DEPARTMENT OF CHEMISTRY
CH. CHARAN SINGH UNIVERSITY, MEERUT

Program: B.Sc.
Program (Specific): B.Sc. (H) Chemistry
Program Code: CUHB58
Year of Implementation: 2022-23
(New Syllabus)

Program Outcomes

PO 1: To develop strong theoretical and practical background in fundamental concepts of science

PO 2: To provide platform to get opportunities in higher education for career advancement in the field of academics and research organizations

PO 3: To make the students effective in skills, tools, and techniques required for an industry/ organization or institute

PO 4: To expose the students to latest scientific knowledge, techniques and innovations and provide a platform to them to explore their research potential.

Program Specific Outcomes

PSO 1: Students gain systematic and coherent understanding of the fundamental concepts in Organic Chemistry, Physical chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.

PSO 2: Students gain knowledge of basic aspects of physics and mathematics

PSO 3: Students will be able to use the evidence based comparative chemistry approach to explain different chemical processes.

PSO 4: Students will be able to understand the basic principle of equipment's, instruments used in the chemistry, physics and analytical laboratories.

PSO 5: Industrial training familiarize the students with real working environments, enhances their knowledge & skills and boosts their confidence to do team work and collaborate with others.

Coordinator
B.Sc. Chemistry (H)
C.C.S.U., Meerut

Semester	Course Code	Course Title	Course Outcome
I	**BCH-101**	**Inorganic Chemistry**	Students will learn to apply the fundamental principles of measurement, matter, atomic theory, chemical periodicity, chemical bonding, general chemical reactivity and solution chemistry to subsequent courses in science.
	BCH-102	**Physical Chemistry**	To inculcate the detailed knowledge of gaseous, liquid and solid state of matter and ionic equilibria.
	BCH-103	**English Communication**	To gain basic knowledge in communication and writing skills effectively.
	BCH 104	**General Elective Mathematics**	Gaining basic knowledge and skills on curve sketching, volumes/areas of solid structures using mathematical tools and partial derivatives.
	BCHPR-101	**Practical Inorganic Chemistry**	Facilitate the learner to enhance the skills of titrimetric analysis, acid base titrations and oxidation reduction titrimetry. make solutions of various molar concentrations.
	BCHPR-102	**Practical Physical Chemistry**:	It helps in developing the key skills in surface tension measurement, viscosity measurement and pH metry.
II	**BCH-201**	**Organic Chemistry**	To help them learn the basic concepts of organic chemistry such as organic intermediates, electronic effects, stereochemistry, conformations, and mechanisms of organic reactions.
	BCH-202	**Physical Chemistry**	To gain the specific knowledge on laws of thermodynamics, chemical equilibrium and solutions and its colligative properties.
	BCH-203	**Physics**	To be acquainted with vectors, ordinary differential equations, laws of motion, momentum & energy, rotational motion, gravitational laws, oscillations. Gain basic understanding of speed theory of relativity and elasticity.
	BCH-204	**Environmental Studies**	To be acquainted with the knowledge of ecosystem and its structure, natural resources and their growing needs with case studies. It also helps in developing knowledge of biodiversity and its conservation, environmental pollution and its effects and design and evaluation of environmental policies and institutions.
	BCHPR-201	**Practical Organic Chemistry**	Students are skilled in basic laboratory procedures involved in purification, identification and preparation of organic compounds.
	BCHPR-	**Practical**	It helps them to learn the practical aspects of

	202	**Physical Chemistry**	thermochemistry.
	BCHPR-203	**Practical Physics**	To gain practical knowledge and skills in correlating experimental data with theory.
III	**BCH-301**	**Inorganic Chemistry**	To gain basic understanding of bonding fundamentals for both ionic and covalent compounds, including electro negativities, bond distances and bond energies using MO diagrams and thermodynamic data.
	BCH-302	**Organic Chemistry**	Students are acquainted with synthesis, physical and chemical properties of common functional groups such as alkyl and aryl halides, alcohols, phenols, carbonyl compounds, carboxylic acids and its derivatives.
	BCH-303	**Physical Chemistry**	Students learn depth concepts about electrochemistry, Surface Chemistry, Phase Equilibria.
	BCH-304	**Physics**	It helps them to know about crystal structure, lattice dynamics, magnetic and dielectric properties of materials.
	BCHPR-301	**Practical Inorganic Chemistry**	To be skilled in identification of functional groups, preparation of organic compounds using conventional/green approach.
	BCHPR-302	**Practical Organic Chemistry**	To be skilled in identification of functional groups, preparation of organic compounds using conventional/green approach.
	BCHPR-303	**Practical Physical Chemistry**	To be skilled in and gain the practical knowledge of critical solution temperature and its composition, construction of phase diagram using cooling curves and study of equilibrium by distribution methods.
	BCHPR-304	**Physics**	To have expertise in experimental skills involved in study of magnetic properties of the solids.
	Industrial Training		To provide the real insight of working procedure and environment of industries. Students will learn advanced tools and techniques, relate, apply and adapt relevant knowledge and skills to compete in the job market with this experience and exposure.
IV	**BCH-401**	**Inorganic Chemistry**	It gives insight of coordination chemistry and basic inorganic reaction mechanisms. Also provide outlines of transition elements and inner transition elements.

	BCH-402	**Organic Chemistry**	Students learn preparation and properties of nitrogen containing compounds, polynuclear compounds, heterocyclic compounds, alkaloids and terpenes.
	BCH-403	**Physical Chemistry**	To gain specific knowledge on quantitative aspects of conductance, chemical kinetics of reactions and role of photochemical reactions in biochemical processes.
	BCH-404	**Analytical Clinical Biochemistry**	Students gain knowledge and basic skills and understanding of structure, properties and functions of carbohydrates, lipids, proteins. Mechanism of enzyme action, lipoproteins.
	BCH-405	**Mathematics**	Helps students learn to solve real life problems using Differential equations.
	BCHPR-401	**Practical Inorganic Chemistry**	Students gain expertise in gravimetric analysis, preparation of inorganic complexes and analysis of their properties.
	BCHPR-402	**Practical Organic Chemistry**	Students are skilled in identification of unknown organic compounds and functional group tests for nitrogen containing functional groups.
	BCHPR-403	**Practical Physical Chemistry**	To develop practical skills in conductometry and study of kinetics of chemical reactions.
V	**(BCH-501)**	**Organic Chemistry**	It helps them to emphasize on interconnection between chemistry and biology. To gain knowledge about nucleic acids, amino acids, peptides, proteins and Enzymes.
	(BCH-502)	**Physical Chemistry**	Students learn the use of nuclear magnetic resonance spectroscopy, mass spectrometry and infrared spectroscopy for organic structure elucidation and are exposed to basic concepts of Quantum Chemistry
	(BCH-503)	**Analytical Methods in Chemistry**	To help them learn analytical tools and skilled in methods used in analysis of Inorganic and organic compounds
	(BCH-504)	**Inorganic Materials for Industrial Importance**	To be acquainted with composition and applications of common industrial materials such as glass, fertilizers, surface coatings, batteries, chemical explosives.
	(BCHPR-501)	**Organic Chemistry**	To be skilled in estimation of amino acids, proteins, action of salivary amylase, isolation and characterization of DNA and determination of saponification and iodine value of an oil or fat.
	(BCHPR-	**Physical**	Students are skilled in verification of Beer-Lambert

	502	**Chemistry**	law and other related experiments using UV/Visible spectrophotometer.
	(BCHPR-503)	**Analytical Methods in Chemistry**	Students learn the practical skills of separation techniques, soil analysis and gain expertise on UV/Visible spectrophotometer.
	(BCHPR-504)	**Inorganic Materials for Industrial Importance**	Students are skilled in analysis of fertilizers, cement, composition of ores, alloys and preparation of pigments
VI	**BCH-601**	**Organic Chemistry**	It helps them to gain instrumentation knowledge of different analytical techniques, synthesis and applications of dyes, polymers and carbohydrates.
	BCH-602	**Inorganic Chemistry**	It equips them with the theoretical principles in qualitative analysis and applications of metals in the biological systems and metallic compounds.
	BCH-603	**Applications of Computers in Chemistry**	It helps them to develop computer skills and using programming language in solving of problems in chemistry.
	BCH-604	**Polymer Chemistry**:	It helps them to develop skills and gain knowledge of polymeric materials, functionality and its importance and polymerization reactions.
	BCHPR-601	**Practical Organic Chemistry**:	To develop practical skills for qualitative analysis of unknown organic compounds and their identification by different analytical techniques.
	BCHPR-602	**Inorganic Chemistry**	Students are skilled in chromatographic separation of the metal ions and qualitative semi micro analysis of mixtures containing anions and cations.
	BCHPR-603	**Applications of Computers in Chemistry**:	To develop simple algorithms for arithmetic and logical problems and translate the algorithms to programs & execution (in C language). It helps them to implement conditional branching, iteration and decompose a problem into functions and synthesize a complete program using divide and conquer approach.
	BCHPR-604	**Polymer Chemistry**	To develop practical skills for the synthesis of polymers by different polymerization processes.

Value Added Courses

Course Code	Paper Title	Core Compulsory/ Elective/AE/DSE/SEC/Value added	Theory/ Practical	Credits	**Teaching Hours**
VCB-1	FTIR Instrumentation Training & Analytical Development	Value added	Theory (20) /Practical (10)	3	30
VCB-2	HPLC Instrumentation Training & Analytical Development	Value added	Theory (20) /Practical (10)	3	30

Value added courses Prerequisites

Students from all courses of University Campus and Colleges are eligible.

Value added courses outcomes

1. **(VCB-1) FTIR Instrumentation Training & Analytical Development:** The course will enhance the understanding of basic principles of FTIR spectroscopy, FTIR software, standard operating procedures and skill them in operation of FTIR spectrophotometer, sampling techniques, method development, spectra recording, data processing and data acquisition.

2. **(VCB-2) HPLC Instrumentation Training & Analytical Development**: The course will provide exposure to basic principle and instrumentation of HPLC/GPC, HPLC software, columns, detectors and standard operating procedures. The students will be skilled in sample/mobile phase preparation, method development, HPLC software operation, molecular weight determination, interpretation and analysis of data and data acquisition.

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Course Structure and Evaluation Scheme

Course Duration: Six Semesters

Course Type: Self financed

Pass Percentage: Theory-40% Practical- 40% Overall- 40%

Attendance Criterion: As per the norms decided by the statutory body

Maximum marks: 4000

Percentage range for Division: First-60%

Sem.	Course Code	Course Title	Duration	Lecture Duration	Lect./Weak (Th+Tu+ Pr)	Max. Marks=100 (Ext.+ Int.)	Credits	External Exam duration
I	BCH-101	Inorganic Chemistry-I	60 hours	60 minutes	4	50+50	**4**	3 hours
	BCH-102	Physical Chemistry – I	60 hours	60 minutes	4	50+50	**4**	3 hours
	BCH-103	English Communication	30 hours	60 minutes	2	50+50	**2**	3 hours
	BCH-104	Mathematics	60 hours	60 minutes	5+1(Tu)	50+50	**6**	3 hours
	BCHPR-101	Practical Inorganic Chemistry-I	60 hours	60 minutes	2	100	**2**	4 hours
	BCHPR-102	Practical Physical Chemistry – I	60 hours	60 minutes	2	100	**2**	4 hours
						600		
II	BCH-201	Organic Chemistry – I	60 hours	60 minutes	4	50+50	4	3 hours
	BCH-202	Physical Chemistry – II	60 hours	60 minutes	4	50+50	4	3 hours
	BCH-203	Physics-I	60 hours	60 minutes	4	50+50	4	3 hours
	BCH-204	Environmental Studies	30 hours	60 minutes	2	50+50	2	3 hours
	BCHPR-201	Practical Organic Chemistry – I	60 hours	60 minutes	4	75	2	4 hours
	BCHPR-202	Practical Physical Chemistry	60 hours	60 minutes	4	75	2	4 hours

		– II						
	BCHPR-203	Practical Physics-I	60 hours	60 minutes	4	50	2	4 hours
	Max. Marks of Semester-II					**600**		
III	BCH-301	Inorganic Chemistry – II	60	60 minutes	4	50+50	4	3 hours
	BCH-302	Organic Chemistry – II	60	60 minutes	4	50+50	4	3 hours
	BCH-303	Physical Chemistry – III	60	60 minutes	4	50+50	4	3 hours
	BCH-304	Physics –II	60	60 minutes	4	50+50	4	3 hours
	Industrial Training					**100**		
	BCHPR-301	Practical Inorganic Chemistry – II	60	60 minutes	4	50	2	4 hours
	BCHPR-302	Practical Organic Chemistry – II	60	60 minutes	4	50	2	4 hours
	BCHPR-303	Practical Physical Chemistry – III	60	60 minutes	4	50	2	4 hours
	BCHPR-304	Practical Physics -II	60	60 minutes	4	50	2	4 hours
	Max. Marks of Semester-III					**700**		
IV	BCH-401	Inorganic Chemistry – III	60	60 minutes	4	50+50	4	3 hours
	BCH-402	Organic	60	60 minutes	4	50+50	4	3 hours

		Chemistry – III						
	BCH-403	Physical Chemistry – IV	60	60 minutes	4	50+50	4	3 hours
	BCH-404	Analytical clinical Biochemistry	60	60 minutes	4	50+50	4	3 hours
	BCH-405	Mathematics	60	60 minutes	5+1 (Tu)	50+50	6	3 hours
	BCHPR-401	Practical Inorganic Chemistry – III	60	60 minutes	4	75	2	4 hours
	BCHPR-402	Practical Organic Chemistry – III	60	60 minutes	4	75	2	4 hours
	BCHPR-403	Practical Physical Chemistry – IV	60	60 minutes	4	50	2	4 hours
	Max. Marks of Semester-IV					**700**		
V	BCH- 501	Organic Chemistry – IV	60	60 minutes	4	50+50	4	3 hours
	BCH- 502	Physical Chemistry – V	60	60 minutes	4	50+50	4	3 hours
	BCH- 503	Analytical Methods in Chemistry	60	60 minutes	4	50+50	4	3 hours
	BCH- 504	Inorganic Materials for Industrial	60	60 minutes	4	50+50	4	3 hours

		Importance						
	BCHPR-501	Practical Organic Chemistry – IV	60	60 minutes	4	100	2	4 hours
	BCHPR-502	Practical Physical Chemistry – V	60	60 minutes	4	100	2	4 hours
	BCHPR-503	Practical Analytical Methods in Chemistry	60	60 minutes	4	50	2	4 hours
	BCHPR-504	Practical Inorganic Materials for Industrial Importance	60	60 minutes	4	50	2	4 hours
	Max. Marks of Semester-V					**700**		
VI	BCH- 601	Organic Chemistry – V	60	60 minutes	4	50+50	4	3 hours
	BCH- 602	Inorganic Chemistry – IV	60	60 minutes	4	50+50	4	3 hours
	BCH- 603	Applications of Computers in Chemistry	60	60 minutes	4	50+50	4	3 hours
	BCH- 604	Polymer Chemistry	60	60 minutes	4	50+50	4	3 hours
	BCHPR-	Practical	60	60 minutes	4	100	2	4 hours

	601	Organic Chemistry – V						
	BCHPR-602	Practical Inorganic Chemistry – IV	60	60 minutes	4	100	2	4 hours
	BCHPR-603	Practical Applications of Computers Chemistry	60	60 minutes	4	50	2	4 hours
	BCHPR-604	Practical Polymer Chemistry	60	60 minutes	4	50	2	4 hours
	Max. Marks of Semester-VI					**700**		

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Sem	Course Code	Course Title	Syllabus
I	BCH-101	Inorganic Chemistry- I	**Unit I: Atomic Structure (14 Lectures)** Recapitulation of Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrödinger's wave equation, significance of Ψ and Ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations. **Unit II: Periodicity of Elements (16 Lectures)** Brief discussion of the following properties of the elements, with reference to *s* & *p*- block and the trends shown: a. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. b. Atomic and Ionic radii. c. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy and trends in group and periods. d. Electron gain enthalpy and trends in group and periods. e. Electronegativity, Pauling's/Allred Rochow's scales. Variation of electronegativity with bond order, partial charge, hybridization, group

			electronegativity. **Unit III: <u>Chemical Bonding</u> (30 Lectures)** (i) **Ionic bond**: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) **Covalent bond**: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3, BrF_2, $[PCl_6]^{-1}$, ICl_2, ICl_4 and SO_4^{2-} Multiple bonding (ζ and π and bond approach), and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moments and electronegativity difference. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. (iii) **Metallic Bond**: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. (iv) **Weak Chemical Forces***:* van-der Waals forces, ion-dipole forces, dipole-dipole

			interactions, induced dipole interaction. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of weak chemical forces, melting and boiling points, solubility, energetics of dissolution process. ***Reference Books:*** 1. *Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010* 2. *Huheey, J.E., Kieter, E.A., Kieter, R.L., Medhi, O.K., Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006* 3. *Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970* 4. *Shriver, D.D., & P. Atkins, Inorganic Chemistrty 2nd Ed, Oxford University Press 1994* 5. *Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications1962*.
	BCH-102	Physical Chemistry – I	**Unit I: Gaseous State (18 Lectures)** Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases including their temperature and pressure dependence relation between mean free path and coefficient of viscosity, calculation of ζ from η; variation of viscosity with temperature and pressure, Maxwell distribution and its use in evaluating molecular velocities (average root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, Z, and its variation with pressure and temperature for different gases. Causes of deviation from ideal behavior. Vander Waals equation of state, its derivation and application in explaining real gas behavior, calculation of Boyle

			temperature. Isotherms of real gases and their comparison with Vander Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states. **Unit II: Liquid state (6 Lectures)** Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapor pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. **Unit III: Solid state (16 Lectures)** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. **Unit IV: Ionic equilibria (20 Lectures)** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degreeof ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono- and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid – base indicators; selection of indicators and their

			limitations. ***Reference Books:*** 1. *Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13(2006).* 2. *Ball, D. W. Physical Chemistry Thomson Press, India(2007).* 3. *Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).* **4.** *Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP(2009).*
	BCH-103	English Communication	**Unit 1** Communication: Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing. **Unit 2** Writing Skills; Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing. **Unit 3** Technical Writing: Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided. ***SUGGESTED READINGS:*** 1. *M. Frank. Writing as thinking: A guided process approach, Englewood Cliffs, Prentice Hall Reagents.* 2. *L. Hamp-Lyons and B. Heasely: Study Writing; A course in written English. For academic and professional purposes, Cambridge Univ. Press.* 3. *R. Quirk, S. Green baum, G. Leech and J. Svartik: A comprehensive grammar of the English language, Longman, London.*

			4. *Daniel G. Riordan & Steven A. Panley: "Technical Report Writing Today" - Biztaantra.* ***Additional Reference Books*** *5. Daniel G. Riordan, Steven E. Pauley, Biztantra: Technical Report Writing Today, 8th Edition (2004).* *6. Contemporary Business Communication, Scot Ober, Biztantra, 5th Edition(2004).*
	BCH-104	Mathematics	**UNIT-I** Ɛ-δ Definition of limits of a function, one sided limit, Limits at infinity, Horizontal asymptotes, Infinity limits, Vertical asymptotes, linearization, differential, differential of function, Concavity, points of inflection, curve sketching, indeterminate forms, L'Hopital's rule, volumes of slicing, volumes of solids of revolution by the disk method. **UNIT-II** Volumes of solid of revolution by the washer method, volume by cylindrical shells, Length of plane curves, Area of surface of revolution, improper integration: Type I and II, Test of convergence and divergence, polar coordinates, Graphing in polar coordinates, Vector valued functions: Limit, Continuity, Derivatives, Integrals, Arc length, Unit tangent vector. **UNIT –III** Curvature, Unit normal vector, torsion, Unit binomial vector, functions of several Variables, Graph, Level curves, Limit, Continuity, Partial derivatives, Differentiability chain Rule, Directional derivatives, tangent plane and normal line, Extreme Values, Saddle points ***Reference Books:*** *1. G. B. Thomas and R.L. Finney,*

			calculus, Pearson Education,11/e(2012) 2. *H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons Inc., 7/e(2011)*
	BCHPR-101	Practical Inorganic Chemistry- I	**(A) Titrimetric Analysis** (i) Calibration and use of apparatus **(ii)** Preparation of solutions of titration of different Molarity/Normality **(B) Acid- Base Titrations** Principles of Acid-base titrants to be discussed. (i) Estimation of sodium carbonate using standardized HCl. (ii) Estimation of carbonate and hydroxide present together in mixture. (iii) Estimation of carbonate and bicarbonate present together in a mixture. **(iv)** Estimation of free alkali present in different soaps/detergents **(C) Oxidation- Reduction Titrimetry** Principles of oxidation-reduction titrants (electrode potentials) to be discussed. (i) Estimation of Fe (II) and oxalic acid using standardized $KMnO_4$solution. (ii) Estimation of oxalic acid and sodium oxalate in a given mixture. (iii) Estimation of Fe (II) with $K_2Cr_2O_7$ using internal indicator (diphenylamine, N-phenyl anthranilic acid) and discussions of external indicator. ***Reference Books:*** *Vogel, A.I. A Textbook of Quantitative Inorganic Analysis,*

	BCHPR-102	Practical Physical Chemistry – I	**Surface tension measurements using stalagnometer.** a) Determine the surface tension by (i) drop number (ii) drop weight method. b) Study the variation of surface tension with different concentration of detergent solutions. Determine CMC. **2. Viscosity measurement using Ostwald's viscometer.** a. Determination of co-efficient of viscosity of an unknown aqueous solution. b. Study the variation of co-efficient of viscosity with different concentration of Poly Vinyl Alcohol (PVA) and determine molarity of PVA. c. Study the variation of viscosity with different concentration of sugar solutions. **3. Solid State:** Indexing of a given powder diffraction pattern of a cubic crystalline system. **4. pHmetry:** a) Study the effect of addition of HCl/NaOH on pH to the solutions of acetic acid, sodium acetate and their mixtures. b) Preparation of buffer solutions of different pH values i.e., Sodium acetate-acetic acid ii. Ammonium chloride-ammonium hydroxide c) pH metric titration of) strong acid with strong base(ii) weak acid with strong base ***Reference Books:*** • *Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.:New Delhi (2011).* • *Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8thEd.; McGraw-Hill: New York(2003).* • *Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman &Co.: New York(2003).*

II	BCH-201	Organic Chemistry – I	**Unit-I: Recapitulation of basics of Organic Chemistry (6 lectures)** Hybridization, Shapes of molecules. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation, Dipole moment, Hydrogen bonding (Applications to be discussed with relevant topics). Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges. Electrophiles and Nucleophiles: Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions: Addition, Elimination and Substitution reactions. **Unit II: Stereochemistry (18 lectures)** Fischer, Newman and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans, syn-anti and E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centers, Di stereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. **Unit III: Chemistry of Aliphatic Hydrocarbons (24 lectures)** **A. Carbon-Carbon sigma bonds** General method of preparation, physical and chemical properties of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity. **B. Carbon-Carbon pi-bonds** General method of preparation, physical and chemical properties of alkenes and alkynes, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff

			addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. **C. Cycloalkanes and Conformational Analysis** Conformational Analysis of alkanes; Relative stability and Energy diagrams. Types of cycloalkanes and their relative stability, Baeyer strain theory; Chair, Boat and Twist boat forms of Cyclohexane with energy diagrams. Relative stability of mono-substituted cycloalkanes. **Unit IV: Aromatic Hydrocarbons (12 lectures)** Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel- Craft's alkylation/acylation with their mechanism. Directing effects of the groups. ***Reference Books:*** 1. *Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).* 2. *Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt.Ltd.(PearsonEducation).* 3. *Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).* 4. *Eliel, E. L. & Wilen, S. H. Stereochemistry of*

			Organic Compounds; Wiley: London, 1994. 5. *Kalsi, P.S. Stereochemistry: Conformation and Mechanism, New age International, 2005.*
	BCH-202	Physical Chemistry – II	**UNIT I: Chemical thermodynamics (36 Lectures)** Intensive and extensive variables; state and path functions; isolated, closed and open systems. **First law:** concept of heat, Q, work, W, internal energy, U and statement of first law; enthalpy, H, relation between heat capacities, calculations of Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and Van der Waals) under isothermal and adiabatic conditions. **Thermo chemistry:** Heats of reactions; standard states; enthalpy of formation and enthalpy of combustion and its applications; effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. **Second Law:** Concept of entropy thermodynamics scale of temperature, statement of the second law of thermodynamics. Calculation of entropy change for reversible and irreversible processes. **Third Law:** Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. Free energy functions, Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; free energy change and spontaneity. Relation between Joule-Thomson Coefficient and other thermodynamic parameters, inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; Thermodynamic equation of state. **UNIT II: Systems of variable composition (8 Lectures)** Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in

			mixing of ideal gases. **UNIT III: Chemical equilibrium (8 Lectures)** Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration (Le-Chatelier Principle, quantitatively). Free energy of mixing and spontaneity, equilibrium between ideal gases and pure condensed phase. **UNIT IV: Solutions and Colligative Properties (8 Lectures)** Dilute solutions; lowering of vapour pressure, Raoult's and Henry's laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four Colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. ***Reference Books:*** 1. *Peter, A. & Paula, J. de. Physical Chemistry 9th Ed, Oxford University Press (2011).* 2. *Castellan, G.W. Physical Chemistry 4th Ed, Narosa (2004).* 3. *Fnjel T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).* 4. *McQuarrie, D.A. & Simon, J.D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).* 5. *Assael, M.J.; Goodwin, A.R.H.; Stamatoudis, M.; Wakeham, W.A. & Will, S. Commonly asked Questions in Thermodynamics. CRC Press:NY (2011).* 6. *Levine, I.N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2006).*

	BCH-203	Physics-I	**UNIT –I: Vectors (4 Lectures)** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **UNIT II: Ordinary Differential Equations:(6 Lectures)** 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. **UNIT III: Laws of Motion: (10 Lectures)** Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **UNIT IV: Momentum and Energy: (6 Lectures)** Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. **UNIT V: Rotational Motion: (5 Lectures)** Angular velocity and angular momentum. Torque. Conservation of angular momentum. **UNIT VI: Gravitation: (8 Lectures)** Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. **UNIT VII : Oscillations: (6 Lectures)** Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

			UNIT VIII: Elasticity: (8 Lectures) Hooke's law- Stress-strain diagram - Elastic moduli- Relation between elastic constants- Poisson's Ratio- Expression for Poisson's ratio in terms of elastic constants- Work done in stretching & work done in twisting a wire- Twisting couple on a cylinder- Determination of Rigidity modulus by static torsion- Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η & σ by Searles method. **UNIT IX: Speed Theory of Relativity: (7 Lectures)** Constancy of speed of light. Postulates of special theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. ***Note:*** *Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.* ***Reference Books:*** 1. University Physics. FW Sears, MW Zemansky& HD Young13/e, 1986.Addison-Wesley 2. Mechanics Berkeley Physics course, v.1:Charles Kittel, et.al. 2007,Tata McGraw-Hill 3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley 4. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press 5. University Physics, Ronald Lane Reese, 2003, ThomsonBrooks/Cole.
	BCH-204	Environmental Studies	**Unit 1: Introduction to environmental studies** • Multi-disciplinary nature of environmental studies. • Scope and importance, Need for public

			awareness. **Unit 2: Ecosystems** • What is the ecosystem? Structure and the function of ecosystem; energy flow in an ecosystem. • Food chains, food webs and Ecological succession. Case studies of the following ecosystems: a) Forest ecosystem b) Grass and ecosystem c) Desert ecosystem **d)** Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) **Unit 3: Natural Resources: Renewable and Non-renewable Resources** • Land resources and land use change, land degradation, soil erosion and desertification. • Deforestation: Causes and impact due to mining dam building on environment, forest biodiversity and tribal population. • Water: Use and over-exploitation of surface and ground water, floods, drought, conflicts over water (international & inter-state). • Energy resources: Renewable and non-renewable energy resources, use of alternate energy sources, growin energy needs, case studies. **Unit 4: Biodiversity and Conservation** • Levels of biological diversity: genetic, species and ecosystem diversity. Bio geographic zones of India Biodiversity patterns and global biodiversity hotspots • India as a mega-biodiversity/ nation: endangered and endemic species of India. • Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions. Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity. • Ecosystem and biodiversity service ecological, economic social, ethical, aesthetic and informational value **Unit 5: Environmental Pollution**

			• Environmental pollution and its types, Causes, effects and control Air, water, soil and noise pollution. • Nuclear hazards and human health risks • Solid waste management: Control measures of urban and industrial waste. • Pollution case studies. **Unit 6: Environmental Policies and Practices** • Sustainability and sustainable development. • Climate change, global warming, ozone layer depletion, acid rain and impact on human communities and agriculture. • Environment laws: environment protection act (prevention and control of pollution); water (prevention and control of pollution) act; wildlife protection act; forest protection conservation act. • Nature reserves, Tribal population and rights, and human wildlife conflicts in Indian context. **Unit 7: Human Communities and Environment** • Human population growth: impact on environment, Human health and welfare • Resettlement and rehabilitation of project affected person; case studies. • Disaster management: floods, earthquakes, cyclones and landslides. • Environmental ethics, role of Indian and other religion and culture in environmental conservation. • Environmental communication and public awareness, case studies.(eg CNG vehicle in Delhi) **Unit 8: Field Work** • Visit to an area to document environmental assets: river/ forest/fauna etc. • Visit to a local polluted site-urban/rural/industrial • Study of common plant, insect, birds and basic principal of identification. • Study of simple ecosystem –pond, river, Delhi ridge etc.

	BCHPR-201	Practical Organic Chemistry – I	1. Checking the calibration of the thermometer 2. Purification of organic compounds by crystallization using the following solvents: a. Water b. Alcohol c. Alcohol- water. 3. Determination of the melting points of unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus) 4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds 5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method) 6. Chromatography a) Separation of a mixture of two amino acids by ascending and horizontal paper chromatography b) Separation of a mixture of two sugars by ascending paper chromatography c) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC) 7. Detection of extra elements 8. Organic Preparations • Bromination of acetanilide / aniline /phenol • Nitration of nitrobenzene /toluene. ***<u>Reference Books</u>*** • *Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education(2009)* • *Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry,5th Ed., Pearson(2012)*
	BCHPR-202	Practical Physical Chemistry – II	***<u>Thermochemistry:</u>*** (a) Determination of heat capacity of a calorimeter for different volumes using

			(i) change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization), and (ii) heat gained equal to heat lost by cold water and hot water respectively. (b) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide. (c) Determination of the enthalpy of ionization of ethanoic acid. (d) Determination of integral enthalpy (endothermic and exothermic) solution of salts. (e) Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step. (f) Determination of enthalpy of hydration of salt. (g) Study of the solubility of benzoic acid in water and determination of ΔH. Any other experiment carried out in the class. ***Reference Books:*** • *Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).* • *Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi(2001).*
	BCHPR-203	Practical Physics-I	**At least 05 experiments from the following:** 1. Measurements of length (or diameter) using vernier calipers, screw gauge and travelling microscope. 2. To determine the Height of a Building using a Sextant.

			3. To determine the Moment of Inertia of a Flywheel. 4. To determine the Young's Modulus of a Wire by Optical Lever Method. 5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle. 6. To determine the Elastic Constants of a Wire by Searle's method. 7. To determine g by Bar Pendulum. 8. To determine g by Kater's Pendulum. 9. To study the Motion of a Spring and calculate (a) Spring Constant(b) Value of g. ***Reference Books:*** • *Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.* • *Advanced level Physics Practicals, Michael Nelson and Jon M. Og born, 4th Edition, reprinted 1985, Heinemann Educational Publishers* • *Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.* • *A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011,KitabMahal,New Delhi.*
III	BCH-301	Inorganic Chemistry – II	**UNIT 1: General Principles of Metallurgy (Lecture-06)** Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, van Arkel-de Boer process and Mond's process, Zone refining. **UNIT 2: Chemistry of *s* Block Elements (Lecture-22)** (i) General characteristics: melting point, flame color, reducing nature, diagonal relationships and anomalous behavior of first member of each group.

			(ii) Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. (iii) Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, super oxides, carbonates, nitrates, sulphates. (iv) Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. (v) Solutions of alkali metals in liquid ammonia and their properties. **UNIT 3: Chemistry of *p* Block Elements (Lectures-06)** Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behavior of first member of each group. **UNIT 4: Structure, bonding and properties: acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat of the following: *(26 lectures)*** • Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group17. • Oxides: oxides of phosphorus, Sulphur and chlorine • Oxoacids: oxoacids of phosphorus and chlorine; per oxoacids of Sulphur • Halides: halides of silicon and phosphorus **Preparation, properties, structure and uses of the following compounds:** • Borazine

			• Silicates, silicones, • Phosphonitrilic halides {$(PNCl_2)_n$ where n = 3 and4} • Interhalogen and pseudo halogencompounds • Clathrate compounds of noble gases, xenon fluorides (MO treatment ofXeF_2). ***<u>Reference Books:</u>*** • *Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann.1997.* • *Lee J.D., Concise Inorganic Chemistry, Pearson Education 2010.* • *Douglas, B.E., Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994* • *Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley,VCH,1999.* • *Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 3rdEd.(adapted), Pearson,2009* • *Shriver, D.F., Atkins P.W and Langford, C.H., Inorganic Chemistry 2ndEd.,Oxford University Press,1994*
	BCH-302	Organic Chemistry – II	**Unit I: Chemistry of Halogenated hydrocarbons: [16 Lectures]** Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs elimination. Aryl halides: Preparation (including preparation from diazonium salt) and properties. Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism. Relative reactivity of Alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li Grignard reagent – Use in synthesis of organic compounds. **Unit II: Alcohols, Phenols, Ethers and**

			epoxide: [16 Lectures] Alcohols: preparation, properties and relative reactivity of 1^0, 2^0, 3^0 alcohols, Bouvaelt- Blanc Reduction. Oxidation of Diols by periodic acid and lead tetraacetate, Pinacol- Pinacolone rearrangement; Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer – Tiemann and Kolbe's – Schmidt Reactions, Fries and Claisen rearrangements with mechanism. Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$ **Unit III: Carbonyl Compounds: [16 Lectures]** Structure, reactivity, preparation and properties; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate. **Unit IV: Carboxylic Acids and their Derivatives: [12 Lectures]** General method of Preparation, physical properties and reactions of monocarboxylic acids, effect of substitution on acid strength. Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids. Preparation and reactions of acid chlorides,

			anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group - Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann- bromamide degradation and Curtius rearrangement. ***<u>Recommended Books:</u>*** *1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).* *2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).* *3. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.* **Practical Organic Chemistry – BCHPR-302 Lab** **1.** Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group. **2.** Organic preparations: i. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidine and o-, m-, p-anisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method: (a) Using conventional method. (b) Using green approach ii. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β -naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction. iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Selective reduction of meta dinitrobenzene to m-nitro aniline. v. Hydrolysis of amides and esters. vi. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. vii. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids

			(benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). viii. Aldol condensation using either conventional or green method. The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for re-crystallization and melting point. ***<u>Reference Books:</u>*** •*Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)* •*Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)* •*Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).* •*Ahluwalia, V.K. &Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).*
	BCH-303	Physical Chemistry – III	**UNIT-1 Phase Equilibria [27 Lectures]** Concept of phases, components and degrees of freedom, derivation of Gibbs Phase rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems (H_2O and S), with applications, phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points. Three component systems; triangular plots, water-chloroform-acetic acid system. Binary solution; Gibbs-Duhem-Margules equation, its derivation and application to fractional distillation of binary miscible of liquids(ideal and non-ideal), azeotropes lever rule partial miscibility of liquids, CST, miscible pairs,

			steam distillation. Nernst distribution law; its derivation and applications. **UNIT-2 Electrochemical cells [27 Lectures]** Rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; standard electrode (reduction), potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone- hydroquinone, glass and $SbO/Sb2O_3$ electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). **UNIT -3 Surface Chemistry [6 Lectures]** Physical adsorption, chemisorption, adsorption isotherms (Langmuir and Freundlich), nature of adsorbed state. Qualitative discussion of BET. ***Reference Books:*** • *Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press(2010).* • *Castellan, G. W. Physical Chemistry, 4th Ed., Narosa(2004).* • *McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.:New Delhi (2004). • Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall(2012).* • *Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY(2011).* • *Zundhal, S.S. Chemistry concepts and applications Cengage India (2011). • Ball, D.W. Physical Chemistry Cengage India(2012).* • *Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP(2009).*

			• *Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill(2011).* • *Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill(2009).*
	BCH-304	Physics –II	**UNIT 1 Crystal Structure: (14 Lectures)** Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **UNIT 2 Elementary Lattice Dynamics: (10 Lectures)** Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids (qualitative only).T^3law **UNIT 3 Magnetic Properties of Matter: (12 Lectures)** Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **UNIT 4 Dielectric Properties of Materials: (11 Lectures)** Polarization, Local Electric Field at an Atom, Depolarization Field, Electric Susceptibility. Polarizability, Clausius Mosotti Equation. Classical Theory of Electric Polarizability, Normal and Anomalous Dispersion, Cauchy and Sellmeir relations, Langevin-Debye equation, Complex Dielectric Constant. Optical Phenomena, Application:

			Plasma Oscillations, Plasma Frequency, Plasmons. **UNIT 5 Elementary band theory: (10 Lectures)** Kronig Penny model. Band gaps, Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient. **UNIT 6 Superconductivity:** (3 Lectures) Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors. ***Reference Books:*** • *Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley IndiaPvt.* • *Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India* • *Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-GrawHill* • *Solid State Physics, N. W. Ashcroft and N. David Mermin, 1976, Cengage Learning* • *Solid State Physics, M.A., Wahab 2011, Narosa Publication.*
	Industrial Training		
	BCHPR-301	Practical Inorganic Chemistry – II	**A. Iodo / IodimetricTitrations** (i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphatesolution (Iodometrically). (ii) Estimation of antimony in tartar-emetic iodimetrically. **B. Complexometric titrations using disodium salt of EDTA** (iii) Estimation of Mg^{2+},Zn^{2+} (iv) Estimation of Ca^{2+} by substitution method **C. Inorganic Preparations** (i) Cuprous Chloride,Cu_2Cl_2 (ii) Manganese(III) phosphate,$MnPO_4.H_2O$

			(iii) Aluminum potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum. ***Reference Books:*** • *Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.1978* • *Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.*
	BCHPR-302	Practical Organic Chemistry – II	Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group. Organic preparations: ix. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidine and o-, m-, p-anisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method: (c) Using conventional method. (d) Using green approach x. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β -naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction. xi. Oxidation of ethanol/ isopropanol (Iodoform reaction). xii. Selective reduction of meta dinitrobenzene to m-nitro aniline. xiii. Hydrolysis of amides and esters. xiv. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. xv. S-Benzylisothiouronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). xvi. Aldol condensation using either conventional or green method. The above derivatives should be prepared using 0.5-1g of the organic compound. The

			solid samples must be collected and may be used for re-crystallization and melting point. ***<u>Reference Books:</u>*** •*Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)* •*Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)* •*Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).* •*Ahluwalia, V.K. &Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).*
	BCHPR-303	Practical Physical Chemistry – III	**Phase Equilibria:** **I.** Determination of critical solution temperature and composition at CST of the phenol- water system and to study the effect of impurities of sodium chloride and succinic acid on it. **II.** Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems. **III.** Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane. **IV.** Study the equilibrium of at least one of the following reactions by the distribution method: a) I_2 (aq) + I^-(aq)→I_3(aq) b) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n^{2+}$ **Potentiometry:** **V.** Perform the following potentiometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Dibasic acid vs. strong base iv. Potassium dichromate vs. Mohr's salt

			Reference Books: • *Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R.Chand & Co.: New Delhi (2011).25* • *Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York(2003).* • *Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.;W.H. Freeman & Co.: New York(2003*).
	BCHPR-304	Practical Physics -II	***AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING*** 1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method) 2. To measure the Magnetic susceptibility of Solids. 3. To determine the Coupling Coefficient of a Piezoelectric crystal. 4. To measure the Dielectric Constant of a dielectric Materials with frequency 5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR). 6. To determine the refractive index of a dielectric layer using SPR. 7. To study the PE Hysteresis loop of a Ferroelectric Crystal. 8. To draw the BH curve of iron using a Solenoid and determine the energy loss fromHysteresis. 9. To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150^{o}C) by four-probe method and to determine its bandgap. 10. To determine the Hall coefficient of a semiconductor sample. ***Reference Books*** • *Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing*

			House. • *Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers* • *Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice- Hall of India*
IV	BCH-401	Inorganic Chemistry – III	**Unit I : Coordination Chemistry: (26 Lectures)** Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors effecting the magnitude of 10 Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6

			coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes. **Unit II: Transition elements: (14 Lectures)** General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states with special of reference to the following compounds: peroxo compounds of chromium, potassium dichromate, potassium permagnate, potassium ferrocyanide, potassium ferricyanide,sodium nitroprusside and sodium cobaltinitrite. **Unit III: Lanthanoids and Actinoids: (6 Lectures)** Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). **Unit IV Inorganic reaction mechanism: (14 Lectures)** Introduction to inorganic reaction mechanism, substitution reaction in squre planer complexs, trans effect , theory trans effect thermodynamics and kinetic stability. ***Recommended Books:*** 1. *Purecell, K.F. and Kotz, J.C., Inorganic Chemistry W.B. Saunders Co.1977.* 2. *Huheey, J.E., Inorganic Chemistry, Prentice Hall,1993.* 3. *Cotton, F.A. & Wilkinson, G., Advanced Inorganic Chemistry Wiley-VCH,1999* 4. *Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley& Sons,*

			NY,1967. 5. *Greenwood, N.N. & Earnshaw A., Chemistry of the Elements, Butterworth- Heinemann,1997.* 6. *Miessler, G. L. &. Tarr, Donald A. Inorganic Chemistry 3rd Ed.(adapted), Pearson, 2009*
	BCH-402	Organic Chemistry – III	**Unit I: Nitrogen Containing Functional Groups (18 Lectures)** Preparation and important reactions of nitro compounds, nitriles and isonitriles. Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1^0, 2^0 and 3^0 amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications. **Unit II: Polynuclear Hydrocarbons (8 Lectures)** Aromaticity of polynuclear hydrocarbons, Strucrure elucidation of naphthalene; preparation and properties of naphthalene, phenantherene and anthracene. **Unit III: HeterocyclicCompounds (22 Lectures)** Classification, nomenclature and structure, aromaticity in 5-membered and 6-membered rings containing one hetero atom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Structure elucidation of quinoline and isoquinoline,(Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis), Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction.

			Unit IV: Alkaloids (6 Lectures) Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. **Unit V: Terpenes (6 Lectures)** Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of citral. ***Recommended Books:*** 1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). **3.** Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt.Ltd. (Pearson Educaion).
	BCH-403	Physical Chemistry – IV	**UNIT I : Conductance (18 Lectures)** Quantitative aspects of faraday's laws of electrolysis Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Huckle theory Debye-Huckle-Onsager equation, Wein effect. Debye-Falkenhagen effect, Walden's rules. Ionic velocities, Ionic mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak

			electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometirc titrations, and (v) hydrolysis constants of salts. **UNIT II: Chemical Kinetics: (22 Lectures)** Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (Steady-State Approximation in reaction mechanism (iv) chain reactions. Temperature dependence of reaction rates, Arrhenius equation activation energy collision theory of reaction rates, Lindeman mechanism, qualitative treatment of the theory of absolute reaction rates. **UNIT III: Catalysis: (8 Lectures)** Types of catalyst, specificity and selectivity, mechanism of catalyzed reaction at solid surfaces. Enzymes catalysis, Michaelis-Menten mechanism, acid – base catalysis. **UNIT IV: Photochemistry: (12 Lectures)** Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficient. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reaction, photosensitized reactions, quenching, Role of photochemical reactions in biochemical processes, photostationary state, chemiluminescence. Photochemical formation of smog. Jablonski diagram in photochemistry.

			Reference Books: • *Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press(2011).* • *Castellan, G. W. Physical Chemistry 4th Ed., Narosa(2004).* • *Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP(2009).* • *Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi(2006).* • *Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall(2012).* • *Rogers, D. W. Concise Physical Chemistry Wiley(2010).* • *Silbey,R.J.;Alberty,R.A.&Bawendi,M.G.PhysicalChemistry4thEd.,JohnWiley&Sons, Inc.(2005).*
	BCH-404	Analytical clinical Biochemistry	**UNIT 1 Introduction**: Basic understanding of the structures, properties and functions of carbohydrates, lipids and proteins: Review of concepts studied in the core course: **UNIT 2 Carbohydrates:** Biological Importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Isolation and characterization of polysachharides. **UNIT 3 Proteins:** Classification, biological importance; Primary and secondary and tertiary structures of proteins: α–helix and β-pleated sheets, Isolation, characterization, denaturation of proteins. Enzymes: Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in Green Chemistry and Chemical Industry. **UNIT 4 Lipids:** Classification, Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and

			their biological functions and underlying applications. Lipoproteins: Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones. **UNIT 5 Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA:** Replication, Transcription and Translation, Introduction to Gene therapy. Enzymes: Nomenclature, classification, effect of pH, temperature on enzyme activity, enzyme inhibition. Biochemistry of disease: A diagnostic approach by blood/ urine analysis. **UNIT 6 Blood:** Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin. **UNIT 7 Urine:** Collection and preservation of samples. Formation of urine. Composition and estimation of constituents of normal and pathological urine. ***Reference Books:*** •T.G. Cooper: Tool of Biochemistry. • Keith Wilson and John Walker: Practical Biochemistry. •Alan H Gowenlock: Varley's Practical Clinical Biochemistry. •Thomas M. Devlin: Textbook of Biochemistry. •Jeremy M. Berg, John L Tymoczko, Lubert Stryer: Biochemistry. •G. P. Talwar and M Srivastava: Textbook of Biochemistry and Human Biology. •A.L. Lehninger: Biochemistry.

			•O. Mikes, R.A. Chalmers: Laboratory Handbook of Chromatographic Methods.
	BCH-405	Mathematics	**UNIT I:** First order ordinary differential equations: Basic concept and ideas, Exact differential equations, integrating factors, Bernoulli equations, orthogonal trajectories of curves, Existence of uniqueness of solutions, Second order differential equations: Homogenous linear equations of second order, Second order homogenous equations with constant coefficients, differential operators, Euler Cauchy equation. **UNIT II:** Existence and uniqueness theory, Wronskian, Non homogenous ordinary differential equations, solution by undetermined coefficients, Solution by variation of parameters , Higher order homogenous equations with constant coefficients system of differential equations, system of differential equations, conversion of Nth order ODEs to a system, Basic concepts and ideas, Homogenous system with constant coefficients. **UNIT III:** Power series method: Theory of power series method, legendre's equation, Legendre polynomial, Partial differential equation: basic concepts and definitions, Mathematical problems, First order equations: Classification, Construction, Geometrical interpretation, method of characteristics, general solution of first order partial differential equations, Canonical Forms and Method of separation of variables for first order partial differential equations, Classification of second order partial differential equations, reduction to Canonical Forms, second order partial differential equations with constant coefficients, general solutions. ***Reference Books:*** • *Mc Quarrie, D. A. Mathematics for Physical*

			Chemistry University Science Books(2008). • *Mortimer, R. Mathematics for Physical Chemistry. 3 Ed. Elsevier(2005).* • *Steiner, E. The Chemical Maths Book Oxford University Press(1996).* • *Yates, P. Chemical calculations. 2 Ed. CRC Press(2007).* • *Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters3-5.* • *Levie, R. de, How to use Excel in analytical chemistry and in general scientificdata analysis,* • *Cambridge Univ. Press (2001) 487pages.* • *Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co.(1985).* • *Venit, S.M. Programming in BASIC: Problem solving with structure and style.Jaico Publishing House: Delhi(1996).*
	BCHPR-401	Practical Inorganic Chemistry – III	**Gravimetric Analysis:** i. Estimation of nickel (II) using Dimethylglyoxime (DMG). ii. Estimation of copper as CuSCN iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$. iv. Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminiumoxinate). **Inorganic Preparations:** i. Tetraamminecopper (II) sulphate,$[Cu(NH_3)_4]SO_4.H_2O$ ii. Acetylacetonate complexes ofCu^{2+}/Fe^{3+} iii. Tetraamminecarbonatocobalt (III)nitrate iv. Potassium tri(oxalato)ferrate(III) **Properties of Complexes** i. Measurement of 10 Dq by spectrophotometric method ii. Verification of spectrochemical series. iii. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions(e.g. bi-dentate ligands like acetyl acetone, DMG, glycine) by substitution method. ***Reference Book:***

			• *Vogel, A.I. A text book of Quantitative Analysis, ELBS1986.* • *G. Marr and B.W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold.1972*
	BCHPR-402	Practical Organic Chemistry – III	***1.*** Functional group test for nitro, amine and amide groups. *2.* Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols , carbonyl compounds and esters) ***<u>Reference Books:</u>*** •*Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)* •*Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)* •*Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).*
	BCHPR-403	Practical Physical Chemistry – IV	**<u>Conductometry</u>:** I. Determination of cell constant II. Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid. III. Perform the following conductometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Mixture of strong acid and weak acid vs. strong base iv. Strong acid vs. weak base **<u>Chemical Kinetics:</u>** IV. Study the kinetics of the following reactions. 1. Iodide-persulphate reaction (i) Initial rate method; (ii)Integrated rate method

			2. Acid hydrolysis of methyl acetate with hydrochloric acid. 3. Saponification of ethylacetate. ***4.*** Comparison of the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methylacetate. ***<u>Reference Books:</u>*** • Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand &Co.: New Delhi(2011). • Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York(2003). • Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
V	BCH-501	Organic Chemistry – IV	**Unit I: Nucleic Acids (Lecture-09)** Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides. (DNA and RNA) **Unit II: Amino acids, Peptides and Proteins (Lecture-18)** Amino acids, Peptides and their classification. .α-Amino Acids-Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups - Solid-phase synthesis primary and secondry and tertiary structure of protein denaturation **Unit III: Enzyme (Lecture-06)** Introduction, classification and characteristics of enxymes. Salient features of active site or enzyme .Mechnism of enzyme action (taking trypsin as example), factors affecting enzyme action coenzyme

			and cofactors, specificity of enzyme action (including sterospecificity) enzyme inhibitors and their importantance. **Unit IV: Lipids (Lecture-08)** Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity. **Unit V: Concept of Energy in Biosystems (Lecture-07)** Cells obtain energy by the oxidation of food stuff (organic molecule)Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs Cycle. Caloric value of food, standred caloric contain of food types **Unit VI: Pharmaceutical Compounds: Structure and Importance (Lecture-12)** Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis).An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine) **Reference Books :** 1. Berg, J. M., Tymoczko, J. L.& Stryer, L.(2006) *Biochemistry***.** Sixth Edition, W. H.Freeman & Co**.** 2. Nelson, D. L. Cox, M. M. *Lehninger's* ***A.L.****(2009) Principles of Bioch*emistry, Fourth Edition, W. H.Freeman and Co**.** 3. Murray**, R.K.,** Granner**, D.K.,** Mayes**,** P.A, and Rodwell, V.W. (2009) Harper's Illustrated

			Biochemistry . XXVIII Edition. Lang Medical Books/ Mc Graw-Hill.
	BCH-502	Physical Chemistry – V	**Unit-I: Quantum Chemistry: (Lecture-15)** Postulates of quantum mechanics, quantum mechanical operators and commutation rule, Setting up of Schrödinger equation and its application to free particle and particle in a box (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg uncertainty principle; wave function, probability distribution functions, nodal properties, extension to two and three dimensional boxes, separation of variables degeneracy qualitative treatment of simple harmonic oscillator model of vibrational motion; setting up of Schrödinger equation and discussion of solution wave functions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrodinger equation in Cartesian and spherical polar (derivation not required). Separation of variables, spherical harmonics. setting up of Schrödinger equation for many-electron atoms (He, Li), need for approximation methods, statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom). **Unit-II: Chemical Bonding : (Lecture-15)** Covalent bonding, valence bond and molecular orbital approaches, LCAO- MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). **Unit-III: Spectroscopy: (Lecture-30)** **Molecular Spectroscopy:** Interaction of

			electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation. **Rotational Spectroscopy:** Selection rules, intensities of spectral lines, determination of bond length of diatomic and linear triatomic molecules, isotopic substitution; **Vibrational Spectroscopy:** Classical equation of vibration, computation of force constants, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies, vibration-rotation spectroscopy diatomic vibrating rotator, P, Q, R branches. Raman spectroscopy: qualitative treatment of rotational Raman Effect; effect of nuclear spin, vibrational Raman spectra, stokes and anti-stokes lines, their intensity difference, rule of mutual exclusion. **Electronic Spectroscopy:** Franck-Condon principle, electronic transition, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation, calculation of electronic transition of polyenes, using free electron Models. **Nuclear Magnetic Resonance (NMR) Spectroscopy:** Principle of NMR spectroscopy, larmour procession, chemical shift and low resolution spectra, different scales (δ and τ), spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) Spectroscopy: Its principle, hyperfine structure, ESR of simple radicals. ***Reference Books:*** 1. *Banwell,C.N. & McCash, E.M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).* 2. *Chandra, A.K. Introductory Quantum Chemistry Tata McGraw-Hill (2001). :**HOUSE, J.E.** Fundamentas of Quantum Chemistry 2ND Ed. Elsevier: **USA** (2004).* 3. *Lowe, J.P. & Peterson ,K. Quantum*

			Chemistry,Acadmeic Press (2005). **4.** *Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).*
	BCH-503	Analytical Methods in Chemistry	**Unit I : Qualitative and Quantitative aspects of analysis (Lecture-05)** Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F, Q and T test, rejection of data, and confidence intervals. **Unit II: Optical methods of analysis (Lecture-25)** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer- Lambert's law. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principle of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers *Flame Atomic Absorption and Emission Spectrometry*: Basic principles of instrumentation (choice of source, monochromator, detector, Choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples. **Unit III: Thermal method of analysis (Lecture-05)** Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. **Unit IV: Electroanalytical methods**

			(Lecture-10) Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence point. Techniques used for the determination of pK_a values. **Unit V: Separation Techniques (Lecture-15)** ***Solvent extraction***: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non aqueous media. ***Chromatography*:** Classification and principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. ***Recommended Books:*** 1. *Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by GH Jeffery and others) 5th Ed. The English Language Book Society of Longman* 2. *Willard, Hobert H. et. al: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.* 3. *Christian, Gary D; Analytical Chemistry, 6th Ed. New York- John Willy, 2004.* 4. *Harris, Daniel C: Exploring Chemical Analysis, 2nd Ed. New York, W.H. Freeman, 2001.* 5. *Khopkar, S.M. Basic Concepts of Analytical Chemistry New Age, International Publisher, 2009.* 6. *SKoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.*

			7. *Mikes, O. & Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.* 8. *Ditts, R.V. Analytical Chemistry – Methods of separation.*
	BCH-504	Inorganic Materials for Industrial Importance	**Unit-I: Silicate Industries (Lectures-16)** *Glass:* Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass. *Ceramics:* Brief introduction to types of ceramics. Superconducting and semiconducting oxides, fullerenes, carbon nanotubes and carbon fibre. *Cements:* Manufacture of cement and the setting process, quick setting cements. **Unit-II: Fertilizers (Lectures-08)** Different types of fertilizers (N, P and K). Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime. **Unit-III: Surface Coatings (Lectures-04)** Brief introduction and classification of surface coatings. Paints and pigments- formulation, composition and related properties. Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, Metallic coatings (electrolytic and electroless), metal spraying and anodizing. **Unit-IV: Batteries (Lectures-10)** Working of the following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

			Unit-V: Catalysis (Lecture-06) General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Application of zeolites as catalysts. **Unit-VI: Chemical explosives (Lecture-06)** Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants. ***Reference Books:*** • *Stocchi, E., Industrial Chemistry, Vol I, Ellis Horwood Ltd. UK,1990* • *Felder, R. M. and Rousseau, R.W., Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi, 2005.* • *Kingery, W. D., Bowen H. K. and Uhlmann, D. R. Introduction to Ceramics, Wiley Publishers, New Delhi,1976.* • *Kent, J.A.(ed) Riegel's Handbook of Industrial Chemistry,9th Ed.,CBS Publishers, New Delhi,1997* • *Jain, P. C. and Jain, M. Engineering Chemistry, Dhanpat Rai & Sons, Delhi 2005* • *Gopalan, R., Venkappayya, D. and Nagarajan, S. Engineering Chemistry, Vikas Publications, New Delhi,2004.* • *Sharma, B. K. Engineering Chemistry, Goel Publishing House, Meerut,2006*
	BCHPR-501	Practical Organic Chemistry – IV	**1.** Estimation of glycine by Sorenson's formalin method. **2.** Study of the titration curve of glycine. **3.** Estimation of proteins by Lowry's method. **4.** Study of the action of salivary amylase on starch at optimum conditions. **5.** Effect of temperature on the action of salivary amylase. **6.** Saponification value of an oil or a fat.

			7. Determination of Iodine number of an oil/fat. 8. Isolation and characterization of DNA from onion/cauliflower/peas. ***<u>Reference Books:</u>*** • Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi. • Arthur, I. V. Quantitative Organic Analysis, Pearson.
	BCHPR-502	Practical Physical Chemistry – V	**<u>COLORIMETRY:</u>** 1. Verify Lambert-Beer's Law and determination the concentration of CuSo4/KMnO4/K2Cr2O7 in a solution of unknown concentration. 2. Determine the concentration of KMnO4 and K2Cr2O7 in a mixture. 3. Study the kinetics of iodination of propanone in acidic medium. 4. Determine the amount of iron present in a sample using 1, 10-Phenathroline. 5. Determine the dissociation constant of an indicator (Phenophetalin). 6. Study the kinetics of interaction of crystal violet/ phenophtalein with sodium hydroxide. 7. Analysis of the given vibration –rotation spectrum of HCl(g). **<u>ADSORPTION :</u>** Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal. **<u>UV/VISIBLE SPECTROSCOPY:</u>** 1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1M H_2SO_4) And determine the ƛmax values. Calculate the energies of the two transition in different units (J molecule-1, kJ mol-1 cm-1, eV). 2. Study the pH dependence of the UV-Visible spectrum (200-500 nm) of $K_2Cr_2O_7$. 3. Record the (200-350 nm) UV spectra of the given compounds (Acetone, acetaldehyde, 2-propanol, Acetic acid) in water. Comment on

			the effect of structure of UV spectra of organic compound. ***Reference Books:*** • Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand& Co.: New Delhi (2011). • Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8thEd.; McGraw-Hill: New York(2003). • Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman& Co.: New York(2003).
	BCHPR-503	Practical Analytical Methods in Chemistry	***Separation Techniques:*** **Chromatography**: (a) Separation of mixtures (i) Paper chromatographic separation of Co^{2+}andNi^{2+}. (ii)Separation and identification of the amino acids present in the given mixture by paper chromatography. Reporting the Rf values. **Solvent Extractions:** (i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry. **Analysis of soil:** (i) Determination of pH of soil. (ii) Total soluble salt (iii) Estimation of calcium, magnesium (iv) Qualitative detection of nitrate, phosphate **Ion Exchange:**

			(i) Determination of exchange capacity of cation exchange resins and anion exchange resins. (ii) Separation of amino acids from organic acids by ion exchange chromatography. **Spectrophotometry** Verification of Lambert-Beer's law and determination of concentration of a coloured species ($CuSO_4$,$KMnO_4$). ***Reference Books:*** • *Vogel, Arthur I: A Text book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .* • *Willard, Hobart H. et al.: Instrumental Methods of Analysis, 7th Ed. Wards worth Publishing Company, Belmont, California, USA,1988.* • *Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.* • *Harris, DanielC: Exploring Chemical Analysis, Ed. NewYork,W.H.Freeman,2001.* • *Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher,2009.* • *Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore,1998.* • *Mikes, O. & Chalmers, R.A. Laboratory Hand Book of Chromatographic &Allied Methods, Elles Horwood Ltd. London.* • *Dilts, R.V. Analytical Chemistry – Methods of separation Van Nostrand1974*
	BCHPR-504	Practical Inorganic Materials for Industrial Importance	1. Determination of free acidity in ammonium sulphate fertilizer. 2. Estimation of Calcium in Calcium ammonium nitrate fertilizer. 3. Estimation of phosphoric acid in superphosphate fertilizer. 4. Electroless metallic coatings on ceramic and plastic material. 5. Determination of composition of dolomite(by

			complexometric titration). 6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples. 7. Analysis of Cement. 8. Preparation of pigment (zinc oxide). ***<u>Reference Books:</u>*** • *Stocchi, E., Industrial Chemistry, Vol I, Ellis Horwood Ltd. UK,1990* • *Felder, R. M. and Rousseau, R.W., Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi,2005.* • *Kingery, W. D., Bowen H. K. and Uhlmann, D. R. Introduction to Ceramics, Wiley Publishers, New Delhi,1976.* • *Kent,J.A.(ed)Riegel'sHandbookofIndustrial Chemistry,9th Ed.,CBS Publishers,New Delhi,1997* • *Jain, P. C. and Jain, M. Engineering Chemistry, Dhanpat Rai & Sons, Delhi.* • *Gopalan, R., Venkappayya, D. and Nagarajan, S. Engineering Chemistry, Vikas Publications, New Delhi,2004.* • *Sharma, B. K. Engineering Chemistry, Goel Publishing House, Meerut,2006*
VI	BCH-601	Organic Chemistry – V	**Unit I: Organic spectroscopy (Lectures-24)** General principles Introduction to absorption and emission spectroscopy. **UV Spectroscopy:** Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ_{max} for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers. **IR Spectroscopy:** Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-

			bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis. **NMR Spectroscopy**: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin–Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds. Applications of IR, UV and NMR for identification of simple organic molecules. **Unit II: Carbohydrates (Lectures-16)** Occurrence, classification and their biological importance. **Monosaccharides:** Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Inter-conversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; **Disaccharides** – Structure elucidation of maltose, lactose and sucrose **Polysaccharides** – Elementary treatment of starch, cellulose. **Unit III: Dyes (Lectures-08)** Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: **Azo dyes** – Methyl Orange; Triphenyl Methane Dyes - Malachite Green, Rosaniline. **Phthalein Dyes** – Phenolphthalein and Fluorescein. **Natural dyes** –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples. **Unit IV: Polymers (Lectures-12)** Introduction and classification including di-block, tri-

			block and amphiphilic polymers **Polymerisation reactions** - Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes **Preparation and applications of plastics** – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); **Fabrics –** natural and synthetic (acrylic, polyamido, polyester) **Rubbers –** natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; **Polymer additives-** Introduction to polymers; Biodegradable and conducting polymers with examples. **Reference Books:** *1. Kalsi, P.S.Textbook of Organic Chemistry (1stEd.), New Age International (P) Ltd. Pub.* *2. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).* *3. Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons,Inc.* *4. Gowariker, V. R., Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd.Pub.* *5. Graham Solomons, T.W. Organic Chemistry, John Wiley &Sons,Inc.* *6. Clayden, J;Greeves N.Wareen S ; Wothers, P; Organic Chemistry , Oxford University Press.* *7. Kemp, W .Organic Spectroscopy, Palgrave.*
	BCH-602	Inorganic Chemistry – IV	**UNIT–I Theoretical Principles in Qualitative Analysis (H_2S Scheme) (Lectures -12)** Basic principles involved in analysis of cations and

			anions. Solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II. **UNIT–II Organometallic Compounds (Lectures-26)** Definition and classification of **organometallic** compounds on the basis of bond type. Concept of hapticity of organic ligands. **Metal carbonyls**: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. **Zeise's salt**: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. **Ferrocene**: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. **UNIT– III Bioinorganic Chemistry (Lectures-14)** Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium /K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine, Cis-platin as an anti-

			cancer drug. Iron and its application in bio-systems, Haemoglobin, Myoglobin; Storage and transfer of iron. **UNIT–IV Catalysis by Organometallic Compounds (Lectures-08)** Study of the following industrial processes and their mechanism: 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Synthetic gasoline (Fischer Tropsch reaction) 3. Polymerisation of ethene using Ziegler-Natta catalyst ***Reference Books:*** • *Vogel, A.I. Qualitative Inorganic Analysis, Longman,1972* • *Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996-03-07.* • *Lippard, S.J. & Berg, J.M., Principles of Bioinorganic Chemistry Panima Publishing Company1994.* • *Cotton, F.A., Wilkinson, G., & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,* • *Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993,Pearson,2006.* • *Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education)2005* • *Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry3rd Ed., John Wiley and Sons, NY,1994.* • *Greenwood, N.N. & Earnshaw, A. Chemistry of the Elements 2nd Ed, Elsevier, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).* • *Lee, J.D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons2008.*

			• *Powell, P. Principles of Organometallic Chemistry, Chapman andHall,1988.* • *Shriver, D.D., Atkins, P. and Langford, C.H., Inorganic Chemistry 2nd Ed., Oxford University Press,1994.* • *Purcell, K.F. & Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co.1977* • *Miessler, G. L. & Tarr, Donald A., Inorganic Chemistry 4th Ed., Pearson,2010.* • *Collman, James P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books,1987.* • *Crabtree,RobertH. The Organometallic Chemistry of the Transition Metals. John Wiley New York, NY,2000.* • *Spessard, Gary O., & Miessler, Gary L., Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall,1996.*
	BCH-603	Applications of Computers in Chemistry	**UNIT–I Basic Computer system (Lectures:18)** Basics of Computer: Introduction to digital computer, basic operations of computer, functional components of computer, Classification of computers. Introduction to operating system: [DOS, windows, linux and android] purpose, function, services and types, Number system: Binary, octal and hexadecimal number systems, their mutual conversions, Binary arithmetic. Basics of programming: approaches to Problem solving, concept of algorithm and flow charts, types of computer languages: Machine language, assembly language and high level language, concept of assembler, compiler. **UNIT 2: (Lectures:12)** Standard I/O in "C", Fundamental Data Types and Storage Classes: Character types, Integer, short, long, unsigned, single and double-precision floating point, storage classes, automatic, register, static and external, Operators and Expressions: Using numeric and relational operators, mixed operands and type conversion, Logical operators, Bit operations,

			Operator precedence and associativity. **UNIT 3: (Lectures:12)** Conditional Program Execution: Applying if and switch statements, nesting if and else, restrictions on switch values, use of break and default with switch, Program Loops and Iteration: Uses of while, do and for loops, multiple loop variables, assignment operators, using break and continue, Modular Programming **UNIT 4: (Lectures:9)** Arrays: Array notation and representation, manipulating array elements, using multidimensional arrays. Structure, union, Functions: introduction, types of functions, functions with array, recursive functions. **UNIT 5: (Lectures:9)** Concept of OOP: Abstraction, Encapsulation, Inheritance, and Polymorphism in C++, MS-Office, Introduction to CHEMDRAW.
	BCH-604	Polymer Chemistry	**Unit I: Introduction and history of polymeric materials (Lectures-04)** Different Schemes of Classification of Polymers, Polymer nomenclature, Molecular forces andchemical Bonding in Polymers, Texture of Polymers. **Unit II: Functionality and its importance (Lectures-08)** Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems. **Unit III: Kinetics of Polymerization (Lectures-08)**

			Mechanism and Kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerization, Mechanism and kinetics of copolymerization , and polymerization technique. **Unit IV: Crystallization and Crystallinity (Lectures-04)** Determination of Crystalline melting point and degree of Crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. **Unit V: Nature and structure of polymers (Lectures-02)** Structure Property relationships. **Unit VI: Determination of molecular weight of polymers (Lectures-08)** (Mn, Mw, etc), by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. **Unit VI: Glass transition temperature (Tg) and determination of Tg (Lectures-08)** Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg). **Unit VII: Polymer Solution (Lectures-08)** Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures. **Unit VIII: Properties of Polymers (Lecture-10)**

			(Physical, thermal, Flow & Mechanical Properties). Brief introduction to preparation, structure, properties and application of the following polymers: Polyolefins, Polystyrene and styrene copolymers, Poly (vinyl chloride) and related polymers, Poly (vinyl acetate) and related polymers, Acrylic polymers, Fluoro Polymers, Polyamides and related polymers. Phenol formaldehyde Resins (Bakelite, Novalac), Polyurethanes, Silicone Polymers, Polydienes, Polycarbonates, Conducting Polymers, [Polyacetylene, Polyaniline, Poly (p-phenylene sulphide Polypyrole, Polythiophene)]. ***<u>Reference Books:</u>*** 1. *Seymour Polymer Chemistry, Marcel Dekker, Inc.* 2. *G.Odian: Principle Of Polymerisation, John Wiely.* 3. *F.W. Billmeyer: Text Book of Polymer Science, John wiely.* 4. *P.Ghosh: Polymer Science & Technology, Tata Megraw-Hill.* 5. *R.W. Lenz: Organic Chemistry of Synthesis High Polymers.*
	BCHPR-601	Practical Organic Chemistry – V	1. Extraction of caffeine from tea leaves. 2. Preparation of urea formaldehyde resin. 3. Qualitative analysis of unknown organic compounds containing mono functional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, e.g. salicylic acid, cinnamic acid, nitrophenols etc. 4. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided). 5. Preparation of methyl orange. ***<u>Reference Books:</u>*** • *Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).* •*Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)*

			•*Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)* •*Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).* •*Ahluwalia, V.K. &Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).*
	BCHPR-602	Practical Inorganic Chemistry – IV	Qualitative semi micro-analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: CO_3^{2-}, NO_2^-, S^{2-}, SO_4^{2-}, SO_3^{2-}, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+},Sb^{3+} Ag^+,Hg_2^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, As^{3+}, Sn^{4+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg_2^+,Na^+ Mixtures should preferably contain one interfering anion, **or** insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, PO_4^{3-} NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot tests should be done whenever possible. Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions: • Ni (II) and Co(II) • Cu(II) and Cd(II) ***<u>Reference Books</u>:*** • *Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.* • *Vogel, A.I. A Textbook of Quantitative Analysis, ELBS.1986*
	BCHPR-	Practical Applications of	1. WAP that accepts the marks of 5 subjects and finds

	603	Computers Chemistry	the sum and percentage marks obtained by the student. 2. WAP that calculates the Simple Interest and Compound Interest. (The Principal, Amount, Rate of Interest and Time are entered through the keyboard). 3. WAP to calculate the area and circumference of a circle. 4. WAP that accepts the temperature in Centigrade and converts into Fahrenheit using the formula C/5=(F-32)/9. 5. WAP that swaps values of two variables using a third variable. 6. WAP that checks whether the two numbers entered by the user are equal or not. 7. WAP to find the greatest of three numbers that finds whether a given number is even or odd. 9. WAP that tells whether a given year is a leap year or not. 10. WAP to demonstrate the use of switch case statement. 11. WAP to understand the concept of pointers. 12. WAP to print the sum of all numbers up to a given number. 13. WAP to find the factorial of a given number. 14. WAP to print sum of even and odd numbers from 1 to N numbers. 15. WAP to print the Fibonacci series. 16. WAP to check whether the entered number is prime or not. 17.WAP to find the sum of digits of the entered number. 18. WAP to find the reverse of a number. 19. WAP to print Armstrong numbers from 1 to 100. 20. WAP to convert binary number into decimal

			number and vice versa. 21. WAP that simply takes elements of the array from the user and finds the sum of these elements. 22. WAP that inputs two arrays & saves sum of corresponding elements of these arrays in third array & prints them. 23. WAP to find the minimum and maximum element of the array. ***Reference Books:*** 1. Computer Concepts and Programming in C, Vikas Gupta, Wiley India Publication 2. Computer Concepts and Programming , Anami, Angadi and Manvi, PHI Publication 3. C programming by Kernighan and Ritchie, PHI 4. Computer Fundamentals and Programming in C. Reema Thareja, Oxford Publication 5. Computer Concepts and Programming in C, E Balaguruswami, McGraw Hill 6. Computer Concepts and Programming in C by D.S. Yadav and Rajeev Khanna, New Age International Publication 7. Programming in C, A Practical approach by Ajay Mittal, Pearson Publication 8. Computer Fundamental and C programming by K K Gupta, Acme Learning Publication 9. Problem Solving and Program Design in C, by Jeri R. Hanly, Elliot B. Koffman, Pearson Addison-Wesley, 2006. 10. Computer Science- A Structured Programming Approach Using C, by Behrouz A. Forouzan, Richard F. Gilberg, Thomson, Third Edition [India Edition], 2007. 11. Object- Oriented Programming In C++ by Rajesh

			K Shukla
	BCHPR-604	Practical Polymer Chemistry	• **Polymer synthesis** 1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA). a. Purification of monomer b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutylonitrile(AIBN) 2. Preparation of nylon 66/6 • **Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein** a. Preparation of IPC b. Purification of IPC c. Interfacial polymerization 3. Redox polymerization of acrylamide 4. Precipitation polymerization of acrylonitrile 5. Preparation of urea-formaldehyde resin 6. Preparations of novalac resin/resold resin. 7. Microscale Emulsion Polymerization of Poly(methylacrylate). • **Polymer characterization** 1. of molecular weight byviscometry: (a) Polyacrylamide-aq.NaNO2solution (b) (Poly vinyl proplylidine (PVP) in water 2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of―head-to-head‖ monomer linkagesin the polymer. 3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group). 4. Testing of mechanical properties of polymers. 5. Determination of hydroxyl number of a polymer using colorimetric method. • **Polymer analysis** 1. Estimation of the amount of HCHO in the given solution by sodium sulphite method 2. Instrumental Techniques 3. IR studies of polymers 4. DSC analysis of polymers ***5.*** Preparation of polyacrylamide and its

			electrophoresis *at least 7 experiments to be carried out. ***Reference Books:*** • *Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rdEd.* • *Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall(2003)* • *Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience(1984)* • *Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall(2003)* • *Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nded. John Wiley & Sons(2002)* • *L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley &Sons (2005)* • *Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford UniversityPress (2005) Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr.(2013*).

FTIR Instrumentation Training & Analytical Development (Value added course: VCB-1) Total Lectures: 30

Theory (Lectures: 20)

Basic principle, types of vibrations, vibrational frequencies of alcohols, carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds) and nitrogen containing compounds.

FTIR Instrumentation, Sample preparation, Introduction to FTIR software, Standard operating procedure, Demonstration of FTIR spectrophotometer, Interpretation and analysis of recorded spectra. Applications of FTIR.

Practicals (Lectures: 10) any five

1. To analyze the effect of concentration on N-H and O-H stretching vibrational frequency of the compounds with the help of FTIR spectrophotometer.
2. To differentiate primary, secondary and tertiary amines with the help of FTIR spectrophotometer.
3. To differentiate primary, secondary and tertiary alcohols with the help of recorded FTIR spectra.
4. To identify unsubstituted and ortho, meta & para derivatives of aromatic compounds with the help of IR bands observed in fingerprint region of recorded FTIR spectra.
5. Analysis of polymer films and sheets with the help of FTIR spectrophotometer.
6. Hands on data collection methods and different file formats of recorded spectra with the help of FTIR spectrometer.

HPLC Instrumentation Training & Analytical Development
(Value added course: VCB-2) Total Lectures: 30

Theory (Lectures: 20)

Basic principle, Instrumentation, types of columns, types of detectors, factors effecting HPLC chromatogram, GPC column & molecular weight determination of polymers, GPC Standards, Construction of calibration curve.

Introduction to HPLC software, Standard operating procedure, HPLC software operation, Sample/mobile phase preparation, method development for new compound, Interpretation and analysis of recorded chromatograph. Applications of HPLC.

Practicals (Lectures: 10) any five

1. To separate and analyse mixture of amino acids with the help of HPLC.
2. To analyze the effect of mobile phase composition on peak area and peak intensity in HPLC chromatogram.
3. To examine the effect of injection volume/flow rate of mobile phase on HPLC chromatogram of a sample.
4. To examine the effect of concentration/ temperature on HPLC chromatogram of a sample.
5. To construct calibration curve with the help of HPLC software.
6. To determine molecular weight of sample using GPC column.
7. To check the purity of a compound with the help of HPLC.
8. Hands on preparation of report formats for obtaining data through recorded HPLC chromatograms.

Coordinator
B.Sc. Chemistry (H)
C.C.S.U., Meerut