **P. C. Rakshit**, 5th Edition (1985), 4th Reprint (1997), Sarat Book House, Calcutta.
2. "Principles of Physical Chemistry", **B. R. Puri, L. R. Sharma, and M. S. Pathania**, 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.
3. "Physical Chemistry", **K. J. Laidler and J. M. Meiser**, 3rd Edition, Houghton Mifflin Comp., New York, International Edition (1999).

B. Sc. (Hons.) Part III

BCH-301 : Analytical Chemistry

Marks : 75

1. **Statistical Evaluation** : Determinate and Indeterminate errors. Normal error curve. Accuracy and Precision, relative and standard deviation. Methods for minimizing errors. Criteria for rejection of an observation. Significant figures and computation rules. 10
2. **Precipitation** : Desirable properties of gravimetric precipitates. Formation of gravimetric precipitates. Conditions for quantitative precipitation. Contamination in precipitates. Methods for removing impurities in precipitates. Organic precipitants (oxine, dithiozone, a-nitroso-(naphthol, cupferron, dimethyl glyoxime) in chemical analysis. 10
3. **Analytical Reagents** : Theoretical and practical aspects of the use of E.D.T.A., cerate, iodate, bromate, chloramine T, Karl Fischer reagent and periodate in chemical analysis. 8
4. **Solvent Extraction** : Distribution law, Craig concept of counter-current distribution, Important solvent extraction systems. 4
5. **Chromatography** : Classification of chromatographic methods, general principle and application of adsorption, partition, ion-exchange, thin layer and paper chromatography. 8
6. **Radioanalytical Methods** : Elementary theory, isotope dilution and Neutron activation methods and applications. 5
7. **Spectrophotometry** : Beer's law and its limitations, nomenclature and units. General instrumentation for spectrophotometry, spectrophotometric determination of one component (iron, chromium, manganese, nickel, titanium and phosphorus) and two components (overlapping and non-overlapping) systems, spectrophotometric determinations of dissociation constants of an indicator, photometric errors and RINGBOM-AYRES plots. 15
8. **Environmental Pollution** : General awareness : Atmospheric pollution. Source of air pollution, Global warming, Auto-exhaust emissions, Air quality parameters, acid rains, Industrial and domestic effluents, Fluoresis, Arsenic, mercury, and MIC poisonings. Noise pollution, current environmental issues in the national context and remedial measures. 10

Books Recommended

1. "Modern Methods of Chemical Analysis", **R. L. Pecsok, L. D. Shields, T. Cairns, and I. C. Mc William**, 2nd Edition (1976), John Wiley, New York.
2. "Basic Concepts of Analytical Chemistry", **S. M. Khopkar**, 2nd Edition (1998), New Age International Publications, New Delhi.
3. "Environmental Chemistry", **A. K. De**, 3rd Edition (1994), Wiley Eastern, New Delhi.
4. "Instrumental Methods of Analysis", **H. H. Willard, L. L. Merritt, and J. A. Dean**, 6th Edition (1986), CBS Publishers & Distributors, Shahdara, Delhi.

Additional References

1. "Analytical Chemistry", **G. D. Christian**, 4th Edition (1986), John Wiley & Sons, New York.
2. "Principles and Methods of Chemical Analysis", **H. F. Walton**, 2nd Edition (1966), Prentice Hall, New Delhi.

1. **Theories of Metal-Ligand bonding** : Limitations of valence bond theory; Crystal-field theory and crystal-field splitting in octahedral and tetrahedral complexes; factors affecting the crystal-field parameters. 8
2. **Magnetic Properties of Transition Metal Complexes** : Types of magnetic behaviour, methods of determining magnetic susceptibility, L-S and J-J coupling, orbital contribution to magnetic moments. Correlation of magnetic moment data and stereochemistry of Co(II) and Ni(II) complexes; anomalous magnetic moments. 10
3. **Electronic Spectra of Transition Metal Complexes** : Types of electronic transitions, selection rule for d-d transitions, spectroscopic ground states. Explanation of electronic spectra on the basis of Orgel energy level diagrams for d^1 , d^4 , d^6 and d^9 states. 10
4. **Thermodynamic and Kinetic aspects of Metal Complexes** : A brief outline of thermodynamic stability of metal complexes and factors affecting the stability. Substitution reactions of square-planar complexes – Trans effect. 6
5. **Chemistry of Second and Third Transition Elements** : A general comparative treatment of 4d and 5d elements with their 3d analogues in respect of ionic radii, oxidation states, magnetic behaviour and electronic spectral properties. 6
6. **Chemistry of f-block Elements** : Comparative study of lanthanide elements with respect to electronic configuration, atomic and ionic radii, oxidation states and complex formation; occurrence and principles of separation. General features and chemistry of actinides, principles of separation of Np, Pu and Am from U. Trans-Uranium elements. 10
7. **Organometallic Chemistry** : Definition, nomenclature and classification of organometallic compounds. Preparation, properties, bonding and applications of alkyl and aryls of Li, Al, Hg, Sn, Ti. A brief account of metal-ethylene complexes and homogeneous hydrogenation. 10
8. Essential and trace element in biological process, oxygen transport with reference to haemoglobin, biological role of alkali metals. 10

Books Recommended

1. “*Concise Inorganic Chemistry*”, **J. D. Lee**, 5th Edition (1996), Chapman & Hall, London.
2. “*Modern Inorganic Chemistry*”, **R. C. Aggarwal**, 1st Edition (1987), Kitab Mahal, Allahabad.
3. “*Basic Inorganic Chemistry*”, **F. A Cotton, G. Wilkinson, and Paul L. Gaus**, 3rd Edition (1995), John Wiley & Sons, New York.
4. “*Inorganic Chemistry*”, **A. G. Sharpe**, 3rd International Student Edition (1999), ELBS / Longman, U.K.
5. “*Inorganic Chemistry*”, **D. F. Shriver and P. W. Atkins**, 3rd Edition (1999), ELBS, London.

BCH-303 : Organic Chemistry

Marks : 75

1. **Polynuclear Aromatic Compounds** : Naphthalene, anthracene and phenanthrene. Carcinogenicity. 7
2. **Alicyclic Compounds** : Cycloalkanes, general synthesis, Bayer's strain theory. Cyclohexane - chair and boat conformations, axial and equatorial bonds, conformation of mono substituted cyclohexanes. 5
3. **Reactive Intermediates (formation, stability, and structure)** : free radicals, carbonium ions, carbanions, carbenes and nitrenes. 8
4. **Methods of Determining Reaction Mechanism** : Guidelines for proposing a reasonable mechanism, product studies, bonds broken and formed, inter and intramolecular migration of groups, crossover experiments, exchange with solvents, importance of byproducts, reactive intermediates, energetics-importance of activation parameters. Isotopic substitution in a molecule, primary and secondary kinetic isotope effects - their importance in mechanistic studies. 12
5. **Molecular Rearrangements Involving Electron Deficient Atoms** : Pinacol-pinacolone, Beckmann, Hofmann and Wolff rearrangements, Baeyer-Villiger oxidation. 8
6. **Photochemistry** : Principles of photochemistry, Photochemical reactions of carbonyl compounds and olefins. 6
7. **Heterocyclic Compounds** : Synthesis and chemistry of indole, quinoline and isoquinoline. 8
8. **Dye Stuffs** : Colour in relation to structure, modern views, synthesis of malachite green, fluorescein and methyl orange. Structure and synthesis of indigo and alizarin. Chemistry of dyeing. 8
9. **Organosulphur and Organophosphorus Compounds** : Introduction to organosulphur compounds, methods of synthesis and reactions of thiols, thioether and aliphatic sulphonic acids. Introduction to organophosphorus compounds, phosphate esters and phosphorus ylides, general methods of preparation and reaction. Wittig reaction. 8

Books Recommended

1. "Organic Chemistry", **I. L. Finar**, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5th Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi.
2. "A Guide Book to Mechanism in Organic Chemistry", **P. Sykes**, 6th Edition (1997), Orient Longman Ltd., New Delhi..
3. "Organic Chemistry", **R. T. Morrison and R. N. Boyd**, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
4. "Organic Chemistry", **S. M. Mukherji , S. P. Singh, and R. P. Kapoor**, 1st Edition (1985), 5th Reprint (1999), New Age International (P) Ltd. Publishers, New Delhi.

1. **Amino acids, Peptides and Proteins** : Amino acids –Preparative methods, physical properties, dipolar nature, chemical reactions and configuration. Peptides : Peptide-linkage, peptide synthesis and structure of polypeptides. Proteins : General characteristics and secondary structure. 10
2. **Alkaloids** : Occurrence, importance, general structural features, Hofmann exhaustive methylation, structure and synthesis of nicotine and piperine. 8
3. **Carbohydrates** : Sucrose, starch and cellulose (structural aspects only). 6
4. **Vitamins and Hormones** : Chemical constitution and physiological functions of vitamins A, B2 (Riboflavin), C (Ascorbic acid); Thyroxin and estrone. 10
5. **Terpens** : Occurrence, isolation, classification, Isoprene rule, structure and synthesis of citral, geraniol and a-terpineol. 6
6. **Drugs** : Classification, preparation and uses of the following :
 - (i) **Antipyretics and Analgesics** : Aspirin, Paracetamol, Phenylbutazone.
 - (ii) **Sulpha drugs** : Sulphanilamide, Sulphapyridine, sulphathiazole, sulphaguani-dine. Mechanism of action of sulpha drugs.
 - (iii) **Antimalarials** : Chloroquine, Primaquine.
 - (iv) **Antibiotics** : Chloramphenicol. 10
7. **Polymers** : Types of polymers and polymerisation process, Addition polymers, stereocontrolled polymers, condensation polymers, radical, ionic and coordination mechanism of polymerisation. Preparation and applications of following polymers : (i) Natural and synthetic rubber, (ii) Synthetic fibers : Polyester, polyamides, polyacrylates and rayons, (iii) Plastics : Polyolefines and Polyurethanes, (iv) Foaming agent : Plasticisers (v) Biodegradable polymers. 20

Books Recommended

1. “*Organic Chemistry*”, **R. T. Morrison and R. N. Boyd**, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
2. “*Organic Chemistry*”, **S. M. Mukherji , S. P. Singh, and R. P. Kapoor**, 1st Edition (1985), 5th Reprint (1999), New Age International (P) Ltd. Publishers, New Delhi.
3. “*Organic Chemistry*”, **I. L. Finar**, Vol. II, 5th Edition (1975), Reprinted in 1996, ELBS and Longman Ltd., New Delhi.
4. “*Organic Polymer Chemistry*”, **K. J. Saunders**, 2nd Edition (1988), Chapman & Hall, London.

1. **Solid State** : Crystal structure of NaCl, KCl, graphite, and diamond. Types of crystal (molecular, covalent, metallic, ionic). Imperfection in crystals : point defect, Schottky defect, Frankel defect, metal excess defect (colour centre), line defect (dislocations), edge and screw dislocations. Imperfection due to transient atomic displacement. 13

2. **Kinetics and Photochemistry** : Heterogeneous catalysis (surface reactions) : kinetics of unimolecular reactions- inhibition and activation energy. Bimolecular surface reactions - reactions between a gas molecule and an adsorbed molecule, reaction between two adsorbed molecules. Nature of surface, concept of active centres. Kinetics of enzymatic reactions: Michaelis-Menten equation, effect of temperature and pH.

Law of photochemical equivalence, quantum efficiency, reasons for low and high quantum efficiency. Kinetics of photochemical reactions ($H_2 + Br_2 = HBr$, $2HI = H_2 + I_2$), photostationary state. Chemical actinometers (ferri-oxalate, uranyl oxalate, MGL [malachite green leucocyanide]) and Reinecke's salt, fluorescence, phosphorescence, and chemiluminescence. 20

3. **Thermodynamics of Solutions** : Partial molal quantities, chemical potential, the Gibbs-Duhem equation, determination of partial molal quantities, variation of chemical potential with temperature and pressure, chemical potential in case of a system of ideal gases, chemical potential of real gases and fugacity, activity and activity coefficient (concept and physical significance), reference and standard states.

Variation of fugacity with temperature and pressure, Lewis-Randall rule, thermodynamic functions of mixing (ΔG_{mix} , ΔS_{mix} , ΔV_{mix} , ΔH_{mix}), ideal solutions and their characteristic properties, Duhem-Margules equation and its application, Henry and Raoult's law. Thermodynamics of colligative properties : Freezing point depression, elevation of boiling point, osmotic pressure. van't Hoff equation. Measurement of osmotic pressure and determination of molecular weight of macromolecules. 15

4. **Electrochemistry** : Theory of strong electrolytes :- Qualitative idea of Debye-Huckel theory of ion-ion interactions, Debye-Huckel limiting law for activity coefficient of ions in electrolyte solution (derivation not required), its modification for concentrated solutions. Debye-Huckel-Onsager (D-H-O) theory of electrolytic conductance : qualitative idea of electrophoretic and relaxation effects, D-H-O equation for conductance of electrolyte solutions, effect of high frequency and high field on conductance. Qualitative idea of electrified interface, electrokinetic effects, derivation of zeta potential. 10

5. **Nuclear and Radiation Chemistry** : Nuclear reactions-Bethe's notation, types of nuclear reactions (n, p, α , d and γ), conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions.

Radiation chemistry : Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's dosimeter), units of radiation energy (Rad, Gray, Rontgen, RBE, Rcm, Sievert). 12

Books Recommended

1. "Physical Chemistry", **P. C. Rakshit**, 5th Edition (1988), 4th Reprint (1997), Sarat Book House, Calcutta.
2. "Physical Chemistry", **K. J. Laidler and J. M. Meiser**, 3rd Edition (International Edition, 1999), Houghton Mifflin Co., New York.
3. "Physical Chemistry", **I. N. Levine**, 4th Edition (International Edition, 1995), Mc Graw-Hill Inc., New York.
4. "Essentials of Nuclear Chemistry" **H. J. Arnikar**, 4th Edition (1995), New Age International (p) Ltd., Wiley Eastern Ltd., New Delhi.

BCH-306 : Physical Chemistry - A Molecular Approach

Marks : 75

1. **Quantum Mechanics and Atomic Structure** : A review of the black body radiation and the old quantum theory. The wave nature of electron. The Uncertainty Principle. Schrödinger's wave mechanics. Eigenfunctions and normalizations. Quantum mechanical operators. Expectation value of a physical quantity. Orthogonality of wave functions. The particle in a one dimensional box problem and its solutions. Particle in a three dimensional box. Degeneracy. The hydrogen atom problem. Atomic orbitals. Orbital quantum numbers and their physical significance. Electron spin. Helium atom and Pauli Principle. The variational principle. 14
2. **The Chemical Bond** : The Molecular Orbital (MO) theory. The hydrogen molecule ion. Hydrogen molecule (MO and VB descriptions). Simple molecular orbitals for homonuclear and heteronuclear diatomic molecules. Bond description. Hybridization. 10
3. **Molecular Spectroscopy** : Emission and absorption spectra. Transition probabilities and selection rules. Pure rotational spectra. Diatomic molecules. Rigid rotor model. Linear triatomic molecules. Vibrational-rotational spectra. Diatomic molecules. Harmonic oscillator-rigid rotor approximation. Anharmonicity effect. Normal modes of vibration. Infrared spectra of linear and bent AB₂ molecules. Characteristic group frequencies. Electronic spectra of diatomic molecules. Vibrational structure. Franck-Condon principle. 14
4. **Magnetic Resonance Spectroscopy** : Nuclear Magnetic Resonance spectroscopy. Chemical shifts. Spin-spin splittings. Relaxation times. Electron Spin Resonance. Nuclear hyperfine splittings. 10
5. **Molecular Statistics** : The Boltzmann distribution. Maxwell distribution law for distribution of molecular speeds. The Maxwell-Boltzmann distribution law for the distribution of molecular energies. The partition functions. Thermodynamic quantities from partition functions. The Sackur-Tetrode equation for molar entropy of monoatomic gases. Rotational and vibrational partition functions. The characteristic temperature. The calculation of Gibbs free energy changes and equilibrium constant in terms of partition functions. 12
6. **Liquid State** : Internal pressure and internal energy. Radial distribution function. Intermolecular forces. 5
7. **Transport Phenomena** : General transport equation. Viscosity and diffusion. 5

Books Recommended

1. "Physical Chemistry", **K. J. Laidler and J. M. Meiser**, 3rd Edition (International Edition ,1999), Houghton Mifflin Co., New York.
2. "Physical Chemistry", **I. N. Levine**, 4th Edition (International Edition, 1995), Mc Graw-Hill Inc., New York.
3. "Physical Chemistry - A Molecular Approach", **D. A. McQuarrie and J. D. Simon**, South Asian Edition (1998), University Science Books, Sausalito CA, by Viva Books, New Delhi.

PRACTICALS

B. Sc. (Hons.) Part I

Section A : *Quantitative Analysis (Physical and Volumetric)*

Marks : 25

1. Determination of water equivalent of calorimeter (cooling curve).
2. Heat of neutralization (strong acid-strong base).
3. Heat of dissociation of weak acid.
4. Heat of solution (NH_4NO_3 , CaCl_2).
5. Basicity of an acid by thermochemical method.
6. Kinetics of First Order reaction.
7. Redox titration : (a) Iodometry (b) Fe^{2+} / $\text{K}_2\text{Cr}_2\text{O}_7$

Section B : *Qualitative Analysis (Organic and Inorganic)*

Marks : 25

1. *Qualitative Organic Analysis* :

(i) Detection of elements (X, N, S)

(ii) Detection of functional groups :

PhOH, -COOH, C-O, -CHO, Ar-NH₂, Ar-NO₂, -CONH₂

2. *Qualitative Inorganic Mixture Analysis* : Not containing more than 4 ions with combination and upto one interfering anion

Note : Experiments may be added/deleted subject to availability of time and facilities.

B. Sc. (Hons.) Part II

Section A : *Quantitative Analysis (Physical and Volumetric)*

Marks : 25

1. Critical Solution Temperature.
2. Effect of impurity on Critical Solution Temperature.
3. Distribution of solute in two immisible solvents (without association).
4. Distribution of solute in two immisible solvents (with association in one solvent).
5. Determination of pH of a given buffer.
6. Coagulation of a sol.
7. Determination of Surface Tension of liquids.
8. Determination of viscosity coefficients of liquids.
9. Complexometric titrations : Zn^{2+} , Mg^{2+} , Ca^{2+} , Fe^{2+} with EDTA; Hardness of water.
10. Iodimetric titration.

Section B : *Qualitative Analysis & Preparation (Organic and Inorganic)*

Marks : 25

1. Organic :

(a) Preparation of following compounds :

- (i) m-dinitrobenzene
- (ii) Acetanilide
- (iii) Tribromophenol
- (iv) Sulphanilic acid
- (v) Oxidation of primary alcohols-Benzoic acid from benzylacohol

(b) Identification of simple organic compounds (derivatives not included)

2. Inorganic :

Preparation of following complexes :

- (i) Potassium trioxalato chromate(III)
- (ii) $CoHg(SCN)_4$
- (iii) Cu(I) thiourea complex
- (iv) Double salts (Chrome alum/ Mohr's salt)
- (v) Bis (2, 4-pentanedionate) zinc hydrate

Note : Experiments may be added/deleted subject to availability of time and facilities.

B. Sc. (Hons.) Part III

Section A : *Physical Chemistry Practicals*

Marks : 50

1. Viscosity-composition curve for a binary liquid mixture.
2. Surface tension-composition curve for a binary liquid mixture.
3. Determination of indicator constant - colorimetry.
4. Determination of pH of a given solution using glass electrode.
5. Beer's Law - Determination of concentration of solution by colorimetry.
6. Order of reaction of I_2 / Acetone / H^+ .
7. Equilibrium constant of methyl acetate hydrolysis reaction.
8. Dissociation constants of weak acid, base.
9. Conductometric titration : acid-base.
10. Potentiometric titration : acid-base.
11. Kinetics of catalytic decomposition of H_2O_2 .
12. Kinetics of acid-catalysed hydrolysis of sugar (chemical method).
13. Determination of relative strengths of two acids by studying the kinetics of acid-catalysed ester hydrolysis.
14. Kinetics of enzymatic reaction (starch-amylase system).

Section B : *Inorganic Chemistry Practicals*

Marks : 50

1. Determination of nickel as nickel (II) dimethyl glyoximate (involving solvent extraction) colorimetrically.
2. Determination of Pb as dithiozone complex colorimetrically.
3. Determination of Al or Mg as their oxinate colorimetrically.
4. Potentiometric titration involving EDTA.
5. Potentiometric titration of Fe^{2+} with Ce^{4+} .
6. Job's method of continuous variation for determination of stoichiometry of the complexes.
7. Gravimetric determination of the following using sintered glass crucible:
 - (a) Ni as $Ni(DMG)_2$
 - (b) Cu as $Cu(SCN)$
 - (c) Al or Mg as oxinate
 - (d) Zn as $Zn NH_4PO_4$
8. Chromatographic separation of the following :
 - (a) Cl^- , Br^- , and I^-
 - (b) Cd^{2+} and Hg^{2+}
 - (c) Ag^{2+} and Pb^{2+}
9. Preparation of Aluminium acetylacetonate and its purification by vacuum sublimation.

Section C : *Organic Chemistry Practicals*

Marks : 50

1. Systematic identification of organic compounds (monofunctional and simple bifunctional) and preparation of their derivatives.
2. Preparation of the following compounds:
Suphanilic acid, dibenzyl acetone, methyl orange, dinitrobenzene from benzene, isolation of caffeine.
3. Estimation of phenol (bromide-bromate method) and aniline (bromide-bromate and acetylation methods).
4. Equivalent weight of an acid (neutralization).
5. Identification of organic functional groups by I.R. spectroscopy.

Note : Experiments may be added/deleted subject to availability of time and facilities.

- 1. Thermodynamics** : Limitation of First Law, spontaneous processes and Second Law of Thermodynamics, Carnot cycle, entropy, entropy changes in reversible and irreversible processes and of universe, physical concept of entropy, entropy changes of an ideal gas in different processes, entropy of an ideal gas, entropy changes in mixture of gases. Third Law of thermodynamics, variation of entropy with temperature, determination of absolute entropies of liquid and gases. The concept of residual entropy. Applications of Third Law.
Free energy and its concept, Gibbs and Helmholtz free energies and their relationship, variation of free energy with temperature and pressure. Maxwell's relations, Gibbs-Helmholtz equations, its application for the determination of ΔG , ΔH , ΔS of a reversible cell reaction. Criteria for reversible and irreversible processes based on entropy and free energy concept. Thermodynamics of phase transition-Claapeyron-Clausius equation and its applications. 15
- 2. Phase Equilibria** : Phase rule, phase, component, degree of freedom, thermodynamic derivation of phase rule, phase diagrams of one component systems (water and sulfur), two component systems (phenol-water, lead-silver, tin-magnesium). The distribution law, applications to cases of dissociation and association of solutes in one of the phases, solvent extraction, equilibrium constant from distribution coefficient ($KI + I_2 = KI_3$). 10
- 3. Electrochemical Cells** : Galvanic cells, reversible and irreversible cells, cell *emf* and its measurement.. Reactions in reversible cells, free energy and *emf* of reversible cell. Single electrode potential (Nernst equation), its measurement and sign convention. Standard electrode potential. *Emf* of reversible cell from electrode potentials. Types of reversible electrode, reference electrodes. Applications of *emf* measurements : determination of ionic activities, pH, potentiometric titrations (acid-base, redox, precipitation type reactions), equilibrium constant. Concentration cells with and without transference. Liquid junction potential and its elimination. Overvoltage, experimental determination of hydrogen overvoltage, application of overvoltage. Fuel cells (hydrogen-oxygen, hydrocarbon-oxygen), Commercial cells (primary and secondary cells), dry cell, acid and alkali storage cells. 15
- 4. Surface and Colloids Chemistry** : Adsorption- Langmuir and Freundlich isotherms. Multi layer adsorption-BET equation (no derivation) and its application to surface area measurement. Sols (reversible and irreversible), emulsions and emulsifiers, association colloids (micelles), gels. Applications of colloids. 6
- 5. Solid State** : Structural distinction between liquid and solid, crystalline state, crystal systems, crystal lattices, space lattice, unit cell, law of rational indices, Miller indices, crystals and x-rays (the Bragg's equation). 6
- 6. Kinetics of Complex Reactions** : reversible (first order in both directions), concurrent, consecutive reactions. Unimolecular gas reactions (Lindmann theory), steady-state approximations, theory of absolute reaction rate and its thermodynamical formulation, temperature dependence of frequency factor, numerical problems. 8

Books Recommended

1. "Physical Chemistry", **P. C. Rakshit**, 5th Edition (1985), 4th Reprint (1997), Sarat Book House, Calcutta.
2. "Principles of Physical Chemistry", **B. R. Puri, L. R. Sharma, and M. S. Pathania**, 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.
3. "Physical Chemistry", **K. J. Laidler and J. M. Meiser**, 3rd Edition, Houghton Mifflin Comp., New York, International Edition (1999).