ST. JOSEPH'S COLLEGE (AUTONOMOUS)
JAKHAMA-NAGALAND

SYLLABUS
(Outcome Based Education)

CURRICULUM AND CREDIT FRAMEWORK
FOR
UNDERGRADUATE PROGRAMMES (NEP-2020)

DEPARTMENT OF CHEMISTRY

With effect from the Academic Year 2023-2024
(1st to 4th FYUGP)

CHEMISTRY HONOURS SYLLABUS

FOUR YEAR DEGREE COURSE
SEMESTER SYSTEM (U.G COURSE)
(Under UGC NEP 2020 Guidelines)

DEPARTMENT OF CHEMISTRY

St. Joseph's College (Autonomous) Jakhama, Nagaland

COURSE STRUCTURE

SEMESTER	MAJOR OR DISCIPLINE SPECIFIC CORE COURSE (4 CREDITS EACH)	INTER DISCIPLINARY MINOR (IDM) (4 CREDITS EACH)	MULTI-DISCIPLINARY/ 3 INTRODUCTORY COURSE (4CREDITS EACH)	ABILITY ENHANCEMENT COURSE (AEC) (2 CREDITS EACH)	SKILL ENHANCEMENT COURSES (SEC) (2 CREDITS EACH)	INTERNSHIP/ APPRENTICESHIP/ PROJECT/ INTERNSHIP /COMMUNITY OUTREACH (2 CREDITS EACH)	VALUE ADDITION COURSE VAC (2CREDITS EACH)	TOTAL CREDITS
I	INORGANIC CHEMISTRY: I CHC 1.1 PHYSICAL CHEMISTRY: I CHC 1.2	INORGANIC CHEMISTRY: I CHM 1 (Minor-1)	ENVIRONMENTAL STUDIES MDC 1 COMMON POOL	AEC-1: ENGLISH COMMUNICATION (2)	BASICS OF ANALYTICAL CHEMISTRY: I CHS 1		VAC-1 (2) CONSTITUTIONAL VALUES VAC 1	22
II	ORGANIC CHEMISTRY: I CHC 2.1 INORGANIC CHEMISTRY: II CHC 2.2	ORGANIC CHEMISTRY: I CHM 2 (Minor-2)	PROGRAMMING USING PYTHON MDC 2 (COMMON POOL)	AEC-2: BASIC FUNCTIONAL ENGLISH (2)	BASICS OF ANALYTICAL CHEMISTRY: II CHS 2		VAC-2(2) CONSUMER RIGHTS VAC 2	22
Students on exit shall be awarded Undergraduate Certificate							Total = 44 Credits	
III	PHYSICAL CHEMISTRY II CHC 3.1 ORGANIC CHEMISTRY: II CHC 3.2 INORGANIC CHEMISTR: III CHC 3.3	PHYSICAL CHEMISTRY: I CHM 3 (Minor-3)	INTELLECTUAL PROPERTY RIGHTS MDC 3 (COMMON POOL)		CHEMISTRY OF FRAGRANCES AND FLAVOURS: AN INDUSTRY'S PERSPECTIVE CHS 3 (2)			22
IV	PHYSICAL CHEMISTRY: III CHC 4.1 ORGANIC CHEMISTRY: III CHC 4.2 INORGANIC CHEMISTRY: IV CHC 4.3	ORGANIC CHEMISTRY: II CHM 4 (Minor-4)		AEC-3: POETRY, PROSE AND SHORT STORIES(2)	ROLE OF METALS IN MEDICINES CHS 4 (2)		VAC -3(2) WORK ETHICS VAC 3	22
Students on exit shall be awarded Undergraduate Diploma							Total = 44 Credits	
V	ORGANIC CHEMISTRY: IV CHC 5.1 PHYSICAL CHEMISTR: IV CHC 5.2 ANALYTICAL METHODS IN CHEMISTRY CHC 5.3	PHYSICAL CHEMISTRY: II CHM 5 (Minor-5)		AEC-4: NOVEL AND DRAMA (2)	CHEMISTRY IN DAIRY PRODUCTS CHS 5 (2)		VAC-4 (2) INDIA THROUGH THE AGES VAC 4	22
VI	PHYSICAL CHEMISTRY: V CHC 6.1 ORGANIC CHEMISTRY: V CHC 6.,2 GREEN CHEMISTRY CHC 6.3 SPECTROSCOPY CHC 6.4	INORGANIC CHEMISTRY: II CHM 6 (Minor-6)			CHEMISTRY AND SOCIETY CHS 6 (2)			22
Students on exit shall be awarded Undergraduate Degree							Total = 44 Credits	
VII	CHEMISTRY OF FOOD NUTRIENTS CHC 7.1 RESEARCH METHODOLGY IN CHEMISTRY CHC 7.2	ORGANIC CHEMISTRY: III CHM 7.1 (Minor-7) BIOINORGANIC CHEMISTRY CHM 7.2 (Minor-8)					RESEARCH DISSERTATION WILL START	20
VIII	NANOSCALE MATERIALS AND THEIR APPLICATIONS CHC 8.1	MEDICINES IN DAILY LIFE CHM 8 (Minor-9)					DISSERTATION ON MAJOR OR THREE PAPERS (4X3=12) 1 MINOR & 2 MAJOR PAPERS	20
							Total = 40 Credits	
Students on exit shall be awarded Undergraduate Degree (Honours with Research)							Total Credits= 172	

(1) Core Course/ Major (20x 4) =80 Credits
(2) Minor (9x4) = 36 Credits
(3) Research methodology = 4 Credits
(4) Multi-disciplinary (4x3) = 12 Credits
(5) Ability Enhancement = 8 Credits
(6) Skill Enhancement (6x2) = 12 Credits
(7) Value Added Course = 8 Credits
(8) Dissertation on Major = 12 Credits

Note: Honours Students not undertaking research project will do three theory courses for 12 credits in lieu of a research project/ dissertation.

PREAMBLE

The syllabus for the B.Sc. Chemistry (Honours) subject was long due for revision. It was incidental that timing of the revision overlapped with that of framing new syllabus in accordance to NEP framework to be implemented in higher educational institutions throughout the state.

Prof. Upasana B. Sinha, Nagaland University Representative, Department of Chemistry Nagaland University Lumami, provided the directions and vital inputs to undertake this uphill task of framing new syllabus for Chemistry subject of the B. Sc. programme. The model syllabus was to be provided by the state level expert committee, but this was to be modified and adopted according to our ingenious needs. The syllabus had to be compatible with the B.Sc. (Honours) programme.

To accomplish the task, Board of Studies nominee, Prof. Upasana B. Sinha, Nagaland University Lumami, Department of Chemistryaligned with the Core Group of Teachers of the Chemistry Dept. SJC (A). The Core Group participated in a meeting on 22.11.23 and shaped a draft in accordance with the objectives of the NEP model curriculum. Several new elements like development of interdisciplinary skills, bridging the skill gap and knowledge-application to local problems were introduced.

Studying Chemistry subject in the B.Sc. and BSc. (Honours) is moulded to Choice Based Credit System (CBCS) and the courses are spread over all semesters. The syllabus is intended to familiarize students with the sound basic understanding of the subject as well as expose them to advanced learning which would link to postgraduate and/or research programmes. Due importance is also given to the study of applicationoriented topics so as to build a foundation to acquiring skills.

The exercise of framing syllabus was a collective endeavour. Four Faculty members of various branches of Chemistry had separate as well as joint brainstorm sessions and arrived at a draft syllabus for Eight semesters.

The Draft was brought to the attention of a wider group of teachers for further refinement and the final version incorporating the suggestions was placed be for the Board of Studies in Chemistry (UG) on 02.12.2023 for approval.

MAJOR/CORE/DISCIPLINE SPECIFIC CORE COURSE (4 CREDITS)

I-SEMESTER

NAME OF THE PAPER (CODE) **: INORGANIC CHEMISTRY-I (CHC-1.1)**

Number of Credit **03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper–**Inorganic Chemistry– I:**

CO 1:	To solve the conceptual questions using the knowledge gained on the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves. The shapes of s,p and d Orbitals.
CO 2:	To Understand the periodic trends in properties of elements in atomic radii, ionic radii, ionization energy and electron affinity of elements
CO 3:	To Understand the concept of lattice energy through Born-Lande and Kapustinskii equation.
CO 4:	To draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams.
CO 5:	To comprehend and understand the theory and application of different acid-base and redox titrations.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Atomic Structure	Recapitulation of the concept of atom in ancient India, Bohr's theory, its limitations and atomic spectrum of hydrogen atom. de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, well behaved wave function, significance of ψ and $\psi 2$. Quantum mechanical treatment of H-atom, Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom.	**CSO 1.1:**to explain the setbacks of Bohr's Atomic Model the triggers the development of quantum mechanic theory. (K) **CSO 1.2:**to discuss the quantum mechanical model of the atom. (K) **CSO 1.3:**to know the de Broglie equation, Heisenberg's Uncertainty Principle and its significance. (K) **CSO 1.4:**to derive the Schrödinger's wave equation. (A)	**15**	**25**	

	Radial function plots, radial probability distribution plots and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Relative energies of orbitals. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau's principle and its limitations.	**CSO 1.5:**to understand the significance of ψ and $\psi 2$. (U) **CSO 1.6:**to discuss the quantum numbers (n,l,m,s). (K) **CSO 1.7:** to discuss the normalized and orthogonal wave function and the sign of wave functions. (U) **CSO 1.8:** to learn radial and angular distribution curves. (K) **CSO 1.9:** to understand the shapes of s, p and d atomic orbitals (U) **CSO 1.10:**to know the rules for filling electrons in various orbitals, electronic configurations of the atoms (K) **CSO 1.11:**to discuss the stability of half-filled and completely filled orbitals. (U) **CSO 1.12:**to understand the concept of exchange energy and relative energies of atomic orbitals. (U)			
UNIT 2 Periodicity of Elements	Brief discussion of the following properties of the elements, with reference to *s* and*p*- block and their trends: (a) Effective nuclear charge, shielding or screening effect, Slater rules (b) Atomic and ionic radii (e) Ionization enthalpy (Successive ionization enthalpies). (f) Electron gain enthalpy (g)Electronegativity: Pauling's electronegativity scales. Variation of electronegativity with bond order and hybridization.	**CSO 2.1:**to compare and study the different properties of s and p block elements. (K) **CSO 2.2:**to calculate the Effective Nuclear Charge of various atoms with regard to the shielding or screening effect. (A) **CSO 2.3:**to understandthe concepts of electronic configuration, atomic and ionic size and their trends in the periodic table. (U) **CSO 2.4:** to discuss ionisation enthalpy, electron gain enthalpy of s- and p-block elements. (U) **CSO 2.5:**to understandthe concepts of electronegativity and the Pauling's electronegativity scales. (U) **CSO 2.6:**to explain	**06**	**18**	

		variation of electronegativity with bond order and hybridization. (U)			
UNIT 3 Ionic bond	General characteristics, types of ions, size effects, radius ratio ruleand its limitations.Packing of ions in crystals. Lattice energy, Born-Landé equation with derivation, Madelungconstant,and importanceofKapustinskiiequation for lattice energy. Born-Haber cycle and its applications. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.	**CSO 3.1:**to discuss on the general characteristics, types of ions. (U) **CSO 3.2:**to understand the lattice enthalpy and its relation to stability of and solubility of ionic compounds. (U) **CSO 3.3:**to derive the Born-Landé equation. (A) **CSO 3.4:**to derive the Kapustinskiiequation and discuss its importance for lattice energy. (A) **CSO 3.5:**to discuss the Born-Haber cycle and its applications. (U) **CSO 3.6:**to understand the concept of polarizing power and polarizability. (U) **CSO 3.7:**to discuss the Fajan's rules.(K)	**08**	**20**	
UNIT 4 Covalent Bond	Valence shell electron pair repulsion theory (VSEPR), shapes ofsimple molecules and ions containing lone pairs and bond pairs of electrons: H2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3. I_3, BrF_2^+, PCl_6^-, ICI_2^- and SO_4^{-2}. Application of VSEPR theory in predicting trends in bond lengths and bond angles. Valence Bond theory (Heitler-London approach).Hybridisation, equivalent and non-equivalent hybrid orbitals, Bent's rule. Molecular orbitaldiagrams of homo and hetero diatomic molecules: N_2, O_2, F_2, CO, NO, and theirions; HCl (idea of s-p mixing and orbital interaction to be given).	**CSO 4.1:**to discuss the VSEPR theory. (A) **CSO 4.2:**to draw the plausible structures and geometries of molecules using VSEPR theory. (A) **CSO 4.3:**to understand the application of VSEPR theory in predicting trends in bond lengths and bond angles. (U) **CSO 4.4:**to explain the covalent bonding using the Valence Bond theory. (U) **CSO 4.5:**to understand the concept of hybridisation with suitable examples. (U) **CSO 4.6:**to draw the plausible structures and geometries of homo diatomic molecules using molecular orbital diagrams. (A) **CSO 4.7:** to draw the plausible structures and geometries of hetero diatomic moleculesusing molecular orbital diagrams.(A)	**10**	**22**	

UNIT 5 Oxidation-reduction	General concept. Electrochemical series and its applications**,**Latimer diagram (chlorine in acidic and basic medium), disproportionationof H_2O_2 into O_2 and H_2O under acidic conditions, Pourbaix diagram (iron species in natural water).	**CSO 5.1:**to evaluate fundamentals of electrochemistry. (K) **CSO 5.2:** to understand electrochemical series. (U) **CSO 5.3:**to discuss the applications of Electrochemical series. (A) **CSO 5.4:**to predict stability relative to higher and lower oxidation states using Latimer diagram. (U) **CSO 5.5:**to explain disproportionation reactions with suitable examples. (U) **CSO 5.6:**to predict spontaneous direction of electrochemical reactions, identifying corrosion products using pourbaix diagram. (K)	**06**	**15**	

Suggested Readings: Theory

1. J.D. Lee, *Concise Inorganic Chemistry* ELBS, 1991.
2. B.E. Douglas, and D.H. McDaniel, *Concepts & Models of Inorganic Chemistry* Oxford, 1970
3. P.W. Atkins&J. Paula, *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
4. M.C. Day, and J. Selbin, *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
5. G.E. Rodger, *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
6. C.E. Housecraft, A.G. Sharpe, *Inorganic chemistry*, 5th edition, Pearson, 2018.

Practical

Name of the Paper: Inorganic Chemistry-I
Paper code: CHC-1.1 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

(A) Titrimetric Analysis
(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality
(B) Acid-Base Titrations
(i) Estimation of oxalic acid using standardized NaOH solution
(ii) Estimation of sodium carbonate using standardized HCl.
(iii) Estimation of carbonate and hydroxide present together in mixture.
(iv)Estimation of carbonate and bicarbonate present together in a mixture.
(C) Oxidation-Reduction Titrimetry
(i) Estimation of oxalic acid using standardized KMnO4 solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
Suggested Readings: Practicals

1. J.A. I. Mendham, Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. D.C. Harris, C. A.Lucy, *Quantitative Chemical Analysis*, 9th Edition, Freeman and company, 2016.

NAME OF THE PAPER (CODE) : PHYSICAL CHEMISTRY– I (CHC-1.2)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper**– Physical Chemistry– I:**

CO 1:	Derive the mathematical expressions on different properties of gas and liquids.
CO 2:	Determine the density of aqueous solutions and dilute solutions as per required concentrations.
CO 3:	Acquire knowledge about viscosity of fluids.
CO 4:	Understand the theory of the surface tensions of liquids.
CO 5:	Learn the theory of dilute solutions, distribution laws and applications.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Outcomes (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Gaseous state-I	Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy. Definition, expression, applications and temperature and pressure dependence of each of the following properties of ideal gases: collision frequency; collision diameter; mean free path. Coefficient of viscosity, definition, units and	**CSO 1.1:**to describe the microscopic properties of atoms and their interrelations. (K) **CSO 1.2:**to explain the process of particles by the diffusion mechanism using the kinetic theory of gases. (U) **CSO 1.3:**to understand the use of Maxwell distribution in evaluating molecular velocities and average kinetic energy. (U) **CSO 1.4:**to define and explain the temperature and pressure dependence of collision frequency, collision diameter, mean free path. (K) **CSO 1.5:**to understand the concept of coefficient of	**11**	**27**	

	origin of viscosity of gases, relation between mean free path and coefficient of viscosity, temperature and pressure dependence of viscosity of a gas, calculation of molecular diameter from viscosity. Barometric distribution law, its derivation and applications, alternative forms of barometric distribution law in terms of density and number of molecules per unit volume, effect of height, temperature and molecular mass of the gas on barometric distribution.	viscosity. (U) **CSO 1.6:**to derive relationship between mean free path and coefficient of viscosity. (K) **CSO 1.7:**to explain the temperature and pressure dependence of viscosity of a gas. (K) **CSO 1.8:**to calculate molecular diameter from viscosity. (A) **CSO 1.9:**to derive the Barometric distribution law. (A) **CSO 1.10:**to discuss the applications of Barometric distribution law. (U) **CSO 1.11:**to explain the effect of height, temperature and molecular mass of the gas on barometric distribution. (U)			
UNIT 2 Gaseous state-II	Behaviour of real gases: compressibility factor Z, variation of compressibility factor with pressure at constant temperature (plot of Z vs P) for different gases (H_2, CO_2, CH_4, and NH_3), cause of deviation from ideal gas behaviour and explanation of the observed behaviour of real gases in the light of molecular interactions. Vander Waals equation of state, limitations of ideal gas equation of state and its modifications in the form of Vander Waals equation, physical significance of Vander Waals constants,	**CSO 2.1:**to explain the differences between the behaviour of an ideal gas and a real gas. (K) **CSO 2.2:**to define compressibility factor Z and discuss its variation with pressure at constant temperature for different gases. (K) **CSO 2.3:**to understand how molecular volumes and intermolecular attractions cause the properties of real gases to deviate from those predicted by the ideal gas law. (U) **CSO 2.4:**to understand the behaviour of real gases using Vander Waals equation of state. (U) **CSO 2.5:** to discuss the	**10**	**20**	

	application of Vander Waals equation to explain the observed behaviour of real gases. Isotherms of real gases; critical state, relation between critical constants and Vander Waals constants, correlation of critical temperature of gases with intermolecular forces of attraction, continuity of states, limitations of Vander Waals equation, reduced equation of state and law of corresponding states (statements). Viral equation of state: physical significance of second and third viral coefficients, Vander Waals equation expressed in virial form, relation between virial coefficient and Vander Waals constants	limitations of ideal gas equation of state and its modifications in the form of Vander Waals equation. (K) **CSO 2.6:**to explain the physical significance of Vander Waals constants. (U) **CSO 2.7:**to label the different phases, the critical point and the critical isotherm. (A) **CSO 2.8:** to derive the relation between critical constants and Vander Waals constants. (A) **CSO 2.9:** to discuss correlation of critical temperature of gases with intermolecular forces of attraction. (K) **CSO 2.10:**to discuss the reduced equation of state and law of corresponding states. (K) **CSO 2.11:**to explain the concept of viral coefficients. (K) **CSO 2.12:**to discuss the relation between virial coefficient and Vander Waals constants. (U)			
UNIT 3 Liquid state I	Qualitative treatment of the structure of the liquid state; physical properties of liquids-vapour pressure, its origin and definition, vapour pressure of liquids and intermolecular forces and boiling point. Surface tension, its origin and definition, Capillary action in relation to cohesive and adhesiveforces, determination of	**CSO 3.1:**to understand liquid state and its importance in solution. (U) **CSO 3.2:**to understand equilibrium vapor pressure of a liquid depending on the temperature and the intermolecular forces present. (U) **CSO 3.3:**to explain the concept of Surface tension. (K) **CSO 3.4:** to explain certain properties of water using the concepts of cohesive and	**10**	**18**	

	surface tension by (i) using stalagmometer (drop number and dropmass method) and (ii) capillary rise method, Effects of addition of sodium chloride,ethanol and detergent on the surface tension of water and its interpretation in terms ofmolecular interactions, Role of surface tension in the cleansing action of detergents.	adhesive forces and surface tension. (U) **CSO 3.5:**to understand the determination of surface tension of a given liquid at room temperature using stalagmometer. (U) **CSO 3.6:**to explain the determination of surface tension by capillary rise method. (U) **CSO 3.7:** to understand the effects of addition of sodium chloride, ethanol and detergent on the surface tension of water. (U) **CSO 3.8:**to explain the role of surface tension in the cleansing action of detergents. (K)			
UNIT 4 Liquid state II	Coefficient of viscosity and its origin in liquids, Interpretation of viscosity data of pure liquids (water, ethanol, ether and glycerol) in the light of molecular inter actions, Effects of addition of sodium chloride, ethanol and polymer on the viscosity of water, relative viscosity,specific viscosity and reduced viscosity of a solution, comparison of the origin of viscosity ofliquids and gases, effect of temperature on the viscosity of a liquid and its comparison with that of a gas.	**CSO 4.1:**to explain the viscosities of the liquids at the desired temperature kinematically and dynamically. (K) **CSO 4.2:** to interpret viscosity data of pure liquids in the light of molecular inter actions. (A) **CSO 4.3:**to explain theeffects of addition of sodium chloride, ethanol and polymer on the viscosity of water. (K) **CSO 4.4:**to define relative viscosity, specific viscosity and reduced viscosity of a solution. (K) **CSO 4.5:**to understand the origin of viscosity of liquids and gases. (U) **CSO 4.6:** to discuss on the effect of temperature on the viscosity of a liquid and its	**07**	**20**	

		comparison with that of a gas. (U)			
UNIT 5 Dilute Solutions	Review of colligative properties and concentration terms. Determination of molecular mass of a solute by; Berkeley-Hartley's method, Beckmann's method (ΔT^f) and Landsberger method. Nernst distribution law-statement, distribution constant, factors affecting distribution constant, validity of distribution law, modification of distribution law when molecules undergo a) association b) dissociation. Application of distribution law in solvent extraction.	**CSO 5.1:** to describe the relationship between solute concentration and the physical properties of a solution. (K) **CSO 5.2:**to explain the determination of molecular mass of a solute by; Berkeley-Hartley's method. (A) **CSO 5.3:** to explain the determination of molecular mass of a solute by Beckmann's method (ΔT^f) and Landsberger method. (A) **CSO 5.4:**to understand the Nernst distribution law. (U) **CSO 5.5:** to explain distribution constant and the factors affecting distribution constant. (U) **CSO 5.6:** to explain the modification of distribution law when molecules undergo association and dissociation.(U) **CSO 5.7:** to discuss the application of distribution law in solvent extraction. (K)	**07**	**15**	

Suggested Readings: Theory

1. P.W. Atkins &J. Paula, de *Atkin's Physical Chemistry* 10th Ed., Oxford University Press, 2014.
2. B.W. Ball, *Physical Chemistry* Thomson Press, India, 2007.
3. G.W. Castellan, *Physical Chemistry* 4th Ed. Narosa, 2004.
4. R.G. Mortimer, *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP, 2009.

Practical:

Name of the Paper: Physical Chemistry-I
Paper Code: CHC-1.2 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1. Gases

a. To verify the Charles law using Charles law apparatus

b. To determine the value of universal gas constant R using the reaction

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

2. Surface tension measurements using stalagmometer.

a. Determine the surface tension by (i) drop number (ii) drop weight method.

b. Study the variation of surface tension of detergent solutions with concentration of detergent solutions. Determine CMC

c. Study the variation of surface tension with different concentration of sodium chloride solutions.

3. Viscosity measurement using Ostwald's viscometer.

a. Determination of viscosity of aqueous solutions of

(i) Ethanol and (ii) sugar at room temperature.

b. Study the variation of viscosity of sucrose solution with the concentration of solute.

c. Determination of co-efficient of viscosity of two unknown aqueous solution.

Suggested Readings: Practical

1. B. D. Khosla, V. C. Garg, &A. Gulati, *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi, 2011.
2. C. W.Garland, J. W. Nibler, &D. P. Shoemaker, *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York, 2003.
3. A. M. Halpern, &G. C. McBane, *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York, 2003.

II **SEMESTER**

NAME OF THE PAPER (CODE) **: ORGANIC CHEMISTRY – I (CHC-2.1)**

Number of Credit **03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper**– Organic Chemistry– I:**

CO 1:	Understand the concepts of organic reactions and techniques of writing the movement of electrons, bond breaking, bond forming and acquire basic knowledge of reactive intermediates.
CO 2:	Recognize and draw constitutional isomers, stereoisomers, including enantiomers and diasteromers, racemic mixture and mesocompounds.
CO 3:	Understand the synthesis, isomerism, properties and stabilities of alkanes and cycloalkanes.
CO 4:	Understand the nomenclature, synthesis, physical and chemical properties of alkanes.
CO 5:	Know the fundamental principles of organic chemistry and predict outcomes and derive mechanism of various types of organic reactions.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit &Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Basics of Organic Chemistry	Electronic Displacements:Inductive,electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity;Types, shape and their relative stability of	**CSO 1.1:** to understand the basic concepts in organic chemistry. (U) **CSO 1.2:** to understand the electron displacement effect providing a fundamental understanding of bond polarisation and molecular reactivity. (U) **CSO 1.3:** to explain inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications **CSO 1.4:** to discuss the relative strength of organic	**09**	**25**	

	Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.	acids and bases. (K) **CSO 1.5:**to discuss the different types of covalent bond fission. (U) **CSO 1.6:**to explain electrophiles and eucleophiles, nucleophlicity and basicity. (U) **CSO 1.7:**to discuss on the types, shape and relative stability of Carbocations, Carbanions. (U) **CSO 1.8:** to discuss on the types, shape and relative stability of Free radicals and Carbenes. (U) **CSO 1.9:** to explain the reaction mechanisms of various organic reactions. (U)			
UNIT 2 Stereochemistry	Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers,diastereomers. Specific rotation; Configuration and projection formulae: Newman, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration. Racemic mixture and their resolution. Relative and	**CSO 2.1:**to understand the fundamental concepts of stereochemistry. (U) **CSO 2.2:** to explain optical activity and optical isomerism. (K) **CSO 2.3:**to define symmetry, chirality, enantiomers, diastereomers. (K) **CSO 2.4:**to explain the distinction between enantiomers, diastereomers and explain their physical properties. (U) **CSO 2.5:**to draw the Newman, Sawhorse, Fischer projection	**12**	**22**	

	absolute configuration: D/L and R/Sdesignations (CIP rules). Geometrical isomerism: cis-trans, syn-anti and E/Z notations.	(A) **CSO 2.6:**to discuss the interconversion of Newman, Sawhorse, Fischer projection. (A) **CSO 2.7:**to discuss the chirality in molecules with one and two stereocentres. (K) **CSO 2.8:** to explain meso compounds with suitable examples. (U) **CSO 2.9:** to understand racemic mixture and the resolution of enantiomers. (U) **CSO 2.10:**to discuss D/L and R/S configurations of various compounds. (K) **CSO 2.11:** to understand geometrical isomerism with examples. (U)			
UNIT 3 Cycloalkanes and Conformational Analysis	Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagramsof Ethane, Propane and butane). Relative stability of cycloalkanes (Baeyerstrain theory),Cyclohexane conformations with energy diagram. Conformations of monosubstitutedcyclohexanes.	**CSO 3.1:**to understand the concept of stereochemistry and conformational analysis in cyclic compounds. (U) **CSO 3.2:**to understand the types of strain inherent in cycloalkanes. (U) **CSO 3.3:**to draw the energy diagrams of Ethane, Propane and butane. (A,K) **CSO 3.4:**to analyse and explain conformational stabilities of Ethane, Propane and butane. (U) **CSO 3.5:**to discuss the Baeyer Strain Theory. (A)	**06**	**16**	

		CSO 3.6: to draw the energy diagrams of cyclohexane conformations and discuss its relative stabilities. (A,U)			
UNIT 4 Aliphatic Hydrocarbons: Carbon-Carbon sigma bonds	**(06 Lectures,10 marks)** Alkanes:Preparation, Halogenation of alkanes, Concept of relative reactivity v/s selectivity.	**CSO 4.1:**to explain various physical properties of alkanes. (K) **CSO 4.2:** to discuss the chemical properties of alkanes. (K) **CSO 4.3:** to discuss the laboratory preparations of alkanes. (K) **CSO 4.4:** to discuss the industrial preparations of alkanes. (K) **CSO 4.5:** to explain the reaction mechanism for halogenation of alkanes. (U) **CSO 4.6:** to understand the concept of relative reactivity v/s selectivity. (U)	**06**	**12**	
UNIT 5 Aliphatic Hydrocarbons: Carbon-Carbon pi-bonds	Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E1, E2, E1cbreactions, Saytzeff and Hoffmann eliminations. Electrophilic additions, mechanism withsuitableexamples, (Markownikoff/Anti-markownikoff addition), syn andanti-addition;addition of H2, X2, oxymercuration-demercuration, hydroboration-oxidation,	**CSO 5.1:**to discuss the general physical and chemical properties of Alkenes and Alkynes. (K) **CSO 5.2:** to discuss the methods of preparation of alkenes using Mechanisms of E1, E2, E1cbreactions. (U) **CSO 5.3:** to discuss the reaction mechanisms of Saytzeff and Hoffmann eliminations. (A) **CSO 5.4:** to explain markownikoff and anti-	**12**	**25**	

	ozonolysis,hydroxylation, reaction with NBS, Reactions of alkynes; acidity, Alkylation of terminalalkynes, electrophilic addition: hydration to form carbonyl compounds, Relative reactivity ofalkenes and alkynes, 1,2-and 1,4-addition reactions in conjugated dienes, Diels Alder reaction(excluding stereochemistry).	markownikoff addition with suitable examples. (A) **CSO 5.5:** to explain the syn and anti-addition of H2, X2. (K) **CSO 5.6:** to discuss the reaction mechanisms of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis,hydroxylation, reaction. (A) **CSO 5.7:**to explain on the acidic character of alkynes. (U) **CSO 5.8:** to explain the 1,2- and 1,4-addition reactions in conjugated dienes. (U) **CSO 5.9:** to discuss on the elative reactivity and stability of alkenes and alkynes. (U) **CSO 5.10:**to discuss the reaction mechanism of Diels Alder reaction. (A)			

Suggested Readings: Theory

1. R.N.Morrison&R.N. Boyd,*Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2010
2. I.L. Finar,*Organic Chemistry* (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2002
3. I.L. Finar,*Organic Chemistry* (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2002
4. E.L. Eliel&S.H. Wilen, *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
5. P.S. Kalsi,*Stereochemistry Conformation and Mechanism*, New Age International, 2005
6. J.E. McMurry, *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

Practical:

Name of the Paper: Organic Chemistry-I

Paper Code: CHC-2.1 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

Note: Students should be provided with handouts prior to the practical class.

1. Calibration of a thermometer and determination of the melting points of the organic compounds using any one of the following methods-Kjeldahl method, electrically heated melting point apparatus and BODMEL).
2. Concept of melting point and mixed melting point.
3. Concept of recrystallisation using alcohol/water/alcohol-water systems (Any two).
4. Determination of boiling point of liquid compounds (boiling point lower than and morethan 100 °C by distillation, capillary method and BODMEL method).
5. Separation of a mixture of two amino acids/sugars by radial/ascending paper chromatography.
6. Separation of a mixture of o-and p-nitrophenol or o- and p-aminophenol by thin layerchromatograph y (TLC).
7. Detection of extra elements.

Suggested Readings: Practical

1. F.G. Mann, &B.C. Saunders, Practical Organic Chemistry, Pearson Education, 2009.
2. B.S.Furniss,A.J. Hannaford,P.W.G.Smith, Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson, 2012.
3. V.K. Ahluwalia, &R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2000.
4. V.K.Ahluwalia, &S. Dhingra, Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2000.

NAME OF THE PAPER (CODE) **: INORGANIC CHEMISTRY-II (CHC-2.2)**

Number of Credit **03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper**– Inorganic Chemistry-II:**

CO 1:	Understand the occurrence, extraction, reactivity and important processes of metals used in metallurgy.
CO 2:	Understand the bonding in inorganic molecules of s- block elements and its salient feature.
CO 3:	Know the general trends in the chemistry behind p-block elements.

CO 4:	Develop fundamental concepts of the compounds of p-block elements, their acidic and basic nature, ionic and covalent nature and chemical reactions.
CO 5:	Learn the properties, preparation and uses of noble gases.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 General Principles of Metallurgy	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, Zone refining. Brief discussion of metals and alloys used in ancient and medieval India.	**CSO 1.1:**to understand the principles of different metallurgical procedures with respect to different metals. (U) **CSO 1.2:**to discuss the chief modes of occurrence of metals based on standard electrode potentials. (K) **CSO 1.3:**to depict a reaction's standard free energy as a function of temperature through Ellingham diagrams. (A) **CSO 1.4:**to define Electrolytic Reduction. (K) **CSO 1.5:**to explain Hydrometallurgy with reference to cyanide process for silver and gold. (K) **CSO 1.6:**to discuss the purification of metals using the Electrolytic process, Van Arkel-De Boer process, Zone refining. (U) **CSO 1.7:** to explain the use of metals and alloys in ancient and medieval India. (K)	**06**	**20**	

UNIT 2 **Chemistry of s- Block Elements**	General characteristics: melting point, flame colouration, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. Common features such as ease of formation, thermal stability, energetics of dissolution, and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates. Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate,	**CSO 2.1:** to study different physical and chemical properties of s block elements. (K) **CSO 2.2:**to discuss on the similarities in chemical properties of first member of each group of s block elements. (K) **CSO 2.3:** to explain the reactions of group 1 elements with oxygen, hydrogen, nitrogen and water. (U) **CSO 2.4:** to explain the reactions of group 2 elements with oxygen, hydrogen, nitrogen and water. (U) **CSO 2.5:** to discuss ease of formation, thermal stability, energetics of dissolution, and solubility of hydrides and oxides. (K) **CSO 2.6:**to explain thermal stability, energetics of dissolution, and solubility of peroxides, superoxides. (K) **CSO 2.7:**to discuss ease of formation, thermal stability, energetics of dissolution, and solubility of carbonates, nitrates, sulphates. (K) **CSO 2.8:**to understand the tendendy of formation of complexes of s-block elements. (U) **CSO 2.9:** to discuss the structure of crown ethers complexes. (U) **CSO 2.10:** to explain the structure of cryptates of Group I: beryllium acetate and beryllium nitrate. (K)	**14**	**27**	

	EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties	**CSO 2.11:** to study EDTA complexes of calcium and magnesium. (K) **CSO 2.12:** to discuss the properties of alkali metal and their solutions in liquid ammonia. (K)			
UNIT 3 Chemistry of *p*-Block Elements	Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Catenation, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.	**CSO 3.1:**to study specific compounds of p block elements w.r.t. their synthesis, structure, properties, bonding and uses. (K) **CSO 3.2:** to discuss the electronic configuration, atomic and ionic size, metallic/non-metallic character of p block elements and their trends in the periodic table. (U) **CSO 3.3:** to explain the ionization enthalpy, electron gain enthalpy, electronegativity of p block elements and their trends in the periodic table. (U) **CSO 3.4:** to explain the linkage of atoms of the same element into longer chains. (K) **CSO 3.5:** to discuss the allotropy of C, P, S. (K) **CSO 3.6:**to discuss the high stability of low oxidation states of heavy p block elements using the inert pair effect. (U) **CSO 3.7:** to discuss the similarities in chemical properties of B and Si. (K) **CSO 3.8:** to discuss the anomalous behaviour of first member of each	**08**	**17**	

		group of p block elements. (K)			
UNIT 4 Compounds of *p*-Block Elements	Acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat on the following: Hydrides of Group 13 (only diborane), Group 14, Group 15 (EH3 where E = N, P,As, Sb, Bi), Group 16 and Group 17. Oxoacids of phosphorus, sulphur and chlorine Interhalogen and pseudohalogen compound. Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF_2)	**CSO 4.1:**to discuss the acidic and basic nature of p block elements. (U) **CSO 4.2:**to explain different chemical reactions of p block elements. (K) **CSO 4.3:** to understand the action of heat on diborane. (U) **CSO 4.4:**to explain the action of heat on Group 14, Group 15, Group 16 and Group 17 of p block elements. (U) **CSO 4.5:** to discuss the structure and oxidation states of oxoacids of phosphorus. (A) **CSO 4.6:** to discuss the structure and oxidation states of oxoacids of sulphur. (A)) **CSO 4.7:** to discuss the structure and oxidation states of oxoacids of chlorine. (A) **CSO 4.8:** to understand Interhalogen and pseudohalogen compounds with suitable examples. (U) **CSO 4.9:**to explain the clathrate compounds of xenon fluorides. (K)	**10**	**20**	
UNIT 5 Noble Gases	Separation and isolation of helium, neon and argon from liquid air, study of the following compounds	**CSO 5.1:** to discuss on the separation and isolation of helium from liquid air. (U) **CSO 5.2:** to explain the separation and isolation of neon (U) **CSO 5.3:**to study the separation	**07**	**16**	

	(preparation, structure and properties of XeF_2, XeF_4, and XeO_3 and $XeOF_4$.	and isolation of argon. (U) **CSO 5.4:**to explain the preparation, structure and properties of XeF_2. (U) **CSO 5.5:** to explain the preparation, structure and properties of XeF_4. (U) **CSO 5.6:** to disuss the preparation, structure and properties of XeO_3. (U) **CSO 5.7:** to understand the preparation, structure and properties of $XeOF_4$. (U)			

Suggested Readings: **Theory**

1. J.D.Lee, *Concise Inorganic Chemistry*, Wiley India, 2010.
2. J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi, *Inorganic Chemistry-Principles of Structure and Reactivity*, Pearson Education, 2009.
3. P.W. Atkins,T.L. Overton,J.P. Rourke,M.T.Weller,F.A. Armstrong, *Shriver and Atkins Inorganic Chemistry*, 5th Edition, Oxford University Press, 2010.
4. G.L.Miessler,P.J. Fischer, D.A. Tarr, *Inorganic Chemistry*, 5th Edition, Pearson, 2014.
5. C.E. Housecraft, A.G. Sharpe,*Inorganic Chemistry*, 5thEdition, Pearson, 2018.
6. G.R. Canham, T. Overton, *Descriptive Inorganic Chemistry***,** 6th Edition, Freeman and Company, 2014.
7. N.N. Greenwood, A.Earnsaw, *Chemistry of Elements*, 2nd Edition, Elsevier, 1997.

Practical:

Name of the Paper: Inorganic Chemistry-II
Paper Code: CHC-2.2 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

2. Redox Titrations

(i) Estimation of Fe(II) with K2Cr2O7 using diphenylamine as internal indicator.

(ii) Estimation of Fe(II) with K2Cr2O7 using N-phenyl anthranilic acid as internal indicator.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using external indicator.

3. Iodo/IodimetricTitrations

(i) Estimation of Cu(II) using sodium thiosulphate solution(Iodometrically).

(ii) Estimation of $K_2Cr_2O_7$ using sodium thiosulphatesolution(Iodometrically).

(iii) Estimation of antimony in tartaremeticiodimetrically.

(iv) Estimation of Iodine content in iodizedsalt.

Suggested Readings: **Practicals**

1. G. H.Jeffery, J.Bassett, J.Mendham,R. C. Denney, Vogel's Text book of *Quantitative Chemical Analysis*, John Wiley and Sons, 1989
2. D. C.Harris, C. A.Lucy, *Quantitative Chemical Analysis*, 9th Edition, Freeman and Company, 2016.
3. R.A.Day,A.L. Underwood, *Quantitative Analysis*, 6th Edition, PHI Learning Private Limited, 2012.

III **SEMESTER**

NAME OF THE PAPER (CODE) **: PHYSICAL CHEMISTRY- II (CHC-3.1)**

Number of Credit **03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper– **Physical Chemistry-II:**

CO 1:	The laws of thermodynamics, concept of properties (extensive, intensive), state and path functions.
CO 2:	Ability to apply the first law of thermodynamics on closed and control volume systems.
CO 3:	Ability to apply the second law of thermodynamics and entropy concepts in analyzing the thermal efficiencies of heat engines such as the Carnot Cycle.
CO 4:	Derive different expressions for thermodynamic functions (U, H, S, G, A).
CO 5:	Understand partial molar properties.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit&Title	**Unit Contents**	**Course Specific Objective (CSOs)**	**Lecture Hours**	**Marks**	**LOs**
UNIT 1 **Basic Concepts of Chemical Thermodynamics**	Intensive and extensive variables; state and path functions; isolated, closed and open systems.Mathematical treatment- Exact and inexact differential, Partial derivatives, Euler's reciprocity rule, cyclic rule.	**CSO 1.1:** to understand the Laws of Thermodynamics, State Functions, Path Functions, Intensive & Extensive variables. (U) **CSO 1.2:**to explain the exchange of energy and matter with its surroundings. (U) **CSO 1.3:**to describe how the system changes in time. (K) **CSO 1.4:**to discuss the Euler's reciprocity rule. (A) **CSO 1.5:**to explain the cyclic rule. (U)	**06**	**13**	
UNIT 2	Concept of heat, Q,	**CSO 2.1:** to state and	**15**	**28**	

First law and Thermochemistry	work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, Joule Thompson Porous Plug experiment, Nature of Joule Thompson coefficient, 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. Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of hydration, enthalpy of formation and enthalpy of combustion and its applications, bond dissociation energy and bond enthalpy; effect of temperature (Kirchhoff's equations) on enthalpy of reactions.	derive the various mathematical expressions of First Law. (A) **CSO 2.2:**to define enthalpy (H) **CSO 2.3:** to explain the principle of the Joule Thompson Porous Plug experiment. (K) **CSO 2.4:**to calculate Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases. (A) **CSO 2.5:** to explain various Enthalpies of reactions and derive the mathematical relations for these enthalpies of reaction. (K) **CSO 2.6:** to explain enthalpy of neutralization, enthalpy of hydration, enthalpy of formation and enthalpy of combustion and its applications. (U) **CSO 2.7:**to describe the amount of energy stored in a bond between atoms in a molecule. (U) **CSO 2.8:**to describe the enthalpy of a reaction variation with temperature changes. (K)			
UNIT 3	Concept of entropy;	**CSO 3.1:**to understand the	**15**	**27**	

Second Law of Thermodynamics	statement of the second law of thermodynamics, Carnot cycle. Calculation of entropy change for reversible and irreversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity (for ideal gases). Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.	concept of entropy. (U) **CSO 3.2:**to explain the feasibility of a rection using the second law of thermodynamics. (K) **CSO 3.3:**to analyse amount of heat absorbed and net work done during Carnot Cycle. (A) **CSO 3.4:**to calculate entropy change for reversible and irreversible processes for ideal gases. (A) **CSO 3.5:**to define Gibbs free energy, and describe its relation to spontaneity. (K) **CSO 3.6:**to explain the variation of S, G, A with T, V, P. (K) **CSO 3.7:** to derive relation between Joule- Thomson coefficient and other thermodynamic parameters. (A) **CSO 3.8:** to define inversion temperature. (K) **CSO 3.9:**to derive the Gibbs-Helmholtz equation. (A) **CSO 3.10:**to calculate changes in the Gibbs free energy of a system as a function of temperature. (A) **CSO 3.11:**to derive the			

		Maxwell relations. (A)			
UNIT 4 **Third Law of Thermodynamics**	Statement of third law, unattainability of absolute zero, calculation of absolute entropy of molecules, concept of residual entropy, calculation of absolute entropy of solid, liquid and gases.	**CSO 4.1:**to state the third law. (K) **CSO 4.2:**to calculate entropy changes for chemical reactions. (A) **CSO 4.3:**to understand the concept of residual entropy. (U) **CSO 4.4:** to calculate absolute entropy of solid, liquid and gases. (A)	**04**	**15**	
UNIT 5 **Systems of Variable Composition**	Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, Change in thermodynamic functions on mixing of ideal gases.	**CSO 5.1:** to explain and derive the mathematical relations for partial molar properties. (K, A) **CSO 5.2:**to discuss the dependence of thermodynamic parameters on composition. (K) **CSO 5.3:** to derive the Gibbs Duhem equation. (A) **CSO 5.4:**to understand the change in partial molar properties with composition at constant temperature and pressure. (U) **CSO 5.5:** to explain the change in thermodynamic functions on mixing of ideal gases. (K)	**05**	**17**	

Suggested Readings: **Theory**

1. A. Peter & J.D. Paula, *Physical Chemistry*, 9th Edition, Oxford University Press, 2011.
2. G. W. Castellan, *Physical Chemistry*, 4th Edition, Narosa, 2004.

Practical:

Name of the Paper: Physcial Chemistry-II
Paper Code: CHC-3.1 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization).

(b) Determination of heat capacity of a calorimeter for different volumes using heat gained equal to heat lost by cold water and hot water.

(c) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(d) Determination of the enthalpy of ionization of ethanoicacid.

(e) Determination of integral enthalpy solution of endothermicsalts.

(f) Determination of integral enthalpy solution of exothermicsalts.

(g) 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 firststep.

(h) Determination of enthalpy of hydration ofsalt.

(i) StudyofthesolubilityofbenzoicacidinwateranddeterminationofΔH.

Any other experiment carried out in the class.

Suggested Readings: **Practical**

1. B.D.Khosla, V.C.Garg, A. Gulati,*SeniorPractical Physical Chemistry*,R. Chand & Co, New Delhi, 2015.
2. K.L.Kapoor, *ATextbook of Physical Chemistry*, Vol.7, 1st Edition, McGraw Hill Education, 2019.
3. C. W.Garland, J. W.Nibler, D. P.Shoemaker, *Experiments in Physical Chemistry*, 8th Edition, McGraw-Hill, New York, 2003.
3. K.L. Kapoor, *A Textbook of Physical Chemistry*, Vol 2, 6th Edition, McGraw Hill Education, 2017.
4. K.L.Kapoor,*ATextbook of Physical Chemistry*, Vol 3, 5th Edition, McGraw Hill Education, 2015.
5. D.A.McQuarrie, J.D.Simon, *Molecular Thermodynamics*, Viva Books Pvt. Ltd, 2004.

NAME OF THE PAPER (CODE) **: ORGANIC CHEMISTRY – II (CHC-3.2)**

Number of Credit **03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper **Organic Chemistry – II (CHC-3.2)**

CO 1:	Have an understanding on the reactions of haloalkanes, haloarenes and oxygen containing functional group.
CO 2:	Interpret the concept of aromaticity and the main properties of aromatic compounds.
CO 3:	Recognize, differentiate and explain different reaction mechanism involving aryl halides.
CO 4:	Know the different classes of alcohols.
CO 5:	Understand the preparation and reactions of phenols, ethers and epoxides.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Outcomes (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Haloalkanes	Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with Stereochemical aspects and effect of solvent; nucleophilic substitution v/s elimination. Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.	**CSO 2.1:**to give a brief introduction of Alkyl Halides. (K) **CSO 2.2:**to discuss the methods ofpreparation of alkyl halides. (K) **CSO 2.3:**to study the different types of Nucleophilic substitution reactions. (K) **CSO 2.4:**to discuss the stereochemical aspects and effect of solvent on alkyl halides. (U) **CSO 2.5:**to give the difference between Elimination vs substitution reactions: (U) **CSO 2.6:**to explain the use of organometallic compounds of Mgin synthesis of organic compounds. (U)	**12**	**25**	

UNIT 2 **Aromatic Hydrocarbons**	Concept of Aromaticity and antiaromaticity;Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/acylation with their mechanism. Directing effects of groups in electrophilic substitution.	**CSO 2.1:**to understand the concept of aromaticity. (U) **CSO 2.2:** to apply criteria to determine if a ring is aromatic, anti-aromatic or non-aromatic. (A) **CSO 2.3:** to study the preparation of some of the compound containing benzene rings. (U) **CSO 2.4:** to study the reaction mechanism of the electrophilic aromaticsubstitutuon. (A) **CSO 2.5:**to study the Friedel-Craft's reactions. (U,A) **CSO 2.6:**to discuss the directing effects of groups in electrophilic substitution. (U)	**08**	**20**	
UNIT 3 **Aryl halides**	Preparation(including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.	**CSO 3.1:**to give an introduction on the aryl halides. (K) **CSO 3.2:**to discuss the preparation of Aryl halides. (U) **CSO 3.3:** To study the reaction mechanism of aromatic nucleophilic substitution reactions.(A) **CSO 3.5:**to discuss the reactivity of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. (U) **CSO 3.6:**to understand therelativestrengthof C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. (U)	**07**	**17**	

UNIT 4 **Alcohols**	Alcohols:Relative reactivity of 1°, 2°, 3° alcohols, reactions of alcohols with sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline KMnO4, acidic dichromate, conc. HNO3). Oppenauer oxidation; Diols: oxidation of diols by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.	**CSO 4.1:** to give the introduction on the alcohol. (K) **CSO 4.2:**to differentiate 1°, 2°, 3° alcohols and to explain their relative reactivity. **CSO 4.3:**to study the different chemical reaction mechanism of alcohols. (U,A) **CSO 4.3:** To study Lucas Test.(A) **CSO 4.4:** To explain esterification and oxidation.(U) **CSO 4.5:**To explain Oppenauer Oxidation.(U) **CSO 4.6:** To study the preparation of ethers.(U) **CSO 4.7:** to study some of the chemical reaction caused by the ethers. (U,A)	**10**	**18**	
UNIT 5 **Phenols, Ethers and Epoxides**	Phenols*:* Preparation using Cumenehydroperoxide, Acidity and factors affecting it, Kolbe's–Schmidt reactions, Riemer-Tiemann reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Fries and Claisen rearrangements and their mechanism. Ethers and Epoxides: Acid and Base catalyzed cleavage reactions.	**CSO 5.1:** to study the preparation of phenol using different methods and reagent/ salts. (U) **CSO 5.2:**to discuss the acidity of phenols and factors affecting it. (U) **CSO 5.3:**to discuss the different chemical reaction mechanism of phenols. (U, A) **CSO 5.4:**to explain the acid and base catalyzed cleavage reactions of Ethers and Epoxides. (K)	**08**	**20**	

Suggested Readings: **Theory**

1. R. N.Morrison, R. N.Boyd, S.K.Bhattacharjee, *Organic Chemistry*, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2010
2. I.L. Finar, *Organic Chemistry*, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education, 2002.
3. V.K.Ahluwalia, P.Bhagat, R.Aggarwal, R. Chandra, *Intermediate for Organic Synthesis***,** I.K. International, 2005.
4. T.W.G.Solomons, C.B.Fryhle, S.A.Snyder, *Organic Chemistry*, 12th Edition, Wiley, 2017.

Practical:

Name of the Paper: Physical Chemistry -II
Paper Code: CHC-3.2 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1. Acetylation of any one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (*β*-naph,thol, salicylic acid) by any one method:
   i. Using conventional method ii. Using green approach
2. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*-toluidines and *o*, *m*-, *p*-anisidine) or one of the following phenols (*β*-naphthol, resorcinol, *p*- cresol) by Schotten-Baumann reaction.
3. Bromination of acetanilide/aniline/phenol by anyone of the following:
   (a) Green method b) Conventional method
4. Nitration of nitrobenzene/chlorobenzene.
5. Haloform reaction of ethanol.
6. Oxidation of benzyl alcohol to benzoic acid
7. Estimation of the given sample of phenol/amine by:

   a) Acetylation b) Bromate-Bromidemethod
8. Functionalgrouptestsforalcohols, phenols, carboxylicacids, phenols,carbonyl compounds,esters.

Suggested Readings: **Practical**

1. F.G.Mann, B.C. Saunders, *Practical Organic Chemistry*, 4th Edition, Pearson Education, 2009.
2. B.S.Furniss, A.J.Hannaford, P.W.G.Smith, A.R.Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, Pearson, 2005.
3. V.K.Ahluwalia, R. Aggarwal, *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press, 2004.

4. V.K.Ahluwalia,S.Dhingra, *ComprehensivePractical Organic Chemistry: Qualitative Analysis*, University Press, 2004.
5. S.Pasricha, A.Chaudhary, *Practical Organic Chemistry: Volume–I*, I K International Publishing house Pvt. Ltd, New Delhi, 2021.
6. S.Pasricha, A.Chaudhary, *Practical Organic Chemistry: Volume–II*, I K International Publishing house Pvt. Ltd, New Delhi, 2021.

NAME OF THE PAPER (CODE) : INORGANIC CHEMISTRY-III (CHC-3.3)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Inorganic Chemistry- III:**

CO 1:	Understand the fundamental principles of transition metal coordination chemistry and ligand field theory, to understand the structure and function of metal ion sites in bio molecules.
CO 2:	Understand the complex bonding principles and reactivity involving the main and transition metals and the key role the metal-carbon bonded systems can play in modern life.
CO 3:	Understand the characteristics and behaviour of inner transition elements.
CO 4:	Ability to describe the properties of f-block elements and give a comparative account with respect to their electronic configurations, oxidation states and chemical behaviour.
CO 5:	Understand the role of inorganic elements in biological processes.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Outcomes (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Coordination Chemistry	Werner'stheory, 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 affecting the	**CSO 1.1:** to explain the structure, formation and nature of bonding in the coordination compounds using the Werner's theory. (U) **CSO 1.2:** to describe the covalent bond formation as well as the electronic structure of molecules using the Valence Bond Theory. (K) **CSO 1.3:** to know the principle of electroneutrality and back	**17**	**29**	

	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.	bonding. (K) **CSO 1.4:** to describe the breaking of orbital degeneracy in transition metal complexes due to presence of ligands. (U) **CSO 1.5:** to predict the stability and reactivity of coordination complexes using the crystal field stabilization energy. (A) **CSO 1.6:**to explain factors affecting the magnitude of 10 Dq (Δo, Δt). (U) **CSO 1.7:**to depict on the relationship between octahedral vs. tetrahedral complexes. (K) **CSO 1.8:**to explain the geometric distortion of a non-linear molecular system using the Jahn-Teller theorem. (A) **CSO 1.9:**to study the Qualitative aspect of Ligand field and MO theory.(A) **CSO 1.10:**to understand bonding and anti-bonding orbitals arising from atomic orbitals. (A) **CSO 1.11:** to know the IUPAC nomenclature of coordination compounds. (K) **CSO 1.12:**to describe isomerism in coordination compounds. (U) **CSO 1.13:**to study the Stereochemistry of complexes with 4 and 6 coordination numbers. (A) **CSO 1.14:**to understand the			

		stability of complexes. (U) **CSO 1.15:** to define the polynuclear complexes, Labile and inert complexes. (K)			
UNIT 2 **Transition Elements**	General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states. Difference between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy).	**CSO 2.1:** to describe the compounds and reactivities of transition metals and trends in their physical and chemical properties. (K) **CSO 2.2:** to know the electronic configuration of transition metals. (K) **CSO 2.3:**to understand the magnetic and catalytic propertiesof transition metals. (U) **CSO 2.4:**to demonstrate the relationship between colour and oxidation number of transition elements. (A) **CSO 2.5:**to understand the ability of transition metals to form complexes. (U) **CSO 2.6:** to explain thestability of oxidation states of various transition metals. (U) **CSO 2.7:** to compare the properties of first, second and third transition series. (K) **CSO 2.8:**to describe the Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states. (K)	**10**	**22**	
UNIT 3	Electronic	**CSO 3.1:**to analyse	**06**	**16**	

Lanthanoids	configuration, oxidation states, ionic radii, lanthanide contraction, tendency to form complexes, colour, separation of lanthanides (ion-exchange method only).	characteristics of 4f and 5f elements. (A) **CSO 3.2:**to discuss the electronic configuration, oxidation states, ionic radii of lanthanoids. (K) **CSO 3.3:** to explain the behaviour of lanthanides to exhibit variable oxidation states. (U) **CSO 3.4:** to understand lanthanide contraction and its reasons. (U) **CSO 3.5:**to explain the behaviour of lanthanides to form complexes. (U) **CSO 3.6:**to discuss the separation of lanthanides using the ion-exchange method. (K)			
UNIT 4 Actinoids	Chemistry of separation of Np, Pu and Am from U. Preparation, reactions, structure and uses of uraniumhexafluoride.	**CSO 4.1:**to explain the properties of actinides (U) **CSO 4.2:**to differentiate between lanthanides and actinides. (U) **CSO 4.3:** to discuss the chemistry of separation of Np, Pu and Am from U. (K) **CSO 4.4:** to explain the preparation and reactions of uraniumhexafluoride. (U,A) **CSO 4.5:**to discuss on the structure and uses of uraniumhexafluoride. (K)	**06**	**11**	
UNIT 5 Bioinorganic Chemistry	Metal ions present in biological systems, classification of	**CSO 5.1:**to understand the role of elements in biological systems. (U)	**06**	**22**	

	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 inmedicine.Iron and its application in biosystems, Haemoglobin; Storage and transfer of iron.	**CSO 5.2:**to study the various metal ions present in biological systems. (K) **CSO 5.3:**to explain the classification of elements according to their action in biological system. (U) **CSO 5.4:**to study the relative and absolute abundance of metals at different regions. (K) **CSO 5.5:**to explain the toxicity, mechanism and health effects of metal ions (Hg, Pb, Cd and As). (K) **CSO 5.6:**to discuss the significance of chelating agents in medicine. (K) **CSO 5.7:** to understand the biochemistry application of iron. (U)			

Suggested Readings: **Theory**

1. K.F. Purcell, J.C. Kotz, *Inorganic Chemistry* W.B. Saunders Co, 1977.
2. J.E.Huheey, *Inorganic Chemistry*, Prentice Hall, 1993.
3. S.J. Lippard, &J.M. Berg, *Principles of Bioinorganic Chemistry* Panima Publishing Company, 1994.
4. F.A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
5. F. Basolo, andR.C. Pearson, *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
6. N.N. Greenwood,A. Earnshaw *Chemistry of the Elements*, Butterworth- Heinemann, 1997.

Practical:

Name of the Paper: Inorganic Chemistry-III
Paper Code: CHC 3.3 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

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 $Al(oxine)_3$ (aluminium oxinate).

Inorganic Preparations

i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$

ii. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III)

iii. Tetraamminecarbonatocobalt (III) ion

iv. Potassium tris(oxalate)ferrate(III)

Suggested Readings:**Practical**

1. J. *A. I.* Mendham, *Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009

SEMESTER IV

NAME OF THE PAPER (CODE) : PHYSICAL CHEMISTRY-III (CHC-4.1)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Physical Chemistry-III:**

CO 1:	Introduction to Phase Equilibria.
CO 2:	Discuss the concept and applications of phase.
CO 3:	Analyse the study of the kinetics of chemical reactions.
CO 4:	Understand and apply core principles and concepts in catalysis.
CO 5:	Understand the concept of surface tension.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Outcomes (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Phase Equilibria I	Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for non-reactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.	**CSO 1.1:** To explain the concept of phases, component and degree of freedom (U) **CSO 1.2:** To derive the Gibbs Phase Rule. (A) **CSO 1.3:** To derive the Clausius-Clapeyron equation. (A) **CSO 1.4:** To give the application of Clausius-Clapeyron to solid-liquid equilibria. (A) **CSO 1.5:** To give the application of Clausius-Clapeyron to liquid-vapour equilibria. (A) **CSO 1.6:** To give the application of Clausius-Clapeyron to solid-vapour equilibria. (A) **CSO 1.7:** To explain the concept of phase diagram for one component systems (U) **CSO 1.8:** To outline the applications of phase diagram. (K) **CSO 1.9:** To explain the phase diagrams for system of solid-liquid equilibria. (U) **CSO 1.10:** To explain the congruent and incongruent melting points. (U) **CSO 1.11:** To make student understand the solid solution. (K)	**12**	**27**	

UNIT 2 Phase Equilibria II	Three component systems, water-chloroform-acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.	**CSO 2.1:** To give the three component system of phase rule. (K) **CSO 2.2:** To define binary solution. (K) **CSO 2.3:** To derive the Gibbs-Duhem-Margules equation. (A) **CSO 2.4:** To Explain the application of the Gibbs-Duhem-Margules equation to fractional distillation.(U) **CSO 2.5:** To introduce the Lever rule. (K) **CSO 2.6:** To explain the partial miscibility of liquids. (U) **CSO 2.7:** To give the student idea about the CST. (U) **CSO 2.8:** To give the Nernst distribution law and its applications. (U) **CSO 2.9:** To derive the Nernst distribution law. (A)	**11**	**22**	
UNIT 3 Chemical Kinetics	Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy.	**CSO 3.1:** To give the order and molecularity of a reaction. (k) **CSO 3.2:** To explain the rate law in terms of the advancement of reactions. (U) **CSO 3.3:** To explain the differential and integrated from of expressions.(U) **CSO 3.4:** To determine the rate law. (A) **CSO 3.5:** To give the Kinetics of complex reactions. (U) **CSO 3.6:** To derive the Arrehenius Equations. (A) **CSO 3.7:** To give the Collision theory of reaction rate. (U) **CSO 3.8:** To explain the Lindemann mechanism. (A) CSO 3.9: To give the quantitative treatment of the theory of absolute reaction rate. (U)	**12**	**27**	

	Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.				
UNIT 4 Catalysis	Types of catalyst, specificity and selectivity, mechanisms of catalysed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.	**CSO 4.1:** To give the type of catalyst. (K) **CSO 4.2:** To explain the specificity and selectivity of catalysed reaction. (U) **CSO 4.3:** To explain the effect of particle size and efficiency of nano particles as catalyst. (U) **CSO 4.4:** To explain the enzyme catalysis. (U) **CSO 4.5:** To explain the Michaelis-Menten mechanism. (A) **CSO 4.6:** To explain the acid-base catalysis. (A)	**6**	**15**	
UNIT 5 Surface Chemistry	Physical adsorption, chemisorption, adsorption isotherms. Nature of adsorbed state.	**CSO 5.1:** To explain the physical adsorption. (U) **CSO 5.2:** To define chemisorption. (K) **CSO 5.3:** To explain adsorption isotherms. (U) **CSO 5.4:** To explain the nature of adsorbed state. (U)	**4**	**9**	

Suggested Readings: Theory

1. P. Atkins & J.D. Paula, *Physical Chemistry 10th Ed.*,Oxford University Press, 2014.
2. G. W. Castellan,*Physical Chemistry4th Ed*., Narosa, 2004.
3. D. A. McQuarrie&J. D. Simon,*Molecular Thermodynamics*, Viva Books Pvt. Ltd. New Delhi, 2004.
4. T. Engel & P. Reid, *Physical Chemistry 3rd Ed.,* Prentice-Hall, 2012.
5. M. J. Assael,A. R. H. Goodwin, M.Stamatoudis, W. A. Wakeham &S.Will,*Commonly Asked Questions in Thermodynamics,*CRC Press, New York, 2011.
6. S.S.Zundhal, *Chemistry concepts and applications,*Cengage India, 2011.
7. D. W. Ball,*Physical Chemistry*, Cengage India, 2012.
8. R. G. Mortimer,*Physical Chemistry 3rd Ed.*,Elsevier: NOIDA, UP, 2009.
9. I. N.Levine,*Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.
10. C. R Metz, *Physical Chemistry 2nd Ed.*,Tata McGraw-Hill, 2009.

Practical

Name of the Paper: Physical Chemistry-III
Paper Code: CHC 4.1 P
Number of Credit: 01

Number of Hours of Lecture: 30 Lectures

I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities 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 cyclohexane.

IV. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_2(aq) + I^- \rightarrow I^-_3(aq)^{2+}$

(ii) $Cu_2^+(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

V. Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
    a. Acid hydrolysis of methyl acetate with hydrochloric acid.
    b. Saponification of ethyl acetate.
3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

VI. Adsorption

1. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Suggested Readings: Practical

1. B. D.KhoslaGarg, V. C. &A. Gulati,*Senior Practical Physical Chemistry*,R. Chand &Co.New Delhi, 2011.
2. C. W.Garland,J. W Nibler, &D. P. Shoemaker,*Experiments in Physical Chemistry 8th Ed.*, McGraw-Hill: New York, 2003.
3. A. M. Halpern, &G. C McBane, *Experimental Physical Chemistry 3rd Ed.*,W.H. Freeman & Co. New York, 2003.

NAME OF THE PAPER (CODE) **: ORGANIC CHEMISTRY-III (CHC-4.2)**

Number of Credit **03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Organic Chemistry-III:**

CSO 1:	Understand the important reactions of nitro and compounds.
CSO 2:	Know the various properties and synthesis of polynuclear aromatic compounds.
CSO 3:	Have a broad understanding of the classes of heterocyclic compounds.
CSO 4:	Understand the structure and functions of alkaloids and its Reactions.
CSO 5:	Understand the structure and functions of Terpenes and its Reactions.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Nitrogen Containing Functional Groups	Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann‘s exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications	**CSO 1.1:** An introduction to the nitro Compound. (K) **CSO 1.2:** To explain the preparation of the nitro compound. (U) **CSO 1.3:** To give the physical properties of the nitro compounds. (K) **CSO 1.4:** To give the mechanism of Gabriel phthalimide. (A) **CSO 1.5:** To give the mechanism of Carbylamine reaction. (A) **CSO 1.6:** To give the mechanism of Mannich reaction. (A) **CSO 1.7:** To give the mechanism of Hoffmann‘s exhaustive methylation and Hofmann-elimination reaction. (A) **CSO 1.8:** To explain the different methods to distinguished between	**12**	**30**	

		1°, 2° and 3° amines. (U) **CSO 1.9:** To give an introduction on Diazonium Salts. (K) **CSO 1.10:** To explain the preparation of Diazonium Salts.(U) **CSO 1.11:** To give the synthetic application of Diazonium Salts. (U)			
UNIT 2 Polynuclear Hydrocarbons	Reactions of naphthalene, phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.	**CSO 2.1:** To give an introduction on the polynuclear hydrocarbonds. (K) **CSO 2.2**: To explain the reaction of naphthalene, phenanthrene and anthracene. (U) **CSO 2.3:** To explain the structure of naphthalene, phenanthrene and anthracene. (U) **CSO 2.4:** To give the preparation of naphthalene, phenanthrene and anthracene. (U) **CSO 2.5:** To explain the structure elucidation of naphthalene, phenanthrene and anthracene. (U) **CSO 2.6:** To give some of the important derivatives of naphthalene, phenanthrene and anthracene. (U)	**6**	**19**	
UNIT 3 Heterocyclic Compounds	Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole	**CSO 3.1:** An introduction to heterocyclic compound. (K) **CSO 3.2:** To classified different types of heterocyclic compound. (U) **CSO 3.3:** To explain the structure of aromaticity in 5-numbered rings containing one heteroatom.	**17**	**27**	

	(Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Fried-lander‘s synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction. Derivatives of furan: Furfural and furoic acid.	(U) **CSO 3.4:** To explain the structure of aromaticity in 6-numbered rings containing one heteroatom. (U) **CSO 3.5:** To explain the mechanism of Paal-Knorr reactions. (A) **CSO 3.6:** To explain the mechanism of Knorr pyrrole. (A) **CSO 3.7:** To explain the mechanism of Hantzsch synthesis. (A) **CSO 3.8:** To explain the structure elucidation of indole. (U) **CSO 3.9:** To explain the mechanism of Hantzsch synthesis. (A) **CSO 3.10:** To explain the mechanism of Madelung synthesis.(A) **CSO 3.11:** To explain the structure elucidation of quinoline and isoquinoline (U) **CSO 3.12:** To explain the mechanism of Skraup synthesis. (A) **CSO 3.13:** To explain the mechanism of Fried-lander‘s synthesis. (A) **CSO 3.14:** To explain the mechanism of Knorr quinoline synthesis. (A) **CSO 3.15:** To explain the mechanism of Doebner- Miller synthesis (A)			

		CSO 3.16: To explain the mechanism of Bischler-Napieralski reaction (A) **CSO 3.17:** To explain the mechanism of Pictet-Spengler reaction, (A) **CSO 3.18**: To explain the mechanism of Pomeranz-Fritsch reaction.. (A) **CSO 3.19:** To explain how the Furfural and furoic acid are derived from furan. (U)			
UNIT 4 **Alkaloids**	Natural occurrence, General structural features, Isolation and their physiological action Hoff-mann‘s exhaustive methylation, Emde‘s modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.	**CSO 4.1:** An introduction to the alkaloids. (K) **CSO 4.2:** To explain the natural occurrence of alkaloids. (U) **CSO 4.3:** To explain the general structure of the alkaloids. (U) **CSO 4.4:** To explain how the alkaloids are isolated and give their physiological actions. (U) **CSO 4.5:** To explain the mechanism of Hoff-mann‘s exhaustive methylation. (A) **CSO 4.6:** To explain the Emde‘s modification **CSO 4.7:** To explain the structure elucidation and synthesis of Hygrine and Nicotine. (U) **CSO 4.8:** To make student aware the medicinal importance of alkaloids. (U)	**6**	**15**	
UNIT 5 **Terpenes**	Occurrence, classification, isoprene rule; Elucidation of structure and synthesis	**CSO 5.1:** A brief introduction on terpenes. (K) **CSO 5.2:** To explain the	**4**	**9**	

	of Citral, Neral and α-terpineol.	occurrence and classification of terpenes. (U) **CSO 5.3:** To explain the structure elucidation of Citral, Neral and α-terpineol. (U) **CSO 5.4:** To study the synthetic mechanism of Citral, Neral and α-terpineol. (A)			

Suggested Readings:

1. R. T. Morrison& R. N. Boyd,*Organic Chemistry*, Dorling Kindersley, India Pvt. Ltd. Pearson Education, 1992.
2. I. L. Finar, *Organic Chemistry* (*Volume 1*),Dorling Kindersley India Pvt. Ltd. Pearson Education, 1954.
3. I. L Finar,*Organic Chemistry* (*Volume 2): Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. Pearson Education, 1959.
4. R.M. Acheson,*Introduction to the Chemistry of Heterocyclic compounds*,John Welly & Sons, 1976.
5. T.W. G.Solomons,*OrganicChemistry*,John Wiley & Sons, Inc., 2016.
6. J.E.McMurry,*Fundamentals of Organic Chemistry, 7th Ed*., Cengage Learning India Edition, 2013.
7. P. S. Kalsi,*Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub., 2002.
8. J. Clayden, N. Greeves, S. Warren &P. Wothers, *Organic Chemistry*,Oxford University Press, 2012.
9. J.Singh, S.M. Ali &J. Singh,*Natural Product Chemistry*,PrajatiParakashan, 2010.

Practical:

Name of the Paper: Organic Chemistry-III
Paper Code: CHC-4.2 P
Number of Credit: 01
Number ofHours of Lecture: 30 Lectures

1. Purification of organic compounds by crystallization using the following solvents:

   a. Water b. Alcohol c. Alcohol-Water

2. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

3. Effect of impurities on the melting point – mixed melting point of two unknown organiccompounds

4. Determination of boiling point of liquid compounds. (Boiling point lower than and more than100 °C by distillation and capillary method)

5. Chromatography

a. Separation of a mixture of two amino acids by ascending 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 layerchromatography (TLC)

Suggested Readings:

1. F.G. Mann&B.C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B.S. Furniss, A.J.Hannaford, P.W.G.Smith & A.R. Tatchell, *Practical Organic Chemistry, 5thEd.*, Pearson, 2012.

NAME OF THE PAPER (CODE) : INORGANIC CHEMISTRY-IV (CHC-4.3)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Inorganic Chemistry-IV:**

CO 1:	Have a good overview of the fundamental principles of organ transition-metal chemistry and know how chemical properties are affected by metals and ligands
CO 2:	Understand the mechanism, stability and reactivity of simple organometallic complexes
CO 3:	Understand efficient catalytic processes and their applications.
CO 4:	Describe the reactions involving inorganic chemistry. Derive various mechanisms of substitutions reactions square planar and octahedral complexes.
CO 5:	Elaborate catalysis reactions and their mechanisms.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	Los
UNIT 1 Theoretical Principles in Qualitative Analysis (H_2S Scheme)	Basic principles involved in analysis of cations and anions and 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	**CSO 1.1:** An introduction to the theoretical principles in Qualitative analysis. (K) **CSO 1.2:** To explain the Basic principles involved in analysis of cations and anions. (U) **CSO 1.3:** To explain the principles involved in separation of cations into groups. (U) **CSO 1.4:** To explain the interfering anions. (U)	**6**	**14**	

	Group II.	**CSO 1.5:** To make student understand why there is a need for the removal of the interfering anions after Group II in the periodic table. (K)			
UNIT2 Organometallic Compounds I	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).	**CSO 2.1:**To appraise the students about the organometallic Chemistry. (K) **CSO 2.2:** To identify the basic concept, terms, and important events in the development of organometallic chemistry. (U) **CSO 2.3:** To learn about the 18 e rule and its violation. (U) **CSO 2.4:** To explain the general methods for the preparation of mono and binuclear carbonyls of 3d series. (U,A) **CSO 2.5:**To explain the structure of mononuclear and binuclear carbonyls of some of the metalsusing VBT. (A) **CSO 2.6:**To learn about the π-acceptor behaviour of CO. (U) **CSO 2.7:** To identify the basic concept, terms, and important events in the development of organometallic chemistry. (U)	**10**	**25**	
UNIT 3 Organometallic Compounds II	*Zeise's salt*: Preparation and structure, evidences of synergic effect and comparison ofsynergic effect with that in carbonyls. *Metal Alkyls*: Important structural features of methyl lithium (tetramer) andtrialkylaluminium (dimer), concept of multicentre bonding in these compounds. Role of	**CSO 3.1:** To learn about the preparation of Zeise's salt. (U) **CSO 3.2:** To explain the structure of Zeise's salt. (U) **CSO 3.3:** To explain how the synergic effect is arising due to metal-ligand bonding. (U) **CSO 3.4:** To learn about the important structural features of methyl lithium. (K) **CSO 3.5:** To make student understand how the multicentre covalent bonds	**12**	**30**	

	triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures. *Ferrocene:* Preparation and reactions (acetylation, alkylation, metallation, MannichCondensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.	involves more than two atoms. (A) **CSO 3.6:** To explain the role of Ziegler – Natta Catalyst in formation of thermoplastics. **CSO 3.7:** To learn the structure of the species containing in solutions of Grignard reagent. (U) **CSO 3.8:** To study the preparation of Ferrocene. (K) **CSO 3.9:** To study the different reaction mechanism for the synthesis of Ferrocene. (A) **CSO 3.10:** To learn the structure and aromaticity of Ferrocene. (U) **CSO 3.11:** To study the difference between the Ferrocene and benzene. (U)			
UNIT 4 Reaction Kinetics and Mechanism	Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.	**CSO 4.1:** To learn the inorganic reaction mechanisms.(U) **CSO 42:** To learn the substitution reaction that are involved in the inorganic reactions. (K) **CSO 4.3:** An introduction to the trans-effect. (K) **CSO 4.4:** To study the mechanism involved in nucleophilic substitution in square planar complexes.(A) **CSO 4.5:** To study the thermodynamics of inorganic reactions. (U) **CSO 4.6:** To study the Kinetic stability of octahedral substitution. (U,A) **CSO 4.7:** To learn how the various d orbitals are affected differently when surrounded by a field of neighbouring ligands. (U) **CSO 4.8:** To explain how the coordinated solvent molecule, such as H_2O is replaced by another ligand. (A)	**9**	**17**	

UNIT 5 Catalysis by Organometallic Compounds	Study of the following industrial processes and their mechanism: 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Hydroformylation (Co salts) 3. Wacker Process 4. Synthetic gasoline (Fischer Tropsch reaction) 5. Synthesis gas by metal carbonyl complexes	**CSO 5.1:**To understand the fundamental reaction types and mechanisms and how to combine these to understand efficient catalytic processes. (K) **CSO 5.2:** To study the mechanism of Wilkinson's Catalyst. (A) **CSO 5.3:** To study the mechanism of Hydroformylation. (A) **CSO 5.4:** To study the mechanism of Wacker Process. (A) **CSO 5.5:** To study the mechanism of Synthetic gasoline. (A) **CSO 5.6:** To study the Synthesis gas by metal carbonyl complexes. (A)	**8**	**14**	

Suggested Readings:

1. G Svehla, *Vogel's Qualitative Inorganic Analysis, 7th Edition*, Prentice Hall, 1996.
2. F.A. Cotton & G. Wilkinson & P.L Gaus, *Basic Inorganic Chemistry 3rd Ed.*,WileyIndia,Huheey, (1988).
3. J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure andReactivity 4th Ed.*, Harper Collins 1993, Pearson,2006.
4. A.G. Sharpe, *Inorganic Chemistry*, Indian Reprint, Pearson Education, 2005.
5. B. E. Douglas, , D.H. McDaniel&J.J. Alexander, *Concepts and Models in InorganicChemistry3rd Ed.*, John Wiley and Sons, New York, 1994.
6. N.N. Greenwood, & A. Earnshaw, *Chemistry of the Elements, Elsevier 2nd Ed, ZieglerNatta Catalyst and Equilibria in Grignard Solution*, 1997.
7. J.D. Lee, *Concise Inorganic Chemistry 5th Ed.*, John Wiley and sons, 2008.
8. P. Powell, *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
9. D.D. Shriver, & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.
10. F. Basolo, &R. Pearson, *Mechanisms of Inorganic Reactions: Study of Metal Complexes inSolution 2nd Ed.*, John Wiley & Sons Inc., New York,1958.
11. K.F. Purcell, &J.C. Kotz, *Inorganic Chemistry*, W.B. Saunders Co., 1977.
12. G. L. Miessler, &D.A. Tarr, *Inorganic Chemistry 4th Ed.*, Pearson, 2010.
13. J. P. Collman, *Principles and Applications of Organic Chemistry*. Mill Valley, CA:University Science Books 1987.

Practical:

Name of the Paper: Inorganic Chemistry-IV
Paper Code: CHC 4.3 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

Qualitative semimicro 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_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+,Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+} Ca^{2+},Mg^{2+}

Mixtures should preferably contain one interfering anion, **or** insoluble component (BaSO4, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, 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.

i. Measurement of 10 Dq by spectrophotometric method

ii. Verification of spectrochemical series.

iii. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.

iv. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. Find the λ_{max} of the complex.

v. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Suggested Readings:

1. G. Svehla, Vogel's*Qualitative Inorganic Analysis,* Pearson Education, 2002.
2. Marr &Rockett,*Practical Inorganic Chemistry.* John Wiley & Sons, 1972.

V- **SEMESTER**

NAME OF THE PAPER (CODE) : ORGANIC CHEMISTRY-IV (CHC-5.1)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Organic Chemistry-IV:**

CO 1:	Explain the important features of nucleic acids and its structural organization.
CO 2:	Describe the classifications of amino acids, peptides and Proteins. Elaborate its structures.
CO 3:	Explain the notes on enzymes and develop their ability to examine their properties and applications.
CO 4:	Understand the functions of Lipids and oils and differentiate them.
CO 5:	Understand the pharmaceuticals importance and its compositions. To know the importance of antimalarials, antibiotics and analgesics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Nucleic Acids	Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.	**CSO 1.1:** An introduction to nucleic acid. (K) **CSO 1.2:** To give the components of nucleic acids, Nucleosides and nucleotides. (U) **CSO 1.3:** To explain the structure of some of the nucleic acid. (U) **CSO 1.4:** To study the reaction mechanism of nucleic acid. (U,A)	**7**	**14**	
UNIT 2 Amino Acids, Peptides and Proteins	Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of	**CSO 2.1:** To give a brief introduction of Amino Acids, Peptides and Proteins. (K) **CSO 2.2:** To Predict the different type of amino acids. (U) **CSO 2.3:** To study the synthesis of amino acid. (A) **CSO 2.4:** Recognize the	**13**	**32**	

	peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis.	basic properties (structure, physical and chemical properties) of amino acids. (U) **CSO 2.5:** To Predict whether the acid and amine groups in amino acids will be protonated at different pH values. (A) **CSO 2.6:** Describe the primary, secondary, tertiary and quaternary structure of proteins. (U)			
UNIT 3 Enzymes	Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).	**CSO 3.1:** To understand structure, and functions of enzymes. Learning kinetics of enzyme catalysed reactions and regulatory process, Enzyme activity, Enzyme Units, Specific activity. (U) **CSO 3.2:** Have a deeper insight in to the fundamentals of enzyme structure, function and kinetics of enzymes. Discussion on current applications and future potential of enzymes. (U,A) **CSO 3.3:** To explain and make student understand the rate of reactions and order of reactions.(U) **CSO 3.4:** To gain knowledge on enzyme catalysis and isoenzymes and on multienzyme complexes. (K) **CSO 3.5:** To learn the models of enzyme action and mapping of enzyme active site. (A) **CSO 3.6:** To provide concept of importance of kinetics of enzyme inhibitions and how they	**8**	**16**	

		influence drug action. (A) **CSO 3.7:** To learn the role of enzyme inhibitors in drug discovery and drug design.(U) **CSO 3.8:** To gain insight into catalytic mechanisms of enzymes and allosteric regulation of enzymes.(A)			
UNIT 4 **Lipids**	Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.	**CSO 4.1:** To provides a basic understanding of the chemistry of lipids. (K) **CSO 4.2:** To define fats and oil. (K) **CSO 4.3:** To make student aware the structure of saturated and unsaturated fatty acids. (U) **CSO 4.4:** To write the saponification reactions. (A) **CSO 4.5:**Todescribe the properties of triglyceride, phospholipid and cholesterol molecules and relate them to their functions in organisms.(K) **CSO 4.6:** To recall that lipids can be classified into simple, complex, and derived lipids. (U)	**7**	**14**	
UNIT 5 **Pharmaceutical Compounds: Structure and Importance**	Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).	**CSO 5.1**: To make student Understand the chemistry of drugs with respect to their pharmacological activity. (U) **CSO 5.2:** To explain the therapeutic approach on management of the medicine towards certain diseases. (U) **CSO 5.3:** To explain the importance of preparation of individualized therapeutic plans based on diagnosis. (A) **CSO 5.4**: To explain the Structural Activity Relationship (SAR) of different class of drugs. (A) **CSO 5.5:** To give the uses of organic compounds in pharmacy. (K) **CSO 5.6:**To let the student	**10**	**24**	

		gain knowledge on structure and medicinal uses of pharmaceutical organic compounds.(K)			

Suggested Readings:

1. R.L.P.Adams, J.T. Knowler &D.P.Leader, *The Biochemistry of the Nucleic Acid 11th Ed,* Springer, 1992.
2. M.I.Gurr, J.L. Harwood, K. N.Frayn, D. J. Murphy & R.H. Michell, *Lipids Biochemistry, Biotechnology and Health 6th Ed.* Wiley-Blackwell, 2016.
3. B. Sharma & U.K. Sharma, *Pharmaceutical Chemistry,* Himalaya Publishing House, India, 2023.

Practical:

Name of the Paper: Organic Chemistry-IV
Paper Code: CHC-5.1 P
Number of Credit: 01
Number ofHours of Lecture: 30 Lectures

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.

Suggested Readings:

1. Manual of Biochemistry Workshop, Department of Chemistry, University of Delhi,2012.

2. I. V. Arthur, *Quantitative Organic Analysis,* Pearson, India,2011.

NAME OF THE PAPER (CODE) **: PHYSICAL CHEMISTRY-IV (CHC-5.2)**

Number of Credit **03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Physical Chemistry-IV:**

CO 1:	Explain the factors that affect conductance, migration of ions and application of conductance measurement.
CO 2:	Understand different types of galvanic cells, their Nernst equations, and measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
CO 3:	Understand applications of Emf measurements in relation to determination of activity coefficients, pH of a solution and Potentiometric titrations.
CO 4:	Basic functions of electrochemistry and its activity in acid-base and redox reactions.
CO 5:	Describe electric and magnetic properties of atoms and molecules. Derive Clausius mosotti reactions.

COURSE SPECIFICOBJECTIVES (CSOs)

Unit &Title	Content	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Conductance I	Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden‘s rules.	**CSO 1.1:** To give the Arrhenius theory of electrolytic dissociation. (K) **CSO 1.2:** To explain the variation of specific conductivity or conductance decreases in dilution with the molar conductance. (U) **CSO 1.3:** To state and derive the Kohlrausch law of independent migration of ions. (U,A) **CSO 1.4**: To derive the Debye-Hückel-Onsager equation. (A) **CSO 1.5:** To explain the Wien effect and Debye-Falkenhagen effect. (U) **CSO 1.6:** To explain the Walden‘s rules for conductance. (U)	**8**	**18**	
UNIT 2 Conductance II	Ionic velocities, mobilities and their determinations,	**CSO 2.1:** To explain the measurement of the ion using Hittorf and Moving Boundary methods. (U)	**8**	**18**	

	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) Conductmetric titrations and (v) hydrolysis constants of salts.	**CSO 2.2:** To give a brief introduction on the application of conductance measurement. (K) **CSO 2.3:** To explain the application of degree of dissociation of weak electrolytes. (U) **CSO 2.4:** To explain the application of ionic product of water.(U) **CSO 2.5:** To explain the solubility and solubility product of sparingly soluble salts.(U) **CSO 2.6:** To explain the Conductmetric titrations. (U) **CSO 2.7:** To explain the hydrolysis constants of salts.(U)			
UNIT 3 Electrochemistry I	Quantitative aspects of Faraday‘s laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation, Standard electrode (reduction) potential and its application to different kinds of half-cells.	**CSO 3.1:**To Know the basic of ions, electrolyte, movement of ions, electrochemistry. (K) **CSO 3.2:**To know how the ionic movements are related to different other fields such as thermodynamics. (U) **CSO 3.3:** To let students gain the basic knowledge on novel energy storage devices. (K) **CSO 3.4:** To explain Quantitative aspects of Faraday‘s laws of electrolysis. (U) **CSO 3.5:** To give applications of electrolysis in metallurgy and industry. (U) **CSO 3.6:** To derive the Nernst equation. (A) **CSO 3.7:** To study thestandard electrode (reduction) potential and its application to different kinds of half-cells. (U)	**16**	**34**	

	Application of EMF measurements in determining (i) Free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes.	**CSO 3.8:**Using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes the application of EMF measurements in determining (i) Free energy, enthalpy and entropy of a cell reaction. (ii) Equilibrium constants, and (iii) pH values. Will be studied. (U,A)			
UNIT 4 Electrochemistry II	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).	**CSO 4.1:** To explain the concentration cell with and without transference. (U) **CSO 4.2:** To determine the activity coefficient and transference numbers. (A) **CSO 4.3:** To discuss the qualitative of potentiometric titrations (acid-base, redox, precipitation). (U)	**5**	**12**	
UNIT 5 Electrical & Magnetic Properties of Atoms and Molecules	Basic ideas of electrostatics,Electrostatics of dielectric media, Clausius- Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement,molecular	**CSO 5.1:** T give the basic ideas of electrostatics. (K) **CSO 5.2:** To explain the electrostatics of dielectric media. (U) **CSO 5.3:** To derive the Clausius-Mosotti equation. (A) **CSO 5.4**: To derive the Lorenz-Laurentz equation. (A) **CSO 5.5:** To calculate the net molecular polarity at either end of the molecular dipole. (A) **CSO 5.6:** To explain the magnetic susceptibility and its measurement, molecular interpretation. (U)	**8**	**18**	

	interpretation.				

Suggested Readings:

1. P.W Atkins&J.D. Paula, *Physical Chemistry10th Ed.*, Oxford University Press, 2014.
2. G. W. Castellan, *Physical Chemistry 4th Ed.,* Narosa, 2004.
3. R. G. Mortimer, *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP, 2009.
4. G. M. Barrow, *Physical Chemistry 5th Ed.,* Tata McGraw Hill: New Delhi, 2006.
5. T. Engel&P. Reid, *Physical Chemistry 3rd Ed.,* Prentice-Hall, 2012.
6. D. W. Rogers, *Concise Physical Chemistry* Wiley, 2010.
7. R. J. Silbey, R. A. Alberty, &M. G. Bawendi, *Physical Chemistry 4th Ed.,* John Wiley & Sons, Inc., 2005.

Practical:

Name of the Paper: Physical Chemistry-IV
Paper Code: CHC-5.2 P
Number of Credit: 01
Number ofHours of Lecture: 30 Lectures

Conductometry

I. Determination of cell constant

II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

III. Perform the following conductometric titrations:

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

Potentiometry

I. 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

Suggested Readings:

1. B. D. Khosla, V. C. Garg, &A. Gulati, *Senior Practical Physical Chemistry*, R. Chand & Co. New Delhi, 2011.
2. C. W. Garland, J. W. Nibler, &D. P. Shoemaker, *Experiments in Physical Chemistry 8th Ed.*,McGraw-Hill, New York, 2003.
3. A. M. Halpern, &G. C. McBane, *Experimental Physical Chemistry 3rd Ed.*,W.H. Freeman & Co. New York, 2003.

NAME OF THE PAPER (CODE) : ANALYTICAL METHODS IN CHEMISTRY (CHC-5.3)

Number of Credits 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Analytical methods in Chemistry:**

CO 1:	Able to expresses the Qualitative and Quantitative analysis methods.
CO 2:	Familiar with interpretation and use of analytical data collected by different techniques, significance of different analytical techniques and their applications, reliability and presentation of data for reporting to different forum.
CO 3:	Explain the basic methods of thermo analytical methods.Describe the physical and chemical properties used to separate mixtures.
CO 4:	To acquire basic knowledge of pH metric, potentiometric and conductometric titrations.
CO 5:	Understand separations techniques. To know different types of chromatography and perform their practicalsseparately.Explainsteroisomeric separation and analysis.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Qualitative and Quantitative Aspects of Analysis	Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.	**CSO 1.1:** To distinguish between qualitative and quantitative aspects of analysis. (K) **CSO 1.2:** To define some common terms of statistical calculations **CSO 1.3:** To understand the normal error curve and estimate the precision of analytical data, **CSO 1.4:** To estimate whether the difference in two sets of data in experimental results is just by chance or there is some source of systematic errors	**4**	**10**	

		in one of the sets. (A)			
UNIT 2 Optical Methods of Analysis.	Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert‘s law. *UV-Visible Spectrometry:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument. *Basic principles of quantitative analysis:* estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job‘s method of continuous variation and mole ratio method. *Infrared Spectrometry:* Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance	**CSO 2.1:**To get a guideline concerning the Origin of spectra. (K) **CSO 2.2:** To explain the fundamental laws of spectroscopy and selection rules. (U) **CSO 2.3:**To explain the validity of Beer-Lambert‘s law. (U) **CSO 2.4:** To give a brief introduction of spectroscopy. (K) **CSO 2.5:** To learn the technique to interpret UV-Visible spectroscopy. (A) **CSO 2.6:** To Explain basic principles of UV-Visible spectroscopy. (U) **CSO 2.7:** To Explain relevant terms of UV-Visible spectroscopy.(U) **CSO 2.8:** To explain working principle, taking spectra and outline of UV spectroscopy device. (A) **CSO 2.9:** To Explain basic principles of IR spectroscopy. (K) **CSO 2.10:** To explain working principles and taking spectrum of IR spectroscopy device. (U) **CSO 2.11:**To explain basic principles of atomic absorption spectroscopy. (K) **CSO 2.12:** To explain the types of atomic absorption spectrometer. (U) **CSO 2.13:** To explain working principles, taking spectrum and outline of atomic absorption spectroscopy device. (U) **CSO 2.14:** To give the Method of background correction, sources of chemical interferences and their method of removal. (U) **CSO 2.15:** To explain the Techniques for the	**20**	**36**	

	of isotope substitution. *Flame Atomic Absorption and Emission Spectrometry:* Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.	quantitative estimation of trace level of metal ions from water samples.(K)			
UNIT 3 Thermal Methods of Analysis	Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.	**CSO 3.1**: To explain the principle of TGA. (K) **CSO 3.2:** describe the experimental setup of TGA. **CSO 3.3:** To interpret the analytical information from TGA curves. (A) **CSO 3.4:** To describe the applications of TGA in qualitative and quantitative analysis of inorganic, organic and polymer material. (A)	**4**	**10**	
UNIT 4 Electroanalytical Methods	Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.	**CSO 4.1**: Students will learn the fundamental theory that supports electroanalytical measurements.(K) **CSO 4.2:** To give the basic principle of pH metric. (K) **CSO 4.3**: Modern techniques used for chemical analysis and mechanistic studies will be presented so that real world analysis problems can be investigated.(U)	**7**	**18**	

	Techniques used for the determination of pKa values.	**CSO 4.4:** To evaluate conductivity measurements and titration curves. (A) **CSO 4.5:** To express the potentiometric titration curve. (A)			
UNIT 5 **Separation Techniques**	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 nonaqueous media. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.	**CSO 5.1:** To define basic principles of common separation techniques. (K) **CSO 5.2:** To connect parts of chromatographic systems into functional order. (A) **CSO 5.3:** To select appropriate separation technique in compliance with characteristics of the sample.(U) **CSO 5.4:** To explain the selection of stationary phase, mobile phase and detector for various chromatographic analysis. (U) **CSO 5.5:** To apply computing tools in processing of the analytical signal. (A) **CSO 5.6:** To demonstrate method validation. (A) **CSO 5.7:** To identify the sources of measurement uncertainty and to calculate the uncertainty. (U) **CSO 5.8:** To make the student understand what is meant by all the parameters in an HPLC analytical method. (U) **CSO 5.9** Follow an HPLC analytical method to set up an HPLC system for analysis. (A) **CSO 5.10:** To explain how to run an HPLC analytical method and acquire chromatographic results. (A) **CSO 5.11:** To Interpret chromatograms obtained from HPLC analysis. (A)	**10**	**26**	

	Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composi-tion using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC). Role of computers in instrumental methods of analysis.				

Suggested Readings:

1. J. Mendham, *Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. H.H. Willard, *Instrumental Methods of Analysis7th Ed*., Wardsworth Publishing Company, Bel-mont, California, USA, 1988.
3. G.D. Christian, *Analytical Chemistry6th Ed.,* John Wiley & Sons, New York, 2004.
4. D.C.Harris, *Exploring Chemical Analysis9th Ed*., New York, W.H. Freeman, 2016.
5. S.M.Khopkar, *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. D.A. Skoog, F.J. Holler. &T.A Nieman, *Principles of Instrumental Analysis 7th Ed.*, Cengage Learning India, 2017.
7. O. Mikes, *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Ana-lytical Chemistry, John Wiley & Sons, 1979.
8. R.V. Ditts, *Analytical Chemistry: Methods of separation,* van Nostrand, 1974.

Practical:

Name of the paper: Analytical Methods in Chemistry
Paper Code: CHC-5.3 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

I. Separation Techniques

(a) Separation of mixtures

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. 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.

(ii) Solvent extraction of zirconium with amberliti LA-1, separation from a mixture of irons and gallium.

III. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

IV. Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometric techniques.

V. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

VI. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

VII. Spectrophotometry:

1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen in water.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).
6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job‘s method.

Suggested Readings:

1. J. Mendham &A.Vogel’s, *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. H.H Willard,*Instrumental Methods of Analysis7th Ed*., Wardsworth Publishing Company, Bel-mont, California, USA, 1988.
3. G.D. Christian, *Analytical Chemistry6th Ed*., John Wiley & Sons, New York, 2004.
4. D.C. Harris, *Exploring Chemical Analysis9th Ed*., New York, W.H. Freeman, 2016.
5. S.M. Khopkar, *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.

6. D.A. Skoog, F.J. Holler. &T.A Nieman, *Principles of Instrumental Analysis 7th Ed.*, Cengage Learning India, 2017.
7. O. Mikes&R.A. Chalmes, *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd. London, 1979.
8. R.V. Ditts, *Analytical Chemistry: Methods of separation.* Van Nostrand, New York, 1974.

VI- SEMESTER

NAME OF THE PAPER (CODE) : PHYSICAL CHEMISTRY-V (CHC-6.1)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Physical Chemistry-V:**

CO 1:	Learn about limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.
CO 2:	Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle and application of quantization to spectroscopy.
CO 3:	Interpret various types of spectra and know about their application in structure elucidation.
CO 4:	Raman spectra. Stokes and anti-stokes lines.
CO 5:	Explain NMR theory. Coupling constants and their derivations.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit& Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Quantum Chemistry I	Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.	**CSO 1.1:** To give a brief introduction on the concept of quantum mechanics. (K) **CSO 1.2:** To make the student understand the Postulates of quantum mechanics. (K) **CSO 1.3:** To understand the concept of different laws of thermodynamics. (U) **CSO 1.4:** To understand the Debye Huckel Theory of ion-ion interactions. (U) **CSO 1.5:** To understand the effect of temperature on reaction rates. (A) **CSO 1.6:** To derive the Heisenberg Uncertainty principle. (A) **CSO 1.7:** To explain the wave functions. (U) **CSO 1.8:** To give the probability distribution function. (K)	**10**	**20**	
UNIT 2 Quantum Chemistry II	Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of	**CSO 2.1:** Student will be able to understand that angular momentum is conserved in closed systems. (U) **CSO 2.2:** To make the student realize that the moment of inertia of an object determines the extent to which it is accelerated as a result of a	**13**	**28**	

	variables. Spherical harmonics. Discussion of solution. Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom). Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, 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 wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localized molecular orbitals treatment of tri-atomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.	reaction torque and that this is why even though Earth spins under us as we move across it, we do not notice it. (U) **CSO 2.3:** To explain the angular momentum is conserved in orbital systems. (K) **CSO 2.4:** To explain the quantum mechanical operators, Schrodinger wave equation and its application to hydrogen & hydrogen like atoms. (U,A) **CSO 2.5:** The students will be taught the postulates of quantum mechanics and the application of quantum mechanical ideas in some simple systems such as particle in a box, rigid rotor, and simple harmonic oscillator. (U,A) **CSO 2.6:** To introduce to quantum mechanical treatment of hydrogen-like systems with electron-nuclear distance quantification, extension to many-electron atoms with introduction to variation theory. (U) **CSO 2.7:** To explain quantitative MO and VB treatments of simple molecules. (U,A) **CSO 2.8:** To give an idea of interaction of electromagnetic radiation with molecules to generate spectra, knowing about characteristics of rotational, vibrational and Raman spectra of molecules. (A) **CSO 2.9:** To give an introduction to electronic transitions, Frank-Condon principle, dissociation and electronic spectra of molecule. (U,K)			
UNIT 3 Molecular Spectroscopy.	Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection	**CSO 3.1:** To learn about the selection rule for infrared-active transitions.(K) **CSO 3.2:** To Determine the vibrations for a triatomic	**8**	**18**	

	rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.	molecule and identify whether they are infrared-active. (A) **CSO 3.3:** To Justify the difference in intensity between Stokes and anti-Stokes lines. (A) **CSO 3.4:** To learn about symmetry elements and symmetry operations. (U) **CSO 3.5:** To learn about the Application of group theory i.e. Hybridization. (U,A) **CSO 3.6:** To determine the vibrations for a triatomic molecule and identify whether they are infrared-active. (A) **CSO 3.7:** To determine whether the molecular vibrations of a triatomic molecule are Raman active. (A) **CSO 3.8:** To explain the difference between Stokes and anti-Stokes lines in a Raman spectrum. (U) **CSO 3.9:** To Justify the difference in intensity between Stokes and anti-Stokes lines. (U)			
UNIT 4 Raman spectroscopy	Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.	**CSO 4.1:** To Explain basic principles of IR spectroscopy. (K) **CSO 4.2:** To explain working principles and taking spectrum of IR spectroscopy device. (U) **CSO 4.3:** To explain basic principles of atomic absorption spectroscopy. (K) **CSO 4.4:**To explain the rotational, vibrational, electronic and Raman spectra of molecules and their applications. (U)	**8**	**18**	
UNIT 5 Nuclear Magnetic Resonance (NMR) spectroscopy I	Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.	**CSO 5.1:** To interpret NMR spectroscopy. (K) **CSO 5.2:** To explain basic principles of NMR spectroscopy. (U) **CSO 5.3:** To explain sample preparation procedure in NMR spectroscopy. (U)	**6**	**16**	

	Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.	**CSO 5.4:** To explain working principles, taking spectrum and outline of NMR spectroscopy device. (K,U)			

***Suggested Readings*:**

1. C. N. Banwell, &E. M. McCash, *Fundamentals of Molecular Spectroscopy 4th Ed.,* Tata McGraw-Hill: New Delhi, 2006.
2. A. K. Chandra, *Introductory Quantum Chemistry,*Tata McGraw-Hill, 2001.
3. J. E. House, *Fundamentals of Quantum Chemistry,2nd Ed.* Elsevier, USA, 2004.
4. R. Kakkar, *Atomic & Molecular Spectroscopy: Concepts & Applications*, Cambridge University Press, 2015.
5. J. P. Lowe, &K. Peterson, *Quantum Chemistry*, Academic Press, 2005.

Practical:

Name of the Paper: Physical Chemistry-V
Paper Code: CHC-6.1 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

Colorimetry:

1. Verify Lambert-Beer's law and determine the concentration of CuSO4/KMnO4/K2Cr2O7 in a solution ofunknown concentration.

2. Determine the concentrations 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-phenanthroline.

5. Determine the dissociation constant of an indicator (phenolphthalein).

6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

Spectrophotometry:

1. Study the 200-500 nm absorbance spectra of KMnO4 and K2Cr2O7 (in 0.1 M H2SO4) and determinetheλmax values. Calculate the energies of the two transitions in different units (kJ molecule-1, kJ mol-1,cm-1, eV).

2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of K2Cr2O7.

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 on the UV spectra of organic compounds.

4. Analysis of the given vibration-rotation spectrum of HCl (g)

***Suggested Readings*:**

1. B. D. Khosla, V. C. Garg& A. Gulati, *Practical Physical Chemistry*, R. Chand & Co. New Delhi, 2011.
2. C. W. Garland, J. W. Nibler&D. P. Shoemaker, *Experiments in Physical Chemistry 8th Ed*.McGraw-Hill: New York, 2003.
3. A. M. Halpern, &G. C.McBane, *Experimental Physical Chemistry 3rd Ed*.,W.H. Freeman & Co. New York, 2003.

NAME OF THE PAPER (CODE) : ORGANIC CHEMISTRY-V (CHC-6.2)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Organic Chemistry-V:**

CO 1:	Demonstrate a good understanding of the electromagnetic spectrum and how this can be applied to the study of chemical molecules.
CO 2:	Interpret NMR spectra of simple organic molecules.
CO 3:	Identify the absorption frequencies of major functional groups, and use this knowledge to interpret IR and UV-Vis spectra of simple organic molecule.
CO 4:	Describe the different types of simple and complex carbohydrates and the functions of carbohydrates in the body
CO 5:	Describe the difference between natural and synthetic dyes and its uses.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit& Title	Unit Contents	Course Specific Objectives	Lectures Hours	Marks	LOs
UNIT 1 Organic Spectroscopy	UV Spectroscopy: Types of electronic transitions, λmax, Chromophores and Auxochromes, Batho-chromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated sys-tems (aldehydes, ketones and dienes); distinction between cis and trans isomers.	**CSO 1.1:** To learn the technique to interpret UV-Visible spectroscopy. (A) **CSO 1.2:** To explain the different shift that occurs in UV spectroscopy. (U) **CSO 1.3:** To Explain basic principles of UV-Visible spectroscopy. (U) **CSO 1.4:** To Explain relevant terms of UV-Visible spectroscopy.(U) **CSO 1.5:** To explain working principle, taking spectra and outline of UV spectroscopy device. (A) **CSO 1.6:** To give the principles and applications of UV-Visible spectroscopy in elucidating the structure of organic compounds. (U,A)	**8**	**18**	
UNIT 2 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;	**CSO 2.1:** To Explain basic principles of IR spectroscopy. (K) **CSO 2.2:** To explain working principles and taking spectrum of IR spectroscopy device. (U) CSO 2.3: To explain basic	**6**	**16**	

	Fingerprint region and its significance; application in functional group analysis.	principles of atomic absorption spectroscopy. (K) **CSO 2.4:** To give Use the technique of infrared spectroscopy to establish which functional groups are present in an unknown organic molecule. (A) **CSO 2.5:** To Predict how an infrared vibrational frequency will change depending on the analyte structure. (A) **CSO 2.6:** Illustrate the principle and applications of IR spectroscopy in elucidating the structure of organic compounds. (K)			
UNIT 3 **NMR Spectroscopy**	Basic principles of Proton Magnetic Resonance, chemical shift and factors influ-encing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, alde-hydes and aromatics, Interpretation of NMR spectra of simple compounds. Applications of IR,UV and NMR for identification of simple organic molecules.	**CSO 3.1:** Apply the techniques of 1H and 13C nuclear magnetic spectroscopy to aid in the elucidation of molecular structures. (A) **CSO 3.2:** To interpret 2D NMR spectra, including COSY, NOESY, HSQC, and HMBC. (U) **CSO 3.3:** To Utilize two-dimensional NMR to solve the atom connectivity and stereochemistry (i.e., structures) of complex organic molecules. (U,A) **CSO 3.4:** To describe the basic principle and applications of NMR spectroscopy in elucidating the structure of organic compounds.(K)	**8**	**18**	
UNIT 4 **Carbohydrates**	Occurrence,classification and biological importance of carbohydrate. Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure	**CSO 4.1:** To define carbohydrates. (K) **CSO 4.2:** To explain the difference between simple and complex carbohydrates. (U) **CSO 4.3:** To discuss the benefits of simple carbohydrates and disadvantages of complex carbohydrates. (K,U) **CSO 4.4:** Structural representation of alpha and	**15**	**30**	

	elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.	beta glucose.(A) **CSO 4.5:** Formation of alpha and beta glycosidic linkages in diasaccharides and polysaccharide. (U)			
UNIT 5 **Dyes**	Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes – structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.	**CSO 5.1:** TO Know about the historical background of dyes. (K) **CSO 5.2:** To Understand the basis of dye selection. (U) **CSO 5.3:** To Classify dyes on the basis of their origin. (K) **CSO 5.4:** To study the concept of dyes, its property and nomenclature dyes. (U) **CSO 5.5:** To study the concept of natural and synthetic dyes. (K) **CSO 5.6:** To familiarize the students with structure elucidation and synthesis of Alizarin and Indigotin. (A)	**8**	**18**	

***Suggested Readings*:**

1. P. S. Kalsi, *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub., 2000.
2. R.T.Morrison& R.N. Boyd, *Organic Chemistry 7th Ed*., Dorling Kindersley, Pvt. Ltd., Pearson Education, India, 2010
3. V. R. Gowariker, N. V. Viswanathan&J. Sreedhar, *Polymer Science*., New Age International (P) Ltd. Pub. 1986.
4. I. L. Finar, *Organic ChemistryVolume 2: Stereochemistry and the Chemistry of Natural Products,* Dorling Kindersley Pvt. Ltd., Pearson Education,India.1956
5. T.W. G. Solomons, *Organic Chemistry*,John Wiley & Sons, 2017.
6. J.E. McMurry, *Fundamentals of Organic Chemistry*, *7th Ed*., Cengage Learning India Edition, 2013.
7. J. Clayden, N.Greeves, S. Warren, &S.Wothers, *Organic Chemistry*, Oxford University Press. 2014.
8. J. Singh, S.M. Ali, &J. Singh, *Natural Product Chemistry*, PrajatiPrakashan, 2010.
9. W. Kemp, *Organic Spectroscopy*, Palgrave, 1991.
10. D. L. Pavia,*Introduction to Spectroscopy 5th Ed*., Cengage Learning India Ed., 2015.

<u>Practical:</u>

Name of the Paper: Organic Chemistry-V
Paper Code: CHC-6.2 P
Number of Credits: 01
Number ofHours of Lecture: 30 Lectures

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.

5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).

***Suggested Readings*:**

1. A.I. Vogel, *Quantitative Organic AnalysisPart 3*, Pearson, 2012.
2. Mann, F.G. & Saunders, *B.C. Practical Organic Chemistry*, Pearson Education, 2009.
3. B.S. Furniss, A.J. Hannaford, P.W.G. Smith &A.R. Tatchell, *Practical OrganicChemistry, 5th Ed.*,Pearson, 2012.
4. V.K. Ahluwalia&R. Aggarwal,*Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press, 2000.
5. V.K. Ahluwalia, &S. Dhingra, *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press, 2000.

NAME OF THE PAPER (CODE) : GREEN CHEMISTRY (CHC-6.3)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper- **Green Chemistry:**

CO 1:	General introduction to Green Chemistry.
CO 2:	Understand the twelve principles of green chemistry and will build the basic understanding of toxicity, hazard and risk of chemical substances.Understand stoichiometric calculations and relate them to green chemistry metrics. They will learn about atom economy and how it is different from percentage yield
CO 3:	Learn to design safer chemical, products and processes that are less toxic, than current alternatives. Hence, they will understand the meaning of inherently safer design for accident prevention and the principle "what you don't have can't harm you". Understand benefits of use of catalyst and bio catalyst, use of renewable feed stock which helps in energy efficiency and protection of the environment, renewable energy sources, and importance led reactions in various green solvents.
CO 4:	Appreciate the use of green chemistry in problem solving skills, critical thinking and valuable skills to innovate and find out solution to environmental problems. Thus the students are able to realise that chemistry can be used to solve rather than cause environmental problems
CO 5:	To make student well aware of the future trend of Green Chemistry.

COURSE SPECIFIC OBJECTIVES (COs)

Unit & Title	Unit Contents	Course Specific Objectives	Lectures Hours	Marks	LOs
UNIT 1 Introduction to Green Chemistry	What is Green Chemistry? Some important environmental laws, pollution prevention Act of 1990, emergenceof green chemistry, Need for Green	**CSO 1.1:** To learn about the meaning, principles and importance of Green Chemistry. (K) **CSO 1.2:** To provide knowledge on green and	**5**	**12**	

	Chemistry. Goals of Green Chemistry, Limitations/ Obstacles in the pursuitof the goals of Green Chemistry	sustainable chemistry, and introduces the learners to various tools and principle of green chemistry. (U) **CSO 1.3:** To describe classes of the most important chemicals (both organic and inorganic) that are hazardous/dangerous for human and animal health, and the environment . (U)			
UNIT 2 Principles of Green Chemistry and Designing a Chemical synthesis	Twelve principles of Green Chemistry and their explanation with examples *Special emphasis on the following:* • Prevention of Waste/ by products; maximum incorporation of the materials used in the process into thefinal products, Environmental impact factor, waste or pollution prevention hierarchy • Green metrics to assess greenness of a reaction, e.g. Atom Economy, calculation of atom economy ofthe rearrangement, addition, substitution and elimination reactions. • Prevention/ minimization of hazardous/ toxic products reducing toxicity • Risk = (function) hazard x exposure • Designing safer chemicals with minimum toxicity yet has the ability to perform the desired functions • Green solvents: super critical fluids with special reference to carbon dioxide, water as a solvent fororganic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, solventsobtained from renewable resources and how to compare greenness of solvents • Energy requirements for reactions – alternative	**CSO 2.1:** Knowing the 12 principles of Green Chemistry. (K) **CSO 2.2:** To understand how green synthetic processes may be designed for different chemicals. (U) **CSO 2.3:** TO identifythegreener solvents and recycling of these including catalysts. (U) **CSO 2.4:** To Calculate the atomic efficiency and E-factors of chemical reactions and processes. (A) **CSO 2.5:** To apply the principles for Green Chemistry in order to make a life cycle assessment for a chemical product including waste treatment (degradation/recycling). (A) **CSO 2.6:**To compare actual industrial chemical syntheses/processes and identify their strengths and weaknesses in a green chemistry perspective **CSO 2.7:** Explain how to design a greener and safer method of synthesis rather than those that cause pollution. (U) **CSO 2.8:** To make student aware of how to use a green solvent. (U) **CSO 2.9**: knowledge on Environmental work place conditions with the emphasis on chemical compounds. (K) CSO 2.10: Waste treatment. (K) **CSO 2.11:**The role of Green	**20**	**36**	

	sources of energy: use of microwaves, ultrasonicenergy and photochemical energy • Selection of starting materials; should be renewable rather than depleting, Illustrate with few examplessuch as biodiesel and polymers from renewable resources (such as green plastic) • Avoidance of unnecessary derivatization – careful use of blocking/protecting groups • Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis andgreen chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetriccatalysis and photocatalysis. • Design for degradation: A product should not persist after the commercial function is over e.g. soapsand detergents, pesticides and polymers • Strengthening/ development of analytical techniques to prevent and minimize the generation ofhazardous substances in chemical processes. • Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD"What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route tocarcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization,simplification, substitution, moderation and limitation.	Chemistry in large scale production of organic chemicals (catalysis/biocatalysis, selection of raw materials and solvents/process evaluation). (U) **CSO 2.12**: Learn the Production of biofuels. (A) **CSO 2.13**: Product evaluation (biodegradeability/toxicity/recycleability). (U) **CSO 2.14**: Learn about Biorefinery processeses. (U)			

UNIT 3 Examples of Green Synthesis/ Reactions	• Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative toStrecker synthesis). • Green Reagents: Non-phosgene Isocyanate Synthesis, Selective Methylation using dimethylcarbonate. • Microwave assisted solvent free synthesis of copper phthalocyanine • Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid andDecarboxylation reaction • Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)	**CSO 3.1:** To study the greener reaction process of some of the organic compound. (A) CSO 3.2: To study the green Reagents. (K) **CSO 3.3:** To explain how the Microwave assisted solvent free synthesis are much better than the convention process. (U,A) **CSO 3.4:** to study the synthetic process using the Ultrasound assisted reactions. (U,A)	**7**	**18**	
UNIT 4 Real World Case Studies Based on the Presidential Green Chemistry Awards of EPA	• Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO2 forprecision cleaning and dry cleaning of garments. • A new generation of environmentally advanced wood preservatives: Getting the chromium and Arsenic outof pressure treated wood. • An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made fromcorn. • Healthier Fats and oils by Green Chemistry: Enzymatic Inter esterification for production of No Trans-Fatsand Oils. • Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting. • Using a naturally occurring protein to stimulate plant growth, improve crop quality,	**CSO 4.1:** To explain Real-world Cases in green chemistry, some examples of replacement of toxic chemicals with environment friendly green compoundsand benefits of utilizing concept of green chemistry for designing chemicals and processes for manufacturing chemicals. (U) **CSO 4.2:** To compare actual industrial chemical syntheses/processes and identify their strengths and weaknesses in a green chemistry perspective. (A) **CSO 4.3:** Learn how to correctly use the knowledge acquired for the identification of environmental problems related to a synthesis conducted in the laboratory and on an industrial scale. (A) **CSO 4.4:** Learn how to apply the knowledge acquired in discriminating advantages and problems in the use of plastics and bioplastics. (U)	**7**	**18**	

	increase yields, andsuppress disease.				
UNIT 5 Future Trends in Green Chemistry	Oxidation reagents and catalysts; Biomimcry and green chemistry, Biomimetic, Multifunctional Reagents;mechanochemical and solvent free synthesis of inorganic complexes; co crystal controlled solid state synthesis(C2S3); Green chemistry in sustainable development.	**CSO 5.1:** To know about the future trends in Green Chemistry. (K) **CSO 5.2:** To learn how Green chemistry has the potential to reduce the carbon footprint on the environment by enhancements in solvent technologies, catalysis, and synthetic efficiency. (U) **CSO 5.3:** To explain Green chemistry as sustainable development. (U)	**6**	**16**	

***Suggested Readings*:**

1. P.T. Anastas &J.C.Warner, *Green Chemistry, Theory and Practice,*Oxford University Press,1998.

2. M. Lancaster, *Green Chemistry an Introductory Text 2nd Ed.,* RSC Publishing,2016.

3. M. C. Cann&M. E. Connely, *Real-World cases in Green Chemistry***,** American Chemical Society, Washingto, 2000.

4. A.S. Matlack, *Introduction to Green Chemistry***,** Marcel Dekker, 2001.

5. V. K. Alhuwalia&M. R., Kidwai, *New Trends in Green chemistry*, Anamalaya Publishers,2005.

Practical:

Name of the Paper: Green Chemistry
Paper Code: CHC-6.3 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

Characterization by m. pt., U.V.-Visible spectroscopy, IR spectroscopy, and any other specific method shouldbe done (wherever applicable).

Safer starting materials

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plantextracts.

Using renewable resources

2. Preparation of biodiesel from waste cooking oiland characterization (TLC, pH, Solubility, Combustion Test,Density, Viscosity, Gel Formation at Low Temperature and IR can be provided).

Use of enzymes as catalysts

3. Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

Alternative green solvents

4. Extraction of D-limonene from orange peel using liquid CO2 prepared form dry ice.

5. Mechanochemical solvent free, solid–solid synthesis of azomethine using p- toluidine and o-vanillin/pvanillin(various other combinations of primary amine and aldehyde can also be tried).

Alternative sources of energy

6. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).

7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reducing waste

8. Designing and conducting an experiment by utilizing the products and by products obtained in abovepreparations which become waste otherwise if not used. This is done by critical thinking and literaturesurvey.

Some representative examples:

• Use of nanoparticles as catalyst for a reaction

• Benzoin converted into Benzil and Benzil into Benzilic acid by a green method

• Use of azomethine for complex formation

• Rearrangement reaction from Benzopinacol to Benzopinacolone

• Conversion of byproduct of biodiesel to a useful product

• Students should be taught to do spot tests for qualitative inorganic analysis for cations and anions, andqualitative organic analysis for preliminary test and functional group analysis.

***Suggested Readings*: Practical**

1. M. Kirchoff & M.A. Ryan, *Greener approaches to undergraduate chemistry experiment,*AmericanChemical Society, Washington DC,2002.

2. R.K. Sharma, I.T. Sidhwani&M.K. Chaudhari, *Green Chemistry Experiments: A monograph***,** I.K.International Publishing House Pvt Ltd. New Delhi,2013.

3. D.L. Pavia, G.H.B Lamponam& G.S.W. Kriz, *Introduction to organic Laboratory Technique-A Microscale approach 4th Ed.,* Brrooks-Cole Laboratory Series for Organic chemistry,2006.

4. Sidhwani,Wealth from *Waste: A green method to produce biodiesel from waste cooking oil and generation of usefulproducts from waste further generated. Indu Tucker University of Delhi, Journal ofUndergraduate Research and Innovation, Volume 1,* 2015.

5. Sidhwani, I. Tucker&S. Chowdhury, *Greener alternatives to Qualitative Analysis for Cations withoutH2S and other sulfur containing compounds*, J. Chem. Educ. 85, 1099,2008.

6. Sidhwani, I. Tucker &S. Chowdhury, *DU Journal of Undergraduate Research and Innovation,Volume 2, Issue 2*, 70-79.2016.

NAME OF THE PAPER (CODE) : SPECTROSCOPY (CHC-6.4)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (Cos) for the paper-**Spectroscopy:**

CO 1:	Interpret various types of spectra and know about their application in structure elucidation
CO 2:	Explore new areas of research in both chemistry and allied fields of science andtechnology
CO 3:	Determine the structure of organic molecules using UV, IR and NMR spectroscopic techniques.
CO 4:	Explain different type's spectroscopy
CO 5:	Understand the mass spectroscopy and their reactions.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 UV-Visible Spectroscopy	Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selectionrules. Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; application of Woodward Rules for calculation of λmax for the conjugated dienes: alicyclic, homoannular and heteroannular; extended conjugated systems distinction between cis and trans isomers (Cis and trans stilbene).	**CSO 1.1:** To learn the technique to interpret UV-Visible spectroscopy. (A) **CSO 1.2:** To Explain basic principles of UV-Visible spectroscopy. (U) **CSO 1.3:** To Explain relevant terms of UV-Visible spectroscopy.(U) **CSO 1.4:** To explain working principle, taking spectra and outline of UV spectroscopy device. (A) **CSO 1.5:** To learn the application of Woodward Rules for calculation of λmax for the conjugated dienes. (U)	**9**	**20**	
UNIT 2 Infrared Spectroscopy: IR Spectroscopy:	Fundamental and non-fundamental molecular vibrations; Hooke's law selection rule, IR absorption positions of various functional groups (C=O, OH, NH, COOH and nitrile) , Effect of H-bonding, conjugation, resonance and ring size of cyclic ketones and lactones on IR absorptions; Fingerprint region and its significance; application in functional group analysis and interpretation of I.R. spectra of simple organic compounds.	**CSO 2.1:**To learn the basic of Fundamental and non-fundamental molecular vibrations. (U) **CSO 2.2:**To Explain Hooke's law selection rule. (U) **CSO 2.3:** To explain IR absorption positions of various functional groups (C=O, OH, NH, COOH and nitrile. (U) **CSO 2.4:** To explain basic Effect of H-bonding, conjugation, resonance and ring size of cyclic ketones and lactones on IR absorptions.	**9**	**20**	

	Identification of the Carbonyl group in Ketones, Aldehydes, Carboxylic acids, Esters and Amides using IR Spectroscopy	(K) **CSO 2.5:** To explain the fingerprint region and its significance; application in functional group analysis and interpretation of I.R. spectra of simple organic compounds. (A) **CSO 2.6:** To Identification of the Carbonyl group in Ketones, Aldehydes, Carboxylic acids, Esters and Amides using IR Spectroscopy. (A)			
UNIT 3 **^{1}H-NMR Spectroscopy (PMR)**	NMR Spectroscopy: introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; choice of solvent and internal standard; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of first-order multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR ;anisotropic effects in alkene, alkyne, aldehydes and aromatics; NMR peak area, integration; relative peak positions with coupling patterns of common organic compounds; interpretation of NMR spectra of simple compounds.	**CSO 3.1:** To give the introduction on NMR.(K) **CSO 3.2:** To give the basic principle of Proton Magnetic Resonance. (K) **CSO 3.3:** Apply the techniques of 1H nuclear magnetic spectroscopy to aid in the elucidation of molecular structures. (A) **CSO 3.4:** To describe the basic principle and applications of NMR spectroscopy in elucidating the structure of organic compounds.(K.A) **CSO 3.5:** To interpret NMR spectra of simple compounds. (A)	**14**	**26**	
UNIT 4 **Applications of Different Spectroscopy**	IR, UV and NMR spectroscopy for identification of simple organic molecules such as Ethanol, Ethyl acetate, acetone, acetaldehyde, dimethyllformamide, Cis and trans 1,2-dimethyl cyclopropanone, propene, vinyl chloride, acetophenone, benzaldehyde, phenol, Toluene andethyl benzene.	**CSO 4.1:** To Identify different organic compound using IR, UV and NMR spectroscopy. (A) **CSO 4.2:** To explain how to characterized the given organic compounds such as Ethanol, Ethyl acetate, acetone, acetaldehyde, dimethyllformamide, etc. using the different spectroscopic technique. (A)	**6**	**16**	
UNIT 5	Principle of mass spectrometry,	**CSO 5.1:** To give the	**7**	**18**	

Introduction to Mass Spectrometry	the mass spectrum, mass spectrometry diagram, molecular ion, metastable ion, fragmentation process, McLafferty rearrangement.	Principle of mass spectrometry. (K) **CSO 5.2:** To explain how the mass of compound can be analysed using mass spectrometry. (U) **CSO 5.3:** To explain the McLafferty rearrangement. (U)			

***Suggested Readings*:**

1. J.E. McMurry, *Fundamentals of Organic Chemistry, 7th Ed*., Cengage Learning India Edition, 2013.
2. J. Clayden, N. Greeves, S. Warren, & S.Wothers, *Organic Chemistry*, Oxford University Press. 2014.
3. J. Singh, S.M. Ali, & J. Singh, *Natural Product Chemistry*, PrajatiPrakashan, 2010.
4. W. Kemp, *Organic Spectroscopy,* Palgrave, 1991.
5. D. L. Pavia, *Introduction to Spectroscopy 5th Ed*., Cengage Learning India Ed., 2015.

Practical:

Name of the Paper: Spectroscopy
Paper Code: CHC-6.4 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1. **Spectrophotometry**
   To verify Beer – Lambert Law for KMnO4/K2Cr2O7 and determining the
   Concentration of the given solution of the substance from absorption measurement
   Determination of pKa values of indicator using spectrophotometry. Determination of chemical oxygen demand
   (COD).
   Determination of Biological oxygen demand (BOD).
2. **Spectroscopy**
   Assignment of labelled peaks in the IR spectrum of the same compoundexplaining the relative frequencies of the absorptions (C-H, O-H, N-H,C-O, C-N, C-X, C=C, C=O, N=O, C≡C, C≡N stretching frequencies;characteristic bending vibrations are included. Spectra to be provided).
   Assignment of labelled peaks in the 1H NMR spectra of the known organiccompounds explaining the relative δ-values and splitting pattern.Identification of simple organic compounds by IR spectroscopy andNMR spectroscopy (Spectra to be provided).

***Suggested Readings*:**

1. A.I. Vogel, *Quantitative Organic AnalysisPart 3*, Pearson, 2012.
2. Mann, F.G. & Saunders, *B.C. Practical Organic Chemistry*, Pearson Education, 2009.
3. V.K. Ahluwalia&R. Aggarwal,*Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press, 2000.

VII- **SEMESTER**

NAME OF THE PAPER (CODE) **: CHEMISTRY OF FOOD NUTRIENTS (CHC-7.1)**
Number of credit **03**
Number of Hours of Lecture **: 45**

COURSE OBJECTIVES (COs)

The following are the Course Objective (COs) for the paper-**Chemistry of Food Nutrients:**

CO 1:	To make the students understand the basic knowledge of **Carbohydrates and their classifications** and its chemical reactions and role in the food processing.
CO 2:	To outline Lipids sources. Classify lipids based on its properties. Calculate its different value in various classes of fats and oils.
CO 3:	To state its sources, classify Proteins and elaborate its structure and different physical and chemical properties of Proteins.
CO 4:	To list out different types of Vitamins based on its compositions.
CO 5:	To differentiate Minerals based on its existence, its importanceandsome of the reactions and changes in individual food components which occur during processing, handling and storage

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (SCOs)	Lecture Hours	Marks	LOs
UNIT I Carbohydrates	Introduction, sources, functions, classification: monosaccharide, oligosaccharide and polysaccharide, structure and importance of polysaccharides in food chemistry (pectin, cellulose, starch, gums), chemical reactions of sugar: mutarotation, caramelisation; non enzymatic browning and its prevention, role of carbohydrates as sweeteners in food.	**CSO 1.1:** To define the Term Carbohydrates and briefly discuss its term and Classify them.(K) **CSO 1.2:** To elaborate the strucuture of Polysaccharides and outline its importance in food Chemistry i.e. pectin,cellulose,starch& gums. **CSO 1.3:** To discuss the chemical reactions of sugar i.e. Mutarotaion. **CSO 1.4:** To discuss the chemical reactions of carmelisation. **CSO 1.5:** To discuss the chemical reactions of Non enzymatic browning compound formation and its prevention. **CSO 1.6:** To illustrate the role of carbohydrates as sweeteners in food.	**10**	**22**	
UNIT 2 Lipids	Introduction, sources, classification (fatty acids, phospholipids, fats & oils, waxes), Common fatty acids present in oils and fats,omega-3 & 6 fatty acids, trans fats, chemical properties-Reichert Meissl value, Polenske value,	**CSO 2.1:** To define the term Lipds and classify them with their properties into Fatty acids, Phospholipids, fats & Oils and waxes. (K) **CSO 2.2:** To understand the common fatty acids present in oils,fats and Omega-3 (U) **CSO 2.3:** To evaluate 6 fatty	**12**	**26**	

	Peroxide value, Saponification value, effect of frying on fats, changes in fats and oils-randicity, lipolysis, flavour reversion, auto-oxidation denaturation	acids,trans fats and study its chemical properties.(A) **CSO 2.4:** To define Reichert Meissl value (K) **CSO 2.5:** To analyse Reichert Meissl value.(A) **CSO 2.6:** To define Polenske value.(K) **CSO 2.7:** To explain Polenske value (U). **CSO 2.8:** To define Peroxide value and Saponification value.(K) **CSO 2.9:** To explain Peroxide value and Saponification value.(U) **CSO 2.10:** To explain effect of frying on fats with changes in fats.(U) **CSO 2.11:** To explain oi-randacity.(U) **CSO 2.12:** To explain the process lipolysis.(U) **CSO 2.13:** To explain Falvour reversion.(U) **CSO 2.14:** T analyse the auto-oxidation denaturation.(A)			
UNIT 3 Proteins	Introduction, sources, Classification (simple,conjugated,derived) structure of protein(primary,secondary and tertiary) physio-chemical & functional properties of proteins,protein denaturation.	**CSO 3.1**: To define Protein.(K) **CSO 3.2:** To understand the basics of protein, their source of origin.(U) **CSO 3.3:** To classify Proteins into primary,secondary and tertiary.(U) **CSO 3.4:** To analyse physio-chemical and functional properties of Proteins.(A) **CSO 3.5:**To explain protein denaturation.(U)	**10**	**22**	
UNIT 4 Vitamins	Vitamins: Introduction, classification: fat-soluble & water-soluble vitamins.	**CSO 4.1:**To define Vitamins.(K) **CSO 4.2:** To understand the basics of Vitamins.(U) **CSO 4.3:**To classifyvitamins into fat-soluble and water-soluble vitamins.(U)	**6**	**14**	
UNIT 5 Minerals	Introduction,classification: macrominerals (Ca,P,Mg) & microminerals (Se,Fe,I,Co,Zn,Cu,Se,Cr) . Physiological importance of vitamins and minerals,	**CSO 5.1:** To define the term Minerals.(K) **CSO 5.2:** To understand the basics of minerals and classify them into microminrelas and	**7**	**16**	

	effect of food processing on vitamins and minerals.	macrominerals.(U) **CSO 5.3:** To explain the physiological importance of vitamins and minerals.(U) **CSO 5.4:** To understand the effect of food processing and apply them on vitamins and minerals.(U)			

Suggested Readings:

1. J.M.deMan, J.W. Finley,W.J. Hurst, Lee, *C.Y.*,*Principles of food Chemistry*,4th Edition, Springer.2018
2. T.A.M. Msagati, Chemistry *of food Additives and Preservatives*,Wiley-Blackwell.2013.
3. O.R. Fennema, Food *Chemistry*,5th Edition, CRC Press.2017.
4. M. Attokaram, *Natural Food Flavors and colorants*,2nd Ed., wiley-Blackwell.2017
5. N.N Potter, J.H. Hotchkiss, J.H, *Food Science*,5th Ed., Chapman & Hall.1995
6. D.Brannen, Davidson, P.M., Salminen,T. ThorngateIII,J.H.,*Food Additives*,2ndEdition,CRC Press.2002
7. T.M. Coultate, Food: *The Chemistry of its components*,6thEdn,Royal Society of Chemistry.2016
8. H.D. Belitz, Grosch,W.,*Food Chemistry*, Springer.2009
9. Course: *FOOD CHEMISTRY*. (iasri.res.in)

Practical:

Name of the Paper: Chemistry of Food Nutrients
Paper Code: CHC-7.1 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1. Determination of moisture in food products by hot air oven-drying method.
2. Colorimetric determination of Iron in Vitamin/dietary tablets.
3. 2,6-Dichlorophenol indophenols method for estimation of vitamin C in a given solution/lemon juice/chillies.
4. Estimation of total soluble sugar content by ferricyanide method (volumetric analysis).
5. Determination of saponification value of the given fat/oil.
6. Determination of iodine value of the given fat/oil.
7. Qualitative tests for proteins and carbohydrates.
8. Qualitative estimation of cholesterol by Liebermann Buchard method.

Suggested Readings:

1. S. Ranganna ,Handbook of analysis and quality control for fruits and vegetable products, 2ndEdn., McGraw Hill Education.2017
2. S.K. Sawhney, R.Singh,Introductory Practical Biochemistry ,Narosa Publishing House.2011

NAME OF THE PAPER (CODE) : RESEARCH METHODOLOGY IN CHEMISTRY (CHC-7.2)
Number of Credit 04
Number of Hours of Lecture 60

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper-**Research Methodology in Chemistry:**

CO 1:	To Demonstrate the ability to choose appropriate methods to research topics and objectives.
CO 2:	To Understand the problems and limitations of specific research methods.
CO 3:	To Develop skills in data analysis and presentations both quantitatively and qualitatively.
CO 4:	To Demonstrate enhanced writing skills and have advanced critical thinking skills.
CO 5:	To Elaborate basic fundamentals of Electronics and its applications to other instruments in digital as well as operational amplifiers.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Literature Survey	**Print:** Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. **Digital:** Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs,	**CSO 1.1:**to explain sources of Information i.e. Primary, secondary and Tertiary sources.(U) **CSO 1.2:**to define Journals.(K) **CSO 1.3:** To discuss the notes on journal abbreviations, abstracts, Current titles, reviews, monographs, dictionaries, textbooks and current contents.(U) **CSO 1.4:**to understand the introduction of print to chemical abstracts and Beilstein.(U) **CSO 1.5:**to understand the introduction of print to Subject index,substanceIndex,AuthorIndex,Formula index and other Indices by taking bvarious examples. **CSO 1.6:**to explain the term Web sources,E-Journals.Journal access.(U) **CSO 1.7:**to explain the term TOC alerts,Hot articles. (U) **CSO 1.8:**to explain the term Citation index,Impactfactor,H-Index,E-consurtium,UGCinfonet,E-Books.(U) **CSO 1.9:**to explain the term Internet discussiom groups and communities,Blogs,Preprintservers,Search engines.(U) **CSO 1.10:**to explain the term Scirus,Googlescholar,ChemIndustry,Wiki-Databases,ChemSpider,ScienceDi	**16**	**26**	

	Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Data-bases, ChemSpider, Science Direct, SciFinder, Scopus. **Information Technology and Library Resources:** The Internet and World WideWeb.Internet resources for chemistry. Finding and citing published information.	rect,Scifinder,Scopus.(U) **CSO 1.11:**to understand the basic term Internet.(U) **CSO 1.12:**to explain the Terms Internet and World Wide Web.;(U) **CSO 1.13:**to elaborate the Internet resources for Chemistry. (A) **CSO 1.14:**to analyse the finding and citing published information.(A)			
UNIT 2 Methods of Scientific Research and Writing Scientific Papers.	Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions,bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.	**CSO 2.1:**toreport Practical and project work.(K) **CSO 2.2:**to write literature surveys and reviews. **CSO 2.3:**to understand on how to organize a poster display. To discuss on giving an oral presentation.(U) **CSO 2.4:**to write scientific papers and present justification for scientific contributions.(U) **CSO 2.5:**to discuss the term Bibliography, description of methods and conclusions of paper writing.(U) **CSO 2.6:**to understand the need for illustration, style, publications of scientific work. (U) **CSO 2.7:**to analyze the writing ethics of papers and discuss on how to avoid plagiarism.(A)	**10**	**16**	
UNIT 3 Chemical Safety and Ethical Handing of Chemicals.	Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals,	**CSO 3.1:t**o understand the procedures of safe working and protective environment,protectiveapparel,emergencyprocedure,first aid and Laboratory ventilation.(U) **CSO 3.2:**to discuss on safe storage and usage of hazardous chemicals with safety precautions.(K) **CSO 3.3:**to explain the procedure for working with substances that	**16**	**26**	

	procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure– safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	pose hazards, flammable or explosive hazards.(U) **CSO 3.4:**to analyse the procedures for working with gases at pressures above or below atmospheric pressure.(A) **CSO 3.5:**to discuss the process of safe storage and disposal of waste chemicals,recovery,recycling and reuse of laboratory chemicals.(U) **CSO 3.6:t**o explain the procedure for laboratory disposal of explosives.(U) **CSO 3.7:t**o understand the identification, verification and segregation of laboratory waste.(U) **CSO 3.8:t**o analyse the notes on the disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.(A)			
UNIT 4 **Data Analysis**	*The Investigative Approach:* Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments. *Analysis and Presentation of Data:* Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple	**CSO 4.1:**to evaluate the making and recording measurements. **CSO 4.2:** to understand the notes on SI Units and their use.(U) **CSO 4.3:**to understand the application of scientific methods and design of experiments.(A) **CSO 4.4:**To understandDescriptive statistics in data analysis. (U) **CSO 4.5:**to explain on the process of Choosing and using statistical tests.(U) **CSO 4.6:**to define the term Chemometrics and discuss its notes.(K) **CSO 4.7:**to understand the term Analysis of Variance ANOVA),Correlation and regression.(U) **CSO 4.8:**to explain Curve fitting, fitting of linear equations, simple	**12**	**22**	

	linear cases, weighed linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse. Basic aspects of multiple linear regression analysis.	linear cases, weighed linear case, analysis of residuals.(U) **CSO 4.9:**to explain General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse in data processing and analysis.(U) **CSO 4.10:**to understand the Basic aspects of multiple linear regression analysis.(U)			
UNIT 5 Electronics	Basic fundamentals of electronic circuits and their components used in circuits of common instruments like spectrophotometers, typical circuits involving operational amplifiers for electrochemical instruments. Elementary aspects of digital electronics.	**CSO 5.1:t**o define the term Electronics.(K) **CSO 5.2:**to understand the basic fundamentals of electronic circuits.(U) **CSO 5.3:**to explain the components in circuits of common instruments like spectrophotoemters. **CSO 5.4:**to explain the procedures and concepts of typical circuits involving operational amplifiers for electrochemical instruments.(U) **CSO 5.5:**to understand the concept of Elementary aspects of digital electronics.(U)	**6**	**10**	

Suggested Readings:

1. J.R. Dean,A.M. Jones,D. Holmes,R. Reed,J. Weyers&A. Jones, *Practical skills in chemistry*. 2nd Ed. Prentice-Hall, Harlow. . 2011
2. D.B. Hibbert&J.J. Gooding,*Data analysis for chemistry*. Oxford University Press.2006
3. J.Topping,*Errors of observation and their treatment.* Fourth Ed., Chapman Hall, London.1984
4. D.C.Harris,*Quantitative chemical analysis*. 6th Ed., Freeman Chapters 3-5. 2007
5. R.de. Levie, *How to use Excel in analytical chemistry and in general scientific data analysis.* Cambridge Univ. Press 487 pages. 2001
6. *Chemical safety matters* – IUPAC – IPCS, Cambridge University Press, 1992
7. OSU safety manual 1.01.

VIII SEMESTER

NAME OF THE PAPER (CODE): NANOSCALE MATERIALS AND THEIR APPLICATIONS (CHC-8.1)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper-**Nanoscale Materials and their Applications:**

CO 1:	To Understand the concept of nanodimensions and various nano structures.
CO 2:	To make the students know the various methods of preparation of nanomaterials and the processes involved.
CO 3:	To understand the different characterization techniques used for the analysis of nanomaterials and Understand the basic principle behind these techniques.
CO 4:	To Understand the optical and conducting properties of nanostructures.
CO 5:	To Appreciate the real life applications of nanomaterials.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to Nanodimensions	0D, 1D, 2D nanomaterials, Quantum Dots,Nanoparticles, Nanostructures (nanowires, thin films,nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects innano systems, Quantum confinement and its consequences, Semiconductors.Band structure and bandgap.	**CSO 1.1:**to define Nanoparticles and Nanodimensions.(K) **CSO 1.2:**to analyse the concept of 0D,1D,2D naomaterials.(A) **CSO 1.3:**to classify and discuss Nanostructures as Nanowires, thin films and nanorods. **CSO 1.4:**to explain the types of carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes.(U) **CSO 1.5:**to explain the various types of side effects in Nano systems.(U) **CSO 1.6:**to analyse the Quantum confinements and their consequences.(A) **CSO 1.7:**to discuss the concepts of Semiconductors.Band structure and Bandgap.(U)	**10**	**24**	
UNIT 2 Preparation of Nanomaterials	Top down and Bottom up approach, Photolithography. Ball milling.Vacuumdeposition.Physicalvapourdeposition (PVD), Chemical vapor deposition	**CSO 2.1:t**o elaborate the Top down and Bottom up approach.(U) **CSO 2.2:**to define Photolithography and discuss its basic	**10**	**24**	

	(CVD), Thermal decomposition, Chemical reduction, Sol-Gel synthesis, Hydrothermal synthesis, Spray pyrolysis,Electrochemical deposition, Pulsed Laserdeposition.	concepts.(K) **CSO 2.3:**to define terms and explain the concepts of Ball milling.Vacuumdeposition. Physicalvapourdeposition (PVD).(U) **CSO 2.4:**to define the terms and explain the Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, Sol-Gel synthesis.(U) **CSO 2.5:**to define the terms and explain the concepts of Hydrothermal synthesis, Spray pyrolysis,Electrochemical deposition, Pulsed Laserdeposition.(U)			
UNIT 3 Characterization Techniques	*(Basic working principles and interpretation of experimental data usingthese techniques need to be covered)* UV-visible spectroscopy, X-ray diffraction (Powder and Single Crystal), Raman Spectroscopy, ScanningElectron Microscopy (SEM), Transmission Electron Microscopy (TEM), Energy Dispersive X-raySpectroscopy (EDX), X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM),Scanning Tunneling Microscopy (STM), Dynamic light scattering (DLS), Brunauer-Emmett-Teller (BET)Surface area measurement and Thermogravimetric analysis (TG).	**CSO 3.1:** to state the basic concepts ofUV-visible spectroscopy.(K) **CSO 3.2:**to define X-Ray diffraction and explain its classification Techniques Powder and Single Crystal.(U) **CSO 3.3:**to explain Raman Spectroscopy.(U) **CSO 3.4:**to define the terms ScanningElectron Microscopy (SEM), Transmission Electron Microscopy (TEM).(K) **CSO 3.5:**to explain the concepts,principles,experimentation of ScanningElectron Microscopy (SEM), Transmission Electron Microscopy (TEM).(U) **CSO 3.6:**to define the terms Energy Dispersive X-raySpectroscopy (EDX), X-ray Photoelectron Spectroscopy (XPS).(K) **CSO 3.7:**to explain the concepts, principles,experimentation of Energy Dispersive X-raySpectroscopy (EDX),	**8**	**16**	

		X-ray Photoelectron Spectroscopy (XPS).(U) **CSO 3.8:** to define the terms Atomic Force Microscopy (AFM),Scanning Tunneling Microscopy (STM).(K) **CSO 3.9:**to explain the terms, principles,experimentation Atomic Force Microscopy (AFM),Scanning Tunneling Microscopy (STM).(U) **CSO 3.10:** to deifne the terms Dynamic light scattering (DLS), Brunauer-Emmett-Teller (BET), Surface area measurement.(K) **CSO 3.11:**to explain the concepts of Dynamic light scattering (DLS), Brunauer-Emmett-Teller (BET)Surface area measurement.(U) **CSO 3.12:**to define the term Thermogravimetric analysis (TG).(K) **CSO 3.13:**to explain, principles,experimentation Thermogravimetric analysis (TG) with examples and give its uses.(U)			
UNIT 4 **Optical and Conducting Properties**	Surface plasmon resonance, Excitons in direct and indirect band gap semiconductor nanocrystals.Radiative processes: General absorption, emission and luminescence (fluorescence andphotoluminescence).Carrier transport in nanostructures.Tunneling and hoping conductivity. Defects and impurities: Deep leveland surface defects.	**CSO 4.1:t**o define the term Surface Plasmon resonance.(K) **CSO 4.2:**to explain the basic concepts of Surface Plasmon resonance.(U) **CSO 4.3:**to understand the Excitons in direct and indirect band gap semiconductor nanocrystals.(U) **CSO 4.4:**to define Radiative processes.(K) **CSO 4.5:**to explain General absorption and emission of Radiative Processes.(U) **CSO 4.6:**to define the	**10**	**24**	

		terms luminescence-fluorescence andphotoluminescence.(K) **CSO 4.7:**to understand the concepts of luminescence-fluorescence andphotoluminescence.(U) **CSO 4.8:**to define the terms Carrier transport in nanostructures.Tunneling and hoping conductivity. **CSO 4.9:**to elaborate the Carrier transport in nanostructures.Tunneling and hoping conductivity.(U) **CSO 4.10:**to identify Defects and impurities: Deep leveland surface defects. And to discuss their basic concepts.(K)			
UNIT 5 Applications	Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts,Nanocomposites ascatalysts. Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbonnanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).	**CSO 5.1:** to apply the concepts of Nanomaterials as Catalystsin various processes.(A) **CSO 5.2:**to explain the phenomenon involved in semiconductor nanomaterials as photocatalysts,Nanocomposites ascatalysts.Carbon nanostructures as catalytic nanoreactors.(U) **CSO 5.3:**to explain the metal and metal oxides confined inside carbonnanostructures.(U) **CSO 5.4:**to define the termsLEDs, solar cells, transistors.(K) **CSO 5.5:**to understand the Nanowires and thin films for photonic devices - LEDs, solar cells, transistors.(U)	**7**	**12**	

<u>Practical:</u>

Name of the Paper: Nanoscale Materials and their Applications.
Paper Code: CHC-8.1 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

Chemistry Lab: Nanoscale materials and their applications

1. Synthesis of metal nanoparticles by chemical reduction method.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size. (Students can be provided withXRD patterns of known materials and asked to interpret the data.)
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and studyits XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.

Suggested Readings:

1. A.R.West, *Solid State Chemistry and Its Application*, Wiley.2014
2. L.E. Smart, E.A. Moore, *Solid State Chemistry An Introduction*, CRC Press Taylor &Francis.2012
3. C.N.R. Rao, J. Gopalakrishnan, *New Direction in Solid State Chemistry*, CambridgeUniversity Press.1997
4. Jr.Poole,P. Charles,J. Owens, Frank,*Introduction to Nanotechnology*, John Wileyand Sons.2003
5. K.K. Chattopadhyay, A.N. Banerjee,*Introduction to Nanoscience and Technology*, PHI.2009

MINOR PAPERS (4 CREDITS)

Theory: 100 Marks, Practical: 50 Marks

MINOR-1

NAME OF THE PAPER (CODE) : INORGANIC CHEMISTRY-I(CHM-1)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (Cos) for the paper-**Inorganic Chemistry-I:**

CO 1:	Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, and shapes of s, p, and d orbitals.
CO 2:	Understand the periodic trends in properties of elements.
CO 3:	Understand the concept of lattice energy through Born-Lande and equation.
CO 4:	Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams.
CO 5:	Understand the basic concept of redox reactions.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Atomic Structure	Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance	**CSO 1.1:** to discuss the setbacks of Bohr's Atomic Model that triggers the development of quantum mechanic theory. (K) **CSO 1.2:**to explain the dual behaviour of matter and radiation. (K) **CSO 1.3:** to know the de Broglie equation, Heisenberg's Uncertainty Principle and its significance. (K) **CSO 1.4:** to derive the time independentSchrödinger'swave equation. (A) **CSO 1.5:** to understand the significance of ψ and $\psi 2$. (U) **CSO 1.6:** to derive	**14**	**25**	

	of ψ and $\psi 2$, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers *ml* and *ms*. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (*ms*). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.	Schrödinger equation for hydrogen atom. (A) **CSO 1.7:**to discuss the radial and angular parts of the hydogenic wavefunctions and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals. (K) **CSO 1.8:** to learn radial and angular distribution curves. (K) **CSO 1.9:** to discuss the quantum numbers (n,l,m,s) and their significance. (K) **CSO 1.10:** to understand the shapes of s, p and d atomic orbitals. (U) **CSO 1.11:** to know the rules for filling electrons in various orbitals, electronic configurations of the atoms. (K) **CSO 1.12:** to discuss the stability of half-filled and completely filled orbitals. (U) **CSO 1.13:** to understand the concept of exchange energy and relative energies of atomic orbitals. (U)			
UNIT 2 Periodicity in Properties of	Modern periodic law and the present form of periodic table. Periodic trends in properties of	**CSO 2.1:** to understand the placement of elements on the periodic table due to similar properties. (U) **CSO 2.2:** to understand the	**05**	**15**	

elements	elements- (a) Atomic radii (van der Waals) (b) Ionic and crystal radii. (c) Covalent radii (octahedral and tetrahedral) (d) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. (e) Electron gain enthalpy, trends of electron gain enthalpy. (f) Electronegativity	concepts of electronic configuration, atomic and ionic size and their trends in the periodic table. (U) **CSO 2.3:** to define the and explain the periodic trends of covalent radii. (K) **CSO 2.4:** to discuss ionisation enthalpy, electron gain enthalpy and their trends in the periodic table. (U) **CSO 2.5:**to explain the factors affecting ionization energy. (U) **CSO 2.6:** to understand the concepts of electronegativity and the Pauling's electronegativity scales. (U)			
UNIT 3 Ionic Bonding	General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percent-age ionic character.	**CSO 3.1:** to discuss on the general characteristics, types of ions. (U) **CSO 3.2:** to understand the lattice enthalpy and its relation to stability of and solubility of ionic compounds. (U) **CSO 3.3:** to explain the application of Born-Landé equation for calculation of lattice energy. (A) **CSO 3.4:** to discuss the Born-Haber cycle and its applications. (U) **CSO 3.5:** to understand the concept of polarizing power and polarizability. (U) **CSO 3.6:** to discuss the Fajan's rules. (K) **CSO 3.7:** to define bond moment, dipole moment and percent-age ionic character. (K)	**10**	**20**	
UNIT 4 Covalent bonding	VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal	**CSO 4.1:** to draw the plausible structures and geometries of molecules and ions using VSEPR theory. (A) **CSO 4.2:** to understand about the hybridization in inorganic complex with suitable	**10**	**25**	

	planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.	examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. (A) **CSO 4.3:** to understand the concept of resonance and resonating structures in various inorganic and organic compounds. (U) **CSO 4.4:** to discuss the bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals. (K) **CSO 4.5:** to explain the combination of orbitals forming nonbonding molecular orbitals. (U) **CSO 4.6:** to draw the plausible structures and geometries of homonuclear diatomic molecules of 1st and 2nd periods using molecular orbital diagrams. (A) **CSO 4.7:** to draw the plausible structures and geometries of heteronuclear diatomic molecules using molecular orbital diagrams. (A) **CSO 4.8:** to explain the similarities between valence bond and molecular orbital theory. (U)			
UNIT 5 Redox reactions	Concept of oxidation and reduction, redox reactions, electrochemical series and its applications**,**Latimer diagram (chlorine in acidic and basic medium), disproportionationofH_2O_2 into O_2 and H_2O under acidic conditions, Pourbaix diagram (iron species in natural water).	**CSO 5.1:** to evaluate fundamentals of electrochemistry. (K) **CSO 5.2:** to understand electrochemical series. (U) **CSO 5.3:** to discuss the applications of Electrochemical series. (A) **CSO 5.4:** to predict stability relative to higher and lower oxidation states using Latimer diagram. (U) **CSO 5.5:** to explain disproportionation reactions with suitable examples. (U) **CSO 5.6:** to predict spontaneous direction of electrochemical reactions,	**06**	**15**	

		identifying corrosion products using pourbaix diagram. (K)			

Suggested readings:

1. J.D. Lee, *Concise Inorganic Chemistry* ELBS, 1991.
2. F.A.Cotton, G.Wilkinson &P.L.Gaus, *Basic Inorganic Chemistry*, 3rd ed., Wiley, 2007
3. B.E.Douglas, D.H.McDaniel,J.J. Alexander, *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. J.E.Huheey, E.A.Keiter,R.L. Keiter &O.K.Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.

Practical:

Name of the Paper: Inorganic Chemistry-I
Paper Code: CHM-1 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Suggested Readings:

1. G. Svehla, *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. J. Mendham, *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

MINOR-2

NAME OF THE PAPER (CODE) : ORGANIC CHEMISTRY-I (CHM-2)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (Cos) for the paper-**Organic Chemistry-I:**

CO 1:	Understand and explain the differential behaviour of organic compounds based on fundamental concepts learned.
CO 2:	Understand the fundamental concepts of stereochemistry.
CO 3:	Understand the synthesis, isomerism, properties and stabilities of alkanes and cycloalkanes.
CO 4:	Understand the nomenclature, synthesis, physical and chemical properties of alkanes.
CO 5:	Interpret the concept of carbon-carbon pi bonds.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Fundamentals of Organic Chemistry	Physical Effects, Electronic Displacements:Inductive Effect,ElectromericEffect, Resonanceand Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors	**CSO 1.1:** to explain the basic concepts in organic chemistry. (U) **CSO 1.2:** to discuss the electron displacement effect providing a fundamental understanding of bond polarisation and molecular reactivity. (K) **CSO 1.3:** to explain inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications. (U) **CSO 1.4:** to discuss the different types of covalent	**10**	**22**	

	affecting pK values. Aromaticity: Benzenoids and Hückel's rule.	bond fission. (K) **CSO 1.5:** to explain the structure, shape and reactivity of organic molecules. (U) **CSO 1.6:** to explain electrophiles and nucleophiles. (U) **CSO 1.7:** to discuss on the types, shape and relative stability of Carbocations, Carbanions and free radicals. (U) **CSO 1.8:** to discuss the relative strength of organic acids and bases. (K) **CSO 1.9:** to explain the criteria of aromaticity and Huckel's rule. (K)			
UNIT 2 Stereochemistry	Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis –trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z	**CSO 2.1:** to understand the fundamental concepts of stereochemistry. (U) **CSO 2.2:** to understand the differences between conformations and configurations. (U) **CSO 2.3:** to draw and analyze open alkane structures using the different types of projections (Newmann, Sawhorse and Fischer). (K,A) **CSO 2.4:** to discuss the interconversion of Newman, Sawhorse and Fischer representations. (A)	**11**	**25**	

	Nomenclature (forupto two C=C systems).	**CSO2.5:** to discuss the chirality in molecules with one and two stereocentres. (K) **CSO 2.6:** to explain Geometrical and Optical isomerism with examples. (U) **CSO 2.7:** to explain the distinction between enantiomers, diastereomers and explain their physical properties. (U) **CSO 2.8:** to explain meso compounds with suitable examples. (U) **CSO 2.9:** to understand racemic mixture and resolution of enantiomers. (U) **CSO 2.10:** to determine trans and cis, E and Z sequence in organic molecules. (A) **CSO 2.11:** to determines R and S, (+), (-); D and L sequence in organic molecules. (A)			
UNIT 3 Cycloalkanes and Conformational Analysis	Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagrams of Ethane, Propane and butane). Relative stability of cycloalkanes (Baeyer strain theory), Cyclohexane conformations with energy diagram. Conformations of	**CSO 3.1:** to understand the concept of stereochemistry and conformational analysis in cyclic compounds. (U) **CSO 3.2:** to understand the types of strain inherent in cycloalkanes. (U) **CSO 3.3:** to draw the energy diagrams of Ethane,	**06**	**15**	

	mono substituted cyclohexanes.	Propane and butane. (A, K) **CSO 3.4:** to analyse and explain the conformational stabilities of Ethane, Propane and butane. (A) **CSO 3.5:** to discuss the Baeyer Strain Theory. (A) **CSO 3.6:** to draw the energy diagrams of cyclohexane conformations and discuss its relative stabilities. (A, U) **CSO 3.7:** to draw and explain the stabilities of conformations of mono substituted cyclohexanes. (A, U)			
UNIT 4 Aliphatic Hydrocarbons : Carbon-Carbon sigma bonds	Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. **Alkanes:** (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.	**CSO 4.1:** to discuss various physical properties of alkanes. (K) **CSO 4.2:** to explain the chemical properties of alkanes. (K) **CSO 4.3:**to understand the reaction mechanism of Wurtz reaction (U) **CSO 4.4:**to explain the preparation of alkanes using Kolbe's synthesis and Grignard reagent. (K) **CSO 4.5:** to explain the reaction mechanism of halogenation of alkanes. (U)	**06**	**15**	
UNIT 5 Aliphatic Hydrocarbons : Carbon-Carbon pi bonds	**Alkenes:** (Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and	**CSO 5.1:** to explain the general properties of Alkenes and Alkynes. (K) **CSO 5.2:** to discuss the	**12**	**23**	

	dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozo-nolysis, oxymecuration-demercuration, Hydroboration-oxidation. **Alkynes**: (Upto 5 Carbons) *Preparation:* Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. *Reactions:* formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.	methods of preparation of alkenes using Mechanisms of E1, E2, E1cb reactions. (U) **CSO 5.3:** to discuss the reaction mechanisms of Saytzeff and Hoffmann eliminations. (A) **CSO 5.4:** to explain markownikoff and anti-markownikoff addition with suitable examples. (A) **CSO 5.5:** to explain the syn and anti-addition of H2, X2. (K) **CSO 5.6:** to discuss the reaction mechanisms of oxymercuration-demercuration reaction. (A) **CSO 5.7:** to discuss the reaction mechanisms of hydroboration-oxidation, reactions. (A) **CSO 5.8:** to discuss the ozonolysis and hydroxylation reactions. (K) **CSO 5.9:** to discuss on the relative reactivity and stability of alkenes and alkynes. (U) **CSO 5.10:** to explain dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides for conversion of alkynes into			

		higher alkynes. (K) **CSO 5.11:** to discuss the various chemical reactions of alkynes. (K)			

Suggested Readings:

1. T.W.Graham Solomon, C.B. Fryhle, S.A. Dnyder, *Organic Chemistry*, John Wiley & Sons, 2014.
2. J.E. McMurry, *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
3. P. A. Sykes, *Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi, 1988.
4. E.L. Eliel, *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
5. I.L. Finar, *Organic Chemistry* (Vol. I & II), E.L.B.S, 2002.
6. R.T. Morrison&R.N. Boyd, *Organic Chemistry*, Pearson, 2010.
7. A. Bahl, B.S. Bahl, *Advanced Organic Chemistry*, S. Chand, 2010.

Practical:

Name of the Paer: Organic Chemistry I
Paper Code: CHM-2 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)

2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

Suggested Readings:

1. J. Mendham, *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
2. A.I.Vogel, A.R.Tatchell, B.S.Furnis, A.J.Hannaford &P.W.G. Smith, *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
3. F.G. Mann&B.C.Saunders, *Practical Organic Chemistry* Orient-Longman, 1960.

MINOR-3

NAME OF THE PAPER (CODE) : PHYSICAL CHEMISTRY-I (CHM-3)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (Cos) for the paper-**Physical Chemistry-I:**

CO 1:	Derivation of mathematical expressions on different properties of gas and liquids.
CO 2:	Learn the theory of dilute solutions, distribution laws and applications.
CO 3:	Determine the density of aqueous solutions and dilute solutions as per required concentrations
CO 4:	Handle instruments such as stalagmometer and Ostwald viscometer.
CO 5:	Graphical and numerical methods for reducing data.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Chemical Energetics	Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution.	**CSO 1.1:** to understand the Laws of Thermodynamics, State Functions, Path Functions, Intensive & Extensive variables. (U) **CSO 1.2:** to derive the various mathematical expressions of First Law, Second Law, Third Law, ΔU, ΔH, ΔS, ΔG, ΔA for ideal and real gases under different conditions. (A) **CSO 1.3:** to discuss important principles and definitions of thermochemistry. (K) **CSO 1.4:** to explain various Enthalpies of reactions and derive the mathematical relations for these enthalpies of reaction. (K) **CSO 1.5:** to understand the concept of standard state and standard enthalpies of formations. (U) **CSO 1.6:** to discuss the integral and differential enthalpies of solution and dilution. (K)	**07**	**18**	

UNIT 2 Chemical Energetics	Calculation of bond energy,bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff‘s equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.	**CSO 2.1:** to calculate bond energy, bond dissociation energy from thermochemical data. (A) **CSO 2.2:** to calculate the resonance energy. (A) **CSO 2.3:**to derive and the variation of enthalpy of a reaction with temperature. (A, U) **CSO 2.4:** to explain Third Law of thermodynamics. (K) **CSO 2.5:**to calculate absolute entropies of substances. (A)	**09**	**22**	
UNIT 3 Chemical Equilibrium	Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^{o}, Le Chatelier‘s principle. Relationships between K_p, $K_c$and$K_x$for reactions involving ideal gases.	**CSO 3.1:** to describe the relationship between free energy and equilibrium. (K) **CSO 3.2:** to explain the importance of the activity of a species and how it relates to concentration, pressure, and equilibrium. (U) **CSO 3.3:** to discuss the thermodynamic derivation of the law of chemical equilibrium. (A) **CSO 3.4:** to understand the distinction between ΔG and ΔG^{o}. (U) **CSO 3.5:** to determine if a system is at equilibrium and if not which direction the reaction the reaction will shift to achieve equilibrium. (K) **CSO 3.6:** to discuss the Le Chatelier’s principle and its applications. (K, A) **CSO 3.7:** to derive the relationships between K_p, K_c and K_x. (A)	**10**	**20**	
UNIT 4 Ionic	Strong, moderate and weak electrolytes,	**CSO 4.1:** to explain the different types of electrolytes with examples. (K) **CSO 4.2:** to understand the	**10**	**25**	

Equilibria	degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect.	strength of an acid or a base as determined by the percent of ionisation in solution. (U) **CSO 4.3:** to discuss the factors affecting degree of ionization. (K) **CSO 4.4:** to understand acid base conjugate acid-base pair and their relative strengths. (U) **CSO 4.5:** to understand the process of auto-ionisation of water. (U) **CSO 4.6:** to know the value of K_W at 25°C and the relationship between Ka and $K_b$for a conjugate pair. **CSO 4.7:**to explain ionization constant and ionic product of water. (U) **CSO 4.8:**to understand the conversion between hydronium ion concentration, hydroxide ion concentration, pH and pOH for a given solution. (K) **CSO 4.9:**to explain the common ion effect with examples. (U) **CSO 4.10:**			
UNIT 5 **Ionic Equilibria**	Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts, applications of solubility product principle.	**CSO 5.1:**to understand the concept of salt hydrolysis. (U) **CSO 5.2:**to calculate hydrolysis constant, degree of hydrolysis for different salts. (A) **CSO 5.3:**to discuss the relative strength of acid and base produced during hydrolysis. (U) **CSO 5.4:** to determine the pH of the solution made from the salt of a weak acid or the salt of weak base. (A) **CSO 5.5:** to predict the components of buffer solution. (K) **CSO 5.6:**to calculate the pH of a buffer solution, and a buffer solution after the addition of strong acid or strong base. (A) **CSO 5.8:** to explain solubility and solubility product of	**09**	**15**	

		sparingly soluble salts. (U) **CSO 5.9:**to discuss the applications of solubility product principle. (A)			

Suggested readings:

1. G.M. Barrow, *Physical Chemistry* Tata McGraw-Hill, 2007.
2. G.W. Castellan, *Physical Chemistry* 4th Ed. Narosa, 2004.
3. J.C.Kotz, P.M.Treichel &J.R.Townsend, *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi, 2009.
4. B.H. Mahan, *University Chemistry* 3rd Ed. Narosa, 1998.
5. R.H. Petrucci, *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York, 1985.

Practical:

Name of the Paper: Physical Chemistry-I
Paper code: CHM-3 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

Thermochemistry:

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

Ionic equilibria:

pH measurements-

Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

a) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

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

Suggested Readings:

1. B.D.Khosla, V.C.Garg&A.Gulati, *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi, 2011.

MINOR -4

NAME OF THE PAPER (CODE) : ORGANIC CHEMISTRY-II (CHM-4)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (Cos)

The following are the course Objectives (Cos) for the paper-**Organic Chemistry-II:**

CO 1:	Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
CO 2:	Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
CO 3:	Learn and identify many organic reaction mechanisms including free radical substitution.
CO 4:	Learn and identify electrophilic addition and electrophilic aromatic substitution.
CO 5:	Differentiate between various types of organic reactions possible on the basis of reaction conditions

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit and Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Aromatic hydrocarbons	*Preparation* (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).	**CSO 1.1:** To give an introduction on the aromatic hydrocarbons. (K) **CSO 1.2:** To study the preparation of some of the compound containing benzene rings. (U) **CSO 1.3:** To study the reaction mechanism of the electrophilic suntitutuon. (A) **CSO 1.4:** To study the Friedel-Craft's reactions. (U,A) **CSO 1.5:** To explain the side chain oxidation of alkyl benzenes. (U)	**8**	**18**	
UNIT 2 Alkyl and Aryl Halides	Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite &nitro formation, nitrile &isonitrile formation.	**CSO 2.1:** To give a brief introduction of Alkyl and Aryl Halides. (K) **CSO 2.2:** To study the different types of Nucleophilic suntitution reactions **CSO 2.3:** To study the preparation of Alkyl and Aryl Halidesfrom alkenes *and* alcohols with mechanism.(A) **CSO 2.4:** give an introduction of nitriles and	**8**	**18**	

	Williamson‘s ether synthesis: Elimination vs substitution.	isonitriles. (K) **CSO 2.5:** To study the mechanism of Williamson‘s ether synthesis. (A) **CSO 2.6:** To give the difference between Elimination vs substitution reactions: (U)			
UNIT 3 Aryl Halides	*Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gat-termann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.	**CSO 3.1:** To give an introduction on the aryl halides. (K) **CSO 3.2:** To study the preparation of Aryl halides. (U) **CSO 3.3:** To study the reaction mechanism of Aromatic nucleophilic substitution reactions. (A) **CSO 3.4:** To study the effect of the nitro substituent. (U) **CSO 3.5:** To study the Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides. (K,U)	**10**	**22**	
UNIT 4 Alcohols, Phenols and Ethers	Alcohols: *Preparation:* Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), Esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: (Phenol case) *Preparation:* Cumene	**CSO 4.1:** To give the introduction on the alcohol, phenols and ethers. (K) **CSO 4.2:** To study the preparation of alchols using different methods/processes. (U,A) **CSO 4.3:** To study the different chemical reaction of alcohols with the mechanism. (U,A) **CSO 4.4:** To study the preparation of phenol using different methods and reagent/ salts. (U) **CSO 4.5:** To study the chemical reaction mechanism that is caused by the phenols. (U,A) **CSO 4.6:** To study the preparation of ethers.(U) **CSO 4.7:** to study some of the chemical reaction caused by the ethers. (U,A)	**10**	**22**	

	hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reac-tion. Ethers (aliphatic and aromatic): Cleavage of ethers with HI.				
UNIT 5 Aldehydes and ketones (aliphatic and aromatic)	(Formaldehye, acetaldehyde, acetone and benzaldehyde) *Preparation:* from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.	**CSO 5.1:** To explain in brief the introduction of the carbonyl compounds. (K) **CSO 5.2:** To give different types of aldehydes. (U) **CSO 5.3:**To study the preparation of the aldehydes from different compounds. (U) **CSO 5.4:** To study the different chemical reaction mechanism that is effect by the aldehydes. (U,A)	**9**	**20**	

Suggested Readings:

1. T.W.G. Solomon, C.B. Fryhle&S.A. Dnyder, *Organic Chemistry*, John Wiley & Sons, 2014.
2. J.E. McMurry,. *Fundamentals of Organic Chemistry7th Ed*., Cengage Learning India Edition, 2013.
3. P. Sykes, *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi, 1988.
4. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.2002.
5. R.T. Morrison &R.N. Boyd, *Organic Chemistry*, Pearson, 2010.
6. A. Bahl, &B.S. Bahl, *Advanced Organic Chemistry,* S. Chand, 2010.

Practical:

Name of the Paper: Organic Chemistry II
Paper Code: CHM-4 P
Number of Credit: 01

Number of Hours of Lecture: 30 Lectures

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed.
4. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Suggested Readings:

1. F.G. Mann &B.C. Saunders, *Practical Organic Chemistry, 4th Edition,* Pearson Education,2009.
2. B.S. Furniss,A.J.Hannaford,P.W.G.Smith& Tatchell, A.R. , *Vogel's Textbook of Practical Organic Chemistry,* Pearson, 2005.
3. V.K. Ahluwalia & R. Aggarwal, *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press, 2004.

MINOR-5

NAME OF THE PAPER (CODE) : **PHYSICAL CHEMISTRY-II (CHM-5)**

Number of Credit : **Theory-03**

Number of Hours of Lecture **45**

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Physical Chemistry-II:**

CO 1:	To make the student aware of thermodynamic of ideal solution and Partial miscibility of liquids.
CO 2:	To make student understand Phases, components and degrees of freedom of a system**.**
CO 3:	Explain the factors that affect conductance, migration of ions and application of conductance measurement and make the student Understand different types of galvanic cells, their Nernst equations, and measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
CO 4:	Understand applications of Emf measurements in relation to determination of activity coefficients
CO 5:	Understand pH of a solution and Potentiometric titrations.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	**Unit Contents**	**Course Specific Objectives (CSOs)**	**Lectures Hours**	**Marks**	**LOs**
UNIT 1 Solutions	Thermodynamics of ideal solutions: Ideal solutions and Raoult‘s law, deviations from Raoult‘s law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids-Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.	**CSO 1.1:**To explain the thermodynamics of ideal solutions. (U) **CSO 1.2:** An introduction to ideal Raoult’s law. (K) **CSO 1.3:** To derive the Rault’s law. (A) **CSO 1.4:** To explain the vapour pressure composition curve of ideal and non-ideal solution. (U) **CSO 1.5:** To explain the vapour temperature composition curve of ideal and non-ideal solution. (U) **CSO 1.6:** To make student understand the distillation of solution and the lever rule. (U) **CSO 1.7:** To explain the critical solution temperature. (U) **CSO 1.8:** To explain the effect of impurity on partial miscibility of liquids. (U) **CSO 1.9:** To give the introduction of steam distillation. (K) **CSO 1.10:** To derive the Nerst	**12**	**26**	

		distribution law. (A) **CSO 1.11:** To site the applications of Nerst distribution law. (A) **CSO 1.12:** A brief introduction on solvent extraction. (K)			
UNIT 2 Phase Equilibria	Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).	**CSO 2.1:** To study the phase Phases, components and degrees of freedom of a system. (U) **CSO 2.2:** To study the Gibbs phase rule. (U) **CSO 2.3:** To study the thermodynamic derivaties. (U) **CSO 2.4:** To derive Derivation of Clausius – Clapeyron equation. (A) **CSO 2.5:** To study the phase diagrams of one-component systems (water and sulphur) (U) **CSO 2.6:** To study the phase diagrams of two component systems involving eutectics. (U) **CSO 2.7:** To explain the congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).(U)	**12**	**26**	
UNIT 3 Conductance	Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte,	**CSO 3.1:** To give the Arrhenius theory of electrolytic dissociation. (K) **CSO 3.2:** To explain the variation of specific conductivity or conductance decreases in dilution with the molar conductance. (U) **CSO 3.3:** To state and derive the Kohlrausch law of independent migration of ions. (U,A) **CSO 3.4:**To explain the measurement of the ion using Hittorf and Moving Boundary methods. (U) **CSO 3.5:** To give a brief introduction on the application of conductance measurement. (K) **CSO 3.6:** To explain the application of degree of	**8**	**18**	

	solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).	dissociation of weak electrolytes. (U) **CSO 3.7:** To explain the application of ionic product of water.(U) **CSO 3.8:** To explain the Conductmetric titrations. (U) **CSO 3.9:** To explain the hydrolysis constants of salts.(U			
UNIT 4 Electrochemistry	Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential.	**CSO 4.1:** To explain the concentration cell with and without transference. (U) **CSO 4.2:** To determine the activity coefficient and transference numbers. (A) **CSO 4.3:** To discuss the qualitative of potentiometric titrations (acid-base, redox, precipitation). (U) **CSO 4.4:** To derive the Nernst equation. (A) **CSO 4.5:** To study the different types of electrodes. Standard electrode potential. (U)	**5**	**12**	
UNIT 5 Electrochemical series	Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations - qualitative treatment (acid-base and oxidation-reduction only).	**CSO 5.1:** To give an introduction on the electrochemical series. (K) **CSO 5.2:** To calculate the thermodynamic properties, i.e. enthalpy, entropy and Gibbs free energy. (A) **CSO 5.3:** To calculate the equilibrium constant from EMF data. (A) **CSO 5.4:** To study the Concentration cells with transference and without transference. (U) **CSO 5.5:** To learn the Liquid junction potential and salt bridge. (U) **CSO 5.6:** To explain how to determine the pH using Hydrogen electrode and quinhydrone electrode.(A) **CSO 5.7:**To explain how Potentiometric titrations helps in determining the strength of acid and base. (U,A)	**8**	**18**	

Suggested Readings:

1. G.M. Barrow, *Physical Chemistry,* Tata McGraw-Hill, 2007.
2. G.W Castellan,. *Physical Chemistry* 4th Ed. Narosa, 2004.
3. J.C. Kotz, P.M. Treiche&J.R. Townsend, *General Chemistry*, Cengage Learning India Pvt. Ltd. New Delhi, 2009.
4. B.H. Mahan, *University Chemistry3rd Ed.,* Narosa, 1998.
5. R.H. Petrucci, *General Chemistry 5th Ed.,* Macmillan Publishing Co. New York, 1985.

Practical:

Name of the Paper: Physical Chemistry-II
Paper Code: CHM-5 P
Number of Credit: 01
Number ofHours of Lecture: 30 Lectures

1. **Phase equilibria**

   a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

   b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

   c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

2. **Conductance**

   i. Determination of cell constant

   ii. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

   iii. Perform the following conductometric titrations:

   a. Strong acid vs. strong base

   b. Weak acid vs. strong base

3. **Potentiometry**

   1. Perform the following potentiometric titrations:

   i. Strong acid vs. strong base

   ii. Weak acid vs. strong base

   iii. Potassium dichromate vs. Mohr's salt

Suggested Readings:

1. B. D. Khosla,V. C. Garg&A. Gulati, *Senior Practical Physical Chemistry,* R. Chand & Co. New Delhi, 2011.
2. V.K Ahluwalia&R. Aggarwal, *Comprehensive Practical Organic Chemistry*, Universities Press, 2004.

MINOR-6

NAME OF THE PAPER (CODE) : INORGANIC CHEMISTRY – II (CHM-6)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Organic Chemistry-II:**

CO 1:	To make student understand the basic concepts of Lewis acids and bases and Classify solutions as acidic, basic and neutral and the strength of Hard and soft acids and bases.
CO 2:	To establish an understanding for the general principles in metallurgy
CO 3:	To establish an understanding the periodicity and oxidation state of s-, p- block elements
CO 4:	To make the student understand the structure, bonding and the bonding in inorganic molecules of s- and p- block elements and its salient feature.
CO 5	Describe the physical properties of Noble gas elements and establish as chemically unreactive to the student.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Acids and Bases	Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.	**CSO 1.1:** An introduction to the Bronsted-Lowry concept.(K) **CSO 1.2:** To explain the conjugation of acid and base.(U) **CSO 1.3:** To make the student understand the relative strengths of acid and base.(U) **CSO 1.4:** To give the effect of substituent and solvent on acids and bases. (K) **CSO 1.5:** To make student understand differentiating and levelling solvents. (U) **CSO 1.6:** Give the general introduction on Lewis acid-base concept.(K) **CSO 1.7:** To make student aware of the different classification of acids and bases.(U) **CSO 1.8:** To explain the concept of Lux-Flood concept	**6**	**14**	

		and solvent system. (U) **CSO 1.9:** Introduction to HSAB concept. (K) **CSO 1.10:** To give and Explain some of the application of HSAB. (A)			
UNIT 2 General Principles of Metallurgy	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 agents. Hydrometallurgy with reference to cyanide process for gold and silver. Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn, Au): electrolytic refining, zone refining, van Arkel-de Boer process, Parting Process, Mond's process and Kroll Process.	**CSO 2.1:** To give a brief introduction on the occurrence of metal. (K) **CSO 2.2:** To explain the Elligham diagrams. (A) **CSO 2.3:** To explain how the carbon and carbon monoxide act as a reducing agents. (A) **CSO 2.4:** To explain the hydrometallurgy. (U) **CSO 2.5:** To give methods of purifying metals. (U) **CSO 2.6:** Purification of metals by electrolytic refining. (A) **CSO 2.7:** Purification of metals by zone refining. (A) **CSO 2.8:** Purification of metals by van Arkel-de Boer process. (A) **CSO 2.9:** Purification of metals by Parting Process. (A) **CSO 2.10:** Purification of metals by Mond's process and Kroll Process. (A)	**8**	**18**	
UNIT 3 s- and p-Block Elements	Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electronegativity (Pauling scale). General characteristics of *s*-block metals like density, melting and boiling points, flame colour and reducing nature. Oxidation states of *s*- and *p*-block elements, inert-pair effect, diagonal relationships and anomalous behaviour of first member of each group. Allotropy	**CSO 3.1:** To give an introduction of the Periodicity in *s*- and *p*-block elements. (K) **CSO 3.2:** To explain how the atomic and ionic size differ across the periodic. (U) **CSO 3.3:** To explain how the ionization enthalpy differ across the periodic. (U) **CSO 3.4:** To explain how the electron gain enthalpy differ across the periodic. (U) **CSO 3.5:** To explain how the electronegativity differ across the periodic using Pauling scale. (U) **CSO 3.6:** To give the General characteristics of *s*-block metals. (K) **CSO 3.7:** To differentiate the oxidation states of *s*- and *p*-block elements. (A) **CSO 3.8:** To explain the inert-	**14**	**30**	

	in C, P and S. Complex forming tendency of *s* block elements and a preliminary idea of crown ethers and cryptates, structures of basic beryllium acetate, salicylaldehyde/ acetylacetonato complexes of Group 1 metals. Solutions of alkali metals in liquid ammonia and their properties. Common features, such as ease of formation, solubility and stability of oxides, peroxides, superoxides, sulphates and carbonates of *s*-block metals	pair effect. (U) **CSO 3.9:** To analyse the diagonal relationship of *s*- and *p*-block elements. (A) **CSO 3.10:** To explain the anomalous behaviour of *s*- and *p*-block elements.(U) **CSO 3.11:** To make the student understand the allotropy of C, P and S. (U) **CSO 3.12:** To study the complex forming tendency of s-block elements. (A) **CSO 3.13:** To explain how the crown ethers and cryptates are formed. (U) **CSO 3.14:** To explain the structures of basic beryllium acetate.(U) **CSO 3.15:** To explain the structures of basic salicylaldehyde/ acetylacetonato.(U) **CSO 3.16:** An introduction to the complexes of Group 1 metal.(K) **CSO 3.17:** To explain the solutions of alkali metals in liquid ammonia and their properties. (U) **CSO 3.18:** To give the common features of some oxides. (K)			
UNIT 4 Structure, Bonding and Properties (acidic/ basic nature, oxidizing/ reducing nature and hydrolysis) of the following Compounds and their Applications in Industrial and Environ-	Diborane and concept of multicentre bonding, hydrides of Groups 13 (EH3), 14, 15, 16 and 17. Oxides of N and P, Oxoacids of P, S and Cl. Halides and oxohalides of P and S (PCl3, PCl5, SOCl2 and SO2Cl2) Interhalogen compounds. A brief idea of pseudohalides	CSO 4.1: An introduction to diborane. (K) **CSO 4.2:** To explain the concept of multicentre bonding. (U) **CSO 4.3:** To give the hydrides of group 13, 14, 15, 16 and 17. **CSO 4.4:** To make the students aware of the oxides of N and P. (U) **CSO 4.5:** To explain the Oxoacids of P, S and Cl. (U) **CSO 4.6:** To make the student understand the halides and oxohalides of P and S. (U) **CSO 4.7:** An over view of the interhalogen compound. (K) **CSO 4.8:** to give the student a brief idea of pseudohalides. (K)	**12**	**26**	

mental Chemistry Wherever Applicable					
UNIT 5 Noble gases	Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6 ,bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory	**CSO 5.1:** A brief introduction of the noble gases. (K) **CSO 5.2:** To make student know how the preparation of XeF_2, XeF_4 and XeF_6. (A) **CSO 5.3:** To give the properties of XeF_2, XeF_4 and XeF_6. (U) **CSO 5.4:** To explain how the VBT effect the bonding. (U) **CSO 5.5:** Using VSEPR theory the shape of noble gas will be explain. (A)	**5**	**12**	

Suggested Readings:

1. J.D. Lee, *Concise Inorganic Chemistry* ELBS,1991.

2. F.A. Cotton, G. Wilkinson &P.L. Gaus, *Basic Inorganic Chemistry*, *3rd Ed.*, Wiley.

3. B.E. Douglas, D.H McDaniel &J.J. Alexander, *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons,1965.

4. N.N. Greenwood&Earnshaw, *Chemistry of the Elements*, Butterworth-Heinemann,1997.

5. G.E. Rodger, *Inorganic and Solid State Chemistry*, Cengage Learning India Edition,.2002

6. G. L. Miessler&A. Donald,*Inorganic Chemistry* 4th Ed., Pearson,2010.

7. P. Atkin, *Shriver & Atkins'sInorganic Chemistry 5th Ed*., Oxford University Press, 2010.

Practical:

Name of the Paper: Inorganic Chemistry-II
Paper Code: CHM-6 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1.Iodometric estimation of potassium dichromate and copper sulphate

2.Iodimetric estimation of antimony in tartaremetic

3.Estimation of amount of available chlorine in bleaching powder and household bleaches

4.Estimation of iodine in iodized salts.

5.Iodimetric estimation of ascorbic acid in fruit juices.

6.Estimation of dissolved oxygen in water samples.

7.Gravimetric estimation of sulphate as barium sulphate.

8.Gravimetric estimation of aluminium as oximato complex

9.Preparation of the following: potash alum, chrome alum, tetraamminecopper(II) sulphate mono-hydrate, potassium trioxalatoferrate(III) (any two, including one double
salt and one complex).

Suggested Readings:

1.G. Svehla&Vogel's,*Qualitative Inorganic Analysis*, Pearson Education, 2012.

2.J. Mendham&Vogel's, *Quantitative Chemical Analysis*, Pearson, 2009.

MINOR-7

NAME OF THE PAPER (CODE) : ORGANIC CHEMISTRY-III (CHM-7.1)

Number of Credit 03

Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the Paper- **Organic Chemistry-III:**

CO 1:	To Understand and explain the electronic displacements and reactive intermediates and their applications in basic concepts.
CO 2:	To Formulate the mechanistic route of organic reactions by recalling and correlating the fundamental concepts• Identify and comprehend mechanism for free radical substitution, electrophilic addition, nucleophilic substitution and elimination reactions.
CO 3:	To Understand the fundamental concepts of stereochemistry.
CO 4:	To Understand and suitably use the chemistry of hydrocarbons.
CO 5:	To Understand carbohydrates their sources, extractions and compositions.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Carboxylic acids and their derivatives	Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction.	**CSO 1.1:** to define Carboxylic acid (K) **CSO 1.2:** to differentiate and explain the aliphatic and aromatic carboxylic acids.(U) **CSO 1.2:**to define Esters.(K) **CSO 1.3:** to discus the preparation of Acidic amd Alkaline hydrolysis of Esters.(U) **CSO 1.4:** to define Hell – Vohlard - Zelinsky Reaction. (K) **CSO 1.5:** to explain the reactions of Hell – Vohlard - Zelinsky Reaction.(U)	**6**	**12**	
UNIT 2 Carboxylic acid derivatives (aliphatic)(Upto 5 carbons):	*Preparation:* Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.	**CSO 2.1:** to explain the preparation od Acid Chlorides,Anhydrides,Esters and Amides from acids.(U) **CSO 2.2:** to discuss the interconversion process of Acid chlorides, Anhydrides, Esters and Amides from acids. **CSO 2.3:** to define acyl derivatives.(K) **CSO 2.4:**to discuss thecomparative study of nucleophility of acyl derivatives.	**7**	**14**	

		CSO 2.5: to define Reformatsky Reaction.(K) **CSO 2.6:** to explain the Reformatsky Reaction.(U) **CSO 2.7:** to define Perkin condensation.(K) **CSO 2.8:** to explain Perkin condensation.(U)			
UNIT 3 **Amines and Diazonium salts**	Amines (Aliphatic and Aromatic): (Upto 5 carbons) *Preparation*: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. **Diazonium salts**: *Preparation:* from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.	**CSO 3.1:** to define amines.(K) **CSO 3.2:** to differtitate and explain aliphatic and aromatic properties of amines upto to 5 carbons.(U) **CSO 3.3:** to explain the preparation of amins from alkyl halides.(U) **CSO 3.4:** to defineGabriel's Phthalimide synthesis**.(K)** **CSO 3.5:** to explain theGabriel's Phthalimide synthesis.(U) **CSO 3.6:** to define Hofmann Bromamide reaction.(K) **CSO 3.7:** to explain the Hofmann Bromamide reaction.(U) **CSO 3.8:** to explain the hofmann vs Saytzeff elimination reactions.(U) **CSO 3.9:**to explain the Carbylamine test and Hinsberg test using HNO_2.(U) **CSO 3.10:** to define Schotten-Baumann reacrtion.(K) **CSO 3.12:** to explain the reactions of Schotten-Baumann mechanism.(U) **CSO 3.13:** to define Electrophilic substitution.(K) **CSO 3.14:** to explain the nitration,bromination and sulphonation reaction in reference to anilne. **CSO 3.15:** to define diazonium salts.(K) **CSO 3.16:**to discuss the preparation of diazonium salts from aromatic amines.(U) **CSO 3.17:** To understand the	**10**	**18**	

		conversion reactions to benzene,phenol,dyes.(U)			
UNIT 4 **Amino Acids, Peptides and Proteins**	*Preparation of Amino Acids:* Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. *Reactions of Amino acids*: ester of –COOH group, acetylation of –NH2 group, complexation with Cu2+ ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N- terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.	**CSO 4.1:** to explain the preparation of Amino acids from Strecker synthesis using Gabriel Phthalimide synthesis. **CSO 4.2:** to deifnezwitter ion.(K) **CSO 4.3:** to explain zwitter ion with examples.(U) **CSO 4.4:** to define Electrophoresis.(K) **CSO 4.5:**to understand the process involved in Electrophoresis.(U) **CSO 4.6:** to analyse various reactions of Amino acids inlvoving ester of –COOH group,acetylation of $–NH_2$ group.(A) **CSO 4.7:** to analyse complexation reactions with Cu^{2+} ions and processes involving ninhydrin test.(A) **CSO 4.8:** to deinfe proteins.(K) **CSO 4.9:** to discuss the classification of primary.Secomdary,Tertiary and Quaternary structure of proteins with examples.(A) **CSO 4.10:** to analyse the determination of Primary structure of Peptides by degradation involvingEdmann degradation (N- terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme).(A) **CSO 4.11:** to analyse the synthesis of simple peptides (upto dipeptides) by applying N-protection (t-butyloxycarbonyl and phthaloyl). **CSO 4.12:** to discuss activation groups with some examples and explain C-activating groups and	**12**	**30**	

		Merrifield solid-phase synthesis.(U)			
UNIT 5 Carbohydrates	Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.	**CSO 5.1:** to define carbohydrates with examples.(K) **CSO 5.2:** to classify carbohydrates and explain its general properties.(U) **CSO 5.3:** to define Glucose and Fructose.(K) **CSO 5.4:**to explain the Glucos and Fructose with examples (open chain and cyclic structure both for glucose and fructose) **CSO 5.5:** to explain and determine the configuration of monosaccharides.(U) **CSO 5.6:** to understand the absolute configuration of Glucose and fructose in its Structures and reactions.(K) **CSO 5.7:** to define mutarotation.(K) **CSO 5.8:** to explain the ascending and descending phenomenon involved in monosaccharides.(U) **CSO 5.9:** to explain the strucutural organization of disacharrides involving sucrose,cellobiose,maltoseand lactose.(U) **CSO 5.10:** to explain the strucutural organization of polysacharrides involving starch and cellulose.(U)	**10**	**26**	

Suggested Readings:

1. R.T.Morrison & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).2010.
2. I.L.Finar, *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2002.
3. I.L.Finar, *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2002.
4. D.L.Nelson&M.M. Cox, *Lehninger's Principles of Bioch*emistry *7th Ed.,* W. H. Freeman. 2021.

5. J.M.Berg,J.L. Tymoczko,L. &Stryer,*Biochemistry,* W.H. Freeman,2015

Practical:

Name of the Paper: Organic Chemistry-III
Paper Code: CHM-7.1 P
Number of Credit: 01
Number of Hours of Lecture: 30 lectures

Practicals: Organic Chemistry

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

II . Separation of amino acids by paper chromatography

1. Determination of the concentration of glycine solution by formylation method.
2. Titration curve of glycine.
3. Action of salivary amylase on starch.
4. Effect of temperature on the action of salivary amylase on starch.
5. Differentiation between a reducing and a non-reducing sugar.

Suggested Readings:

1. B.D. Khosla, V.C. Garg&A. Gulati,(2011)*Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi.2015
2. V.K. Ahluwalia&R.Aggarwal, *Comprehensive Practical Organic Chemistry,* Universities Press.2001.

NAME OF THE PAPER (CODE) : BIOINORGANIC CHEMISTRY (CHM-7.2)
Number of Credit 03
Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the- **Bioinorganic Chemistry:**

CO 1	To Identify different metals ions as essential, non-essential, trace and toxic in biological systems.
CO 2	To Understand the role of metal ions for biological system.
CO 3	To understand the role of metals in Chlorophyll and Bone formation.
CO 4	To Classify toxic metal ions and their effects in living system.
CO 5	To Explore new areas of research in both chemistry and allied fields.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Title Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs

UNIT 1 **Introduction**	A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non- proteins). Brief idea about membrane transport, channels, pumps.	**CSO 1.1:** to understand bio-inorganic Chemistry briefly.(U) **CSO 1.2:** to explain the importance of metals present in biological systems.(U) **CSO 1.3:** to classify metals present in biological systems based on their properties as essential, non-essential, trace & toxic. **CSO 1.4:** to define Metallobiomolecules. (K) **CSO 1.5:** to classify metallobiomolecules based on enzymes, transport and storage proteins and non- proteins.(U) **CSO 1.6 :** to explain the importance of membrane transport, channels, pumps.(U)	**10**	**22**	
UNIT 2 **(a) Role of s-block Elements in Biological System**	Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump.	**CSO 2.1 :** to explain the role of metal ions in biological systems with special reference to Na^+, K.(U) **CSO 2.2 :** to explain the role of metal ions in biological systems with special reference to Mg^{2+} and Ca^{2+} ions.(U) **CSO 2.3 :** to define Na/K pump.(K) **CSO 2.4:** to explain the Na/K pump.(U) **CSO 2.5 :** to define Ca pump.(K) **CSO 2.6:** to explain the Ca pump.(U)	**8**	**17**	
UNIT 3 **(b) Role of s-block Elements in Biological System**	Role of Mg^{2+} ions in energy production and chlorophyll. Role of calcium in bone formation.	**CSO 3.1 :** to explain the Role of Mg^{2+} ions in energy production and chlorophyll.(U) **CSO 3.2 :** to know the intake of calcium in Bone.(K) **CSO 3.3 :** to understand the Role of calcium in bone formation.(U)	**6**	**14**	
UNIT 4 **Role of iron in Biological System**	Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism, Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon	**CSO 4.1 :** to understand the Role of iron in transport.(K) **CSO 4.2 :** to explain the storage of Iron i.e. haemoglobin and myoglobin. **CSO 4.3 :** to explain the Perutz mechanism.(A) **CSO 4.4 :** to define Cooperative effect.(K) **CSO 4.5 :** to explain the Cooperative effect.(U)	**12**	**28**	

	monoxide. Storage and transport of iron in humans (ferritin and transferrin).	**CSO 4.6 :** to explain the Bohr effect.(U) **CSO 4.7 :** to understand the comparison of oxygen saturation curves of haemoglobin and myoglobin,carbon monoxide. (U) **CSO 4.8:** to explain the Storage and transport of iron in humans-ferritin and transferring.(U)			
UNIT 5: Toxicity of Heavy Metal Ions	Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes	**CSO 5.1:** to define heavy metals.(K) **CSO 5.2:** to explain the Toxicity of heavy metal ions Hg,Pb. **CSO 5.3:** to explain the Toxicity of heavy metal ions Cd,As. **CSO 5.4:** to understand the reasons for toxicity of heavy metals and their antidotes.	**9**	**19**	

Practical:

Name of the Paper: Bioinorganic Chemistry
Paper Code: CHM-7.2P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1. **Spectrophotometric estimation:**

(i) Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$/$CoSO_4$ in a solution of unknown concentration

(ii) Spectrophotometric estimation of Fe^{2+} ions by using 1, 10- phenanthroline

(iii) Determination of the composition of the Fe^{3+} - salicylic acid complex in solution by Job's method.

2. **Complexometric titrations using disodium salt of EDTA:**

(i) Estimation of Zn^{2+} using EBT / Xylenol orange as indicator

(ii) Estimation of Mg^{2+}

(iii) Estimation of Ca^{2+} by substitution method

(iv) To estimate the concentration of Ca in commercially available medicines.

(v) To estimate the Mg present in multivitamins.

Suggested Reading:

1. J.E. Huheey, E.A. Keiter, R. LKeiter & O.K. Medhi, *Inorganic Chemistry-Principles of Structure and Reactivity,* Pearson Education. 2009.

2. D.D. Shriver, P.Atkins&C.H. Langford, *Inorganic Chemistry 2nd Ed.,* Oxford University Press,1994.

3. R.R. Crichton, *Biological Inorganic Chemistry: An Introduction. Amsterdam*, Elsevier. 2008.

4. W. Kaim, B. Schwederski& A. Klein, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide. 2nd Edition*, Wiley. 2014.

Practical:

1.G.H. Jeffery, J. Bassett,J.Mendham &R.C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis,* John Wiley and Sons.1989.

MINOR-9

NAME OF THE PAPER (CODE) : MEDICINES IN DAILY LIFE (CHM-8)
Number of Credit 03
Number of Hours of Lecture 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper-**Medicines in Daily life:**

CO 1:	To Understand the role of different types medicines on human physiology and their origin.
CO 2:	To Gain the knowledge of active pharmaceutical ingredient and their roles in different diseases.
CO 3:	To Learn the proper use of different medicines and their effect and side effects.
CO 4:	To Learn the techniques of administering blood group, pulse rate, blood pressure and may other general diagnostic applications.
CO 5:	To Understand astringents and suppliments and their derivatives.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Course	Course Specific Outcomes (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 General Introduction	Introduction-Health, disease, drugs, chemotherapy, approaches in drug designing, classification of drugs and their origin.	**CSO 1.1:** to introduce basics of Human Health.(K) **CSO 1.2**: to explain the Health disease in Humans.(U) **CSO 1.3:** to define drugs and chemotherapy.(K) **CSO 1.4:** to understand the basic concepts of drugs and chemotherapy.(U) **CSO 1.5:** to understand the various approaches involved in drug designing.(U) **CSO 1.6:** to callsify drugs based on their properties and discuss its origins.	**10**	**22**	
UNIT 2 Different class of medicines	**a)Structure of active ingredients, uses, dosage, side effects and their natural remedies:** **Analgesics and antipyretics**- Aspirin, paracetamol, ibuprofen, morphine, codeine **Antibiotics**- Amoxicillin, norfloxacin, ciprofloxacin **Antihistamines or antiallergics**- Cetrizine and Levocetrizine (role of stereoisomers) **Antiparasitic**- Albendazole.	**CSO 2.1:** to explain the Structure of active ingredients, uses, dosage, side effects and their natural remedies: Analgesics and antipyretics- Aspirin and Paracetamol. **CSO 2.2:** to explain the Structure of active ingredients, uses, dosage, side effects and their natural remedies: Analgesics and antipyretics- Ibuprofen, morphine and codeine. **CSO 2.3:** to define Antibiotics.(K) **CSO 2.4:** to explain the properties of Amoxicilli,norfloxacin and ciprofloxacin. **CSO 2.4:** to define Antihistamines or	**10**	**22**	

		antiallergics(K) **CSO 2.5:** to explain the properties of Cetrizine and Levocetrizine-role of stereoisomers. **CSO 2.6:** to define Antiparasitic.(K) **CSO 2.7:** to explain the properties of Albendazole.			
UNIT 3 Different class of medicines	**b)Structure of active ingredients, uses, dosage, side effects and their natural remedies:** **Antidiabetics-** Insulin, Glipizide and metformin **Antihypertensive** – Amlodipine and its natural remedies- Rauwolfia. **Diuretic**- Lasix **Antidepressant**-Zoloft and its natural treatment **Antifungal** – fluconazole, Itraconazole .	**CSO 3.1:** to exaplin the Structure of active ingredients, uses, dosage, side effects and their natural remedies: Antidiabetics-Insulin,Glipizde and metformin. **CSO 3.2:** to define Antihypertensive.(K) CSO 3.3: to explain the properties of Amlodipine and its natural remedies- Rauwolfia. CSO 3.3: to define Diuretic.(K) CSO 3.4: to explain the propereties of Diuretic- Lasix. CSO 3.5: to deifne Antidepressant. CSO 3.6: to explain theAntidepressant-Zoloft and its natural treatment. CSO 3.7: to define Antifungal.(K) CSO 3.8: to explain the Antifungal– fluconazole, Itraconazole .	**10**	**22**	
UNIT 4 Different Class of Medicines	**Structure of active ingredients, uses, dosage, side effects and their natural remedies:** **Antacids**- Ideal properties of antacids, combinations of antacids, Sodium 40 Bicarbonate, rantidine, milk of magnesia, aluminium hydroxide gel **Anticoagulants/antiplatelet drugs**- Warfarin, heparin and Ecosprin **Anaesthetics-** Atracurium, Desflurane **Poison and Antidote**: Sodium thiosulphate, Activated charcoal, Sodium nitrite.	CSO 4.1: to define Antacids.(K) CSO 4.2: to explain the Ideal properties of antacids.(U) CSO 4.3: to understand the combinations of antacids.(K) **CSO 4.4:**to explain Sodium 40 bicarbonate.(U) CSO 4.5: to explain various properties of Bicarbonate and rantidine.(U) **CSO 4.6:** to explain various properties of milk of magnesia, aluminium hydroxide gel.(U) **CSO 4.7:** to define Anticoagulants/antiplatelet drugs. **CSO 4.8:** to analyse Anticoagulants/antiplatelet drugs- Warfarin, heparin and Ecosprin.(A) **CSO 4.9:** to define	**10**	**22**	

		Anaesthetics.(K) **CSO 4.10:** to analyse Anaesthetics- Atracurium, Desflurane.(A) **CSO 4.11:** to define poison and Antidote.(K) **CSO 4.12**: to explain the properties of Poison and Antidote: Sodium thiosulphate, Activated charcoal, Sodium nitrite.(U)			
UNIT 5 Different Class of Medicines	**Astringents:** Zinc Sulphate, Potash Alum **Supplements-** zinc and calcium, vitamins. Synthesis of small molecule drugs like aspirin and paracetamol	**CSO 5.1:** to define Astringents.(K) **CSO 5.2:** to explain the properties and write the chemical formulas of Astringents:Zinc Sulphate, Potash Alum.(U) **CSO 5.3:** to define supplements.(K) **CSO 5.4:** to explain the properties of supplements- zinc and calcium, vitamins.(U) **CSO 5.5:** to explain the synthesis and reactions involved in smallmolecule drugs like aspirin and paracetamol.(U)	**5**	**12**	

Practical:

Name of the Paper: Medicines in Daily Life
Paper Code: CHM-8 P
Number of Credit: 01
Number of Hours of Lecture: 30 Lectures

1. Determination of heart rate and pulse rate, blood pressure and discussion on medicines affecting them.
2. Identification test- Magnesium hydroxide, Sodium bicarbonate, Calcium gluconate.
3. Preparation of inorganic pharmaceuticals- Boric acid Potash alum
4. Determination of sugar content in the given solution.
5. Estimation of zinc and calcium in a given solution.
6. Qualitative analysis of carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose).
7. Qualitative tests for Proteins
8. Qualitative analysis of vitamin C.
9. Isolation of paracetamol (API) from a commercial tablet
10. Isolation of aspirin (API) from tablet and recording of melting point (synthesis needs discussion)

Suggested Readings:
Theory:
1. G.L. Patrick, *Introduction to Medicinal Chemistry*, Oxford University Press.2001
2. T.L. Lemke & D.A. William,*Foye's Principles of Medicinal Chemistry*, 5th Ed., USA.2002.
3. H.Singh, V.K. Kapoor, *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan.1996.
4. G.R. Chatwal, *Pharmaceutical chemistry*, inorganic (vol. 1), Himalayan publishing house.2010.
5. https://go.drugbank.com./

Practicals:

1. G.H. Jeffery, J. Bassett, J.Mendham, R.C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley and Sons. 1989.
2. V.K. Ahluwalia, S. Dhingra, *ComprehensivePractical Organic Chemistry: Qualitative Analysis*, University Press.2004.
3. S. Munwar, S.Ammaji, *Comprehensive Practical Manual of Pharmaceutical Chemistry***,** Educreation Publishing.2019.
4. P.Mondal, S. Mondal, *Handbook of Practical Pharm***.**2019.

SKILL ENHANCEMENT COURSES (SEC)

I-SEMESTER

NAME OF THE PAPER (CODE) : **BASICS OF ANALYTICAL CHEMISTRY-I (CHS-1)**

Number of Credit **02**

Number of Hours of Lecture **30**

COURSE OBJECTIVES (COs)

The following are the Course Objectives (Cos) for the paper **- Basics of Analytical Chemistry-I:**

CO 1:	Able to handle the chemicals and equipment safely and properly.
CO 2:	Able to handle different glass apparatus and implement safe working practices in the laboratory.
CO 3:	Have an understanding about solution making.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction-Chemistry Laboratory	General introduction to chemistry lab, safety rules and precautions in chemistry laboratories, storage, ventilation, lighting, fumes, cupboard, hazards, precautions, maintenance of laboratory, definition of equipment/ apparatus, cleaning of laboratories, apparatus and preparation room.	**CSO 1.1:**a brief introduction to chemistry lab. (K) **CSO 1.2:**to demonstrate proper and safe laboratory procedures. (K) **CSO 1.3:**to identify and locate safety devices in the laboratory. (K) **CSO 1.4:**to provide guidelines to be used in the event of fire, chemical spill or personal contamination in the laboratory. (K) **CSO 1.5:**to direct the students for proper maintenance of laboratory, cleaning of laboratories and apparatus. (K)	**06**	**10**	
UNIT 2 Lab Apparatus	**(A) Glass apparatus** Beaker, test tube, boiling tube, conical flask, filtration flask, round	**CSO 2.1:**to know safe laboratory practices by handling laboratory	**17**	**30**	

	bottom flask, flat bottom flask, funnel, separating funnel, watch glass, measuring cylinder, petridish, desiccator, measuring cylinder, glass rod, glass tube. **(B)Volumetric and Heating apparatus** **Volumetric apparatus** Volumetric flask, burette, pipette, analytical balance, electronic balance. Heating apparatus: Bunsen burner, water bath, sand bath, hot air oven, heating mantle **(C) Miscellaneous Apparatus** Buchner funnel, burner, test tube stand, tong, burette stand, clamp, china dish, wire gauze, cork, vacuum pumps, crucibles, clay pipe triangle, pestle and mortar, spatulas, thermometer, pH meter, Kipp's apparatus	glassware, equipment appropriately. (K) **CSO 2.2:**to identify and know the function of various laboratory equipment. (K) **CSO 2.3:**to know the names and uses of various glass apparatus. (K) **CSO 2.4:** to identify and know the function of various volumetric and heating apparatus. (K)			
UNIT 3 Solution Preparation	Solutions, components of a solution, types of solution, solubility, concentration terms - percentage, ppm, ppb, g/L, molarity, normality, molality, calculation of masses and volumes for preparation of solutions and their practical approach.	**CSO 3.1:**to provide students with a practical approach towards various techniques. (K) **CSO 3.2:**to explain solutions, components of a solution, types of solution. (U) **CSO 3.3:**to understand and calculate the various concentration terms - percentage, ppm, ppb, g/L, molarity, normality and molality. (A) **CSO 3.4:** to know the calculation of masses and volumes for preparation of solutions. (A)	**07**	**10**	

		CSO 3.5:to incorporate experiments which involves volumetric estimation of chemicals and determination of various properties. (K) **CSO 3.6:** to analyze and gain experimental skill. (K)			

Suggested Readings:

1. Vogel, I. Arthur *A Test book of Quantitative Inorganic Analysis* (Rev. by GH Jeffery and others) 5th Ed. The English Language Book Society of Longman, 1989.

2. Willard, H. Hobert et. al: *Instrumental Methods of Analysis,* 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988

3. Christian, D. Gary *Analytical Chemistry*, 6th Ed. New York- John Willy,2004.

4. Harris, C. Daniel *Quantitative Chemical Analysis*,3 rd Edition, W.H. Freeman and Company, New York,2001.

5. S.M. Khopkar, *Basic Concepts of Analytical Chemistry* New Age, International Publisher, 2009.

6. Koogs, West and Holler, *Fundamentals of Analytical Chemistry*,6 th Edition, Sauders College Publishing, New York, 1991.

II- **SEMESTER**

NAME OF THE PAPER (CODE) **: BASICS OF ANALYTICAL CHEMISTRY-II (CHS-2)**

Number of Credit **02**

Number of Hours of Lecture **30**

COURSE OBJECTIVES (COs)

The following are the Course Objectives (Cos) for the paper **- Basics of Analytical Chemistry-II:**

CO 1:	Have an understanding about the laboratory reagents and solvent reagents.
CO 2:	Develop skill about data handling and carry out sample preparation.
CO 3:	Get the distinction between quantitative and qualitative analysis.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Laboratory Reagents and Solvents Reagents	Classification of reagents according to their action; (i) acids (ii) bases (iii) salts (iv) complexing agents (v) oxidizing and reducing agents (vi) precipitating agents (vii) chelating agents. Each type to be explained with at least one suitable example. Primary and secondary standards: Definition, characteristics, uses examples for different types of reactions. Solvents: Solute, Solvent & Solution, classification of solvents (i) Protic and aprotic (ii) Acidic, basic amphiprotic and neutral (iii) Aqueous and non-aqueous (iv) Polar and nonpolar. Each type is to be explained with at least one example.	**CSO 1.1:**to understand the classification of reagents with examples according to their action. (U) **CSO 1.2:**to discuss the characteristics of primary and secondary standardswithexamples for different types of reactions. (K) **CSO 1.3:**to define solute, solvent and solution. (K) **CSO 1.4:**to explain the classification of solvents giving suitable examples (U)	**12**	**20**	
UNIT 2 Chemical Analysis	Definition, collection of samples, selection of appropriate analytical method, preparation of the sample, analysing the sample using the selected method, technique, interpreting the results, report preparation.	**CSO 2.1:**to define and use the concept of sampling in quantitative chemical analysis. (K) **CSO 2.2:**to discuss the selection of appropriate analytical method and preparation of the sample. (U) **CSO 2.3:** to analyse the sample using the selected method, interpreting the	**08**	**14**	

		results and report preparation. (A)			
UNIT 3 Quantitative Analysis	Titration- Definition and difference between qualitative and quantitative analysis, types of titrations, end point, equivalence point, Indicators-types, oxidizing and reducing agents, gravimetric analysisdetailed description of the steps of gravimetric analysis, applications.	**CSO 3.1:**to understand the concept of titration and to differentiate between qualitative and quantitative analysis. (U) **CSO 3.2:**to describe the difference between an endpoint and an equivalence point in an acid-base titration. (K) **CSO 3.3:**to define and explain oxidizing and reducing agents. (K) **CSO 3.4:** to discuss the detailed description of the steps of gravimetric analysis and its applications. (U, A)	**10**	**16**	

Suggested Readings:

1. R.V, Ditts,*Analytical Chemistry* – Methods of separation, 1974.

2. K.L.Williamson and D.C. Heath.*Macroscale and Microscale Organic Experiments*, 1989.

3. H. Middleton and Edward Arnold, *Systematic Qualitative Organic Analysis*, 1959.

4. H. Clarke and HodderArnold, *Handbook of Organic Analysis*, Qualitative and Quantitative, 1975

5. A.R. Tatchell, John Wiley,*Vogel's Textbook of Practical Organic Chemistry*,1989.

6. A.M. James and F.E. Prichard, Longman, *Practical Physical Chemistry*, 1981

7. B.P. Levitt Longman. *Findley's Practical Physical Chemistry*, 1954

8. R.C. Das and B. Behera, Tata McGraw Hill, *Experimental Physical Chemistry*, 1983

III- **SEMESTER**

NAME OF THE PAPER (CODE) **: CHEMISTRY OF FRAGRANCES AND FLAVOURS: AN INDUSTRY'S PERSPECTIVE (CHS-3)**

Number of Credit **02**

Number of Hours of Lecture **30**

COURSE OBJECTIVES (COs)

The following are the Course Objectives (Cos) for the paper –**Chemistry of Fragrances and Flavours: An Industry's Perspective:**

CO 1:	Synthesis of various fragrance and flavour ingredients. Formulation methods, how different factors affects the formulation process in Fragrance and Flavour industry.
CO 2:	Uphold safety regulation and execute quality processes. Quality control in manufacturing process, legal aspects, classification of odour and odorants.
CO 3:	Different methods used for separation, purification and isolation of perfumes and flavours like distillation, extraction, crystallization, etc.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objective (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Fragrances	Introduction to fragrances, types of fragrances (Fragrance families and classification) History of perfumes, Perfumery raw materials, classification of odour, odour type and odorants India in the context of Fragrance Industry ABCs of perfumery, odour aspects of perfumes, fragrance pyramid, fragrance families Chemistry of aromatic compounds in perfume making, Composition of fragrances Current trends in fragrances, sensory analysis of different products Study of the raw materials used in perfumery (origin, extraction	**CSO 1.1:**to impart theoretical and practical knowledge of basic principles of perfumes. (K) **CSO 1.2:**to explain the types of fragrances. (U) **CSO 1.3:**to discuss the history of perfumes and unlocking the growth of perfume industry in India. (K) **CSO 1.4:** to understand odour aspects of perfumes, fragrance pyramid and fragrance families (U) **CSO 1.5:**to explain the chemistry behind perfume making. (K) **CSO 1.6:**to discuss the origin and extraction	**10**	**20**	

	method, and olfaction) Key chemical reactions for conversion of raw materials to fragrances Extraction of essential oils used in perfumery Difference between alcohol and oil-based perfumes	method of perfume making. (K) **CSO 1.7:**to explain the chemical reactions for conversion of raw materials to fragrances. (U) **CSO 1.8:** to discuss the differences between alcohol and oil-based perfumes. (K)			
UNIT 2 Sustainable Fragrance by Design	The challenges of sustainability and how it impacts the industry Sustainability charter Green chemistry principles Commitment to Biodiversity	**CSO 2.1:**to discuss on the challenges of sustainability and how it impacts the industry Sustainability charter. (K) **CSO 2.2:**to learn green methods that aid to design and develop materials and processes to reduce the use and generation of hazardous substances in industry. (K) **CSO 2.3:**to understand various green chemistry concepts such as twelve principles of green chemistry. (U) **CSO 2.4:** to develop and utilize safer starting materials and synthetic routes for less hazardous substances. (K)	**06**	**10**	
UNIT 3 Flavours	Introduction to flavours, types of flavours, flavour raw materials Understanding of terms like, Flavour and Flavouring agents. Attributes of flavour, taste,	**CSO 3.1:**to discuss the role of flavour chemistry in food industry. (U) **CSO 3.2:** to	**14**	**20**	

	odour, odour stimulation, basic tastes and the human olfactory system. Stability of flavour in food, sensory evaluation of flavours in foods, Various flavour formulation Flavour enhancers, modifiers, precursors, suppressors, solvents. Key chemical reactions for conversion of raw materials to flavours. Selection and application of flavours in foods and beverages Legal aspects (natural flavours and natural flavouring substances, nature identical flavouring substances, artificial flavouring substances), and the FSSA act	understand different classes of flavour compounds, their flavors, sources and interactions in food. (U) **CSO 3.3:**to understand the chemical composition of flavours and the mechanism of their formation. (U) **CSO 3.4:** to discuss the stability of flavour in food, sensory evaluation of flavours in foods and various flavour formulation. (K) **CSO 3.5:** to define flavour enhancers, modifiers, precursors, suppressors with examples. (K) **CSO 3.6:** to explain the chemical reactions for conversion of raw materials to flavours. (U) **CSO 3.7:**to discuss the application of flavours in foods and beverages. (A) **CSO 3.8:**the discuss the legal aspects and the salient features of FSSA act. (A)			

Practicals:

1. Extraction of D-limonene from orange peel using liquid CO2.
2. Extraction of caffeine from coffee beans using liquid CO2.
3. Extraction of essential oils from lemon using steam distillation

4. Extraction of essential oils from lemon using liquid CO2.
5. Extraction of essential oils from fragrant flowers.
6. Determination of esters by Thin Layer Chromatography
7. Memorisation of different raw materials used in perfumery, perfume language, Memorisation of perfumes
8. Testing up of different flavours
9. Analysis of spectra of perfume formulations.
10. Field trip/ Industrial Visit and submit a report to the concerned Teacher.

Suggested Readings:

1. S.Arctander, *Perfume and flavour materials of Natural origin***,** Allured Publishing Corporation, USA, 2008.
2. S.Arctander, Volume I and II, *Perfume and Flavour Chemicals*, (Aroma Chemicals), Allured Publishing Corporation, USA, 2017.
3. T.Curtis, D. C.Williams, 2nd Edition, *An Introduction to Perfumery*, Micelle Press, USA, 2001
4. C. Sell, *Understanding Fragrance Chemistry,*Allured Publishing Corporation, USA, 2008.
5. R.R.Calkin, J.S.Jellinek, *Perfumery: Practice and Principles*, John Wiley & Sons Inc.
6. S.P.Gimelli, *Aroma Science*, Micelle Press, USA, 2001.
7. S. Arctander, *Perfume and Flavour Materials of Natural Origin,*Orchard Innovations, 2019.
8. https://www.beyondbenign.org/lessons/essential-oil-extraction-using-liquid-co2/.

IV- **SEMESTER**

NAME OF THE PAPER (CODE) : ROLE OF METALS IN MEDICINES (CHS-4)

Number of Credit 02

Number of Hours of Lecture 30

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Role of Metals in Medicines:**

CO 1:	Role of metal ions in various biomolecules and their functions.
CO 2:	Role of metals in commercially available medicines and their functions.
CO 3:	Elaborate the different types of Metals in drugs and know its composition.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit	Content	Course Specific Objectives	Lectures Hours	Marks	LOs
UNIT 1 Bio role of Metals.	Brief introduction of following metals in biological system Fe, Cu, Zn, Mn, Cr(III), V, Mo, W, Co, Ni, Na, K, Mg and Ca. Chemical structure, Commercial name, Name of the disease it is made for and its brief mechanism of action shall be taught for all the mentioned metals below.	**CSO 1.1:** A brief introduction to some of the metals. (K) **CSO 1.2:** Chemical structure with explanation of some of the metals. (U,A) **CSO 1.3:** Give some of the commercial name of metals. (K) **CSO 1.4:** To explain some of the diseases that are cause by the metals. (U) **CSO 1.5:** To explain the mechanism on how the metals effect the health.(A)	**6**	**12**	
UNIT 2 Diagnostic and therapeutic agents	Diagnostic and therapeutic agents with Pt (Cisplatin) and Ga for cancer, Au (auranofin) for arthritis and V for diabetes.	**CSO 2.1:** To make the student understand the diagnostic and therapeutic agents of Pt for cancer. (U,A) **CSO 2.2:** To make the student understand the diagnostic and therapeutic agents of Ga for cancer. (U, A) **CSO 2.3:** To explain how Au is used for the arthritis patient. (U, A) **CSO 2.4:** To explain how V is used for the diabetes patient. (U, A)	**8**	**14**	
UNIT 3 Metals in drugs.	Li_2CO_3 (Camcolit) for manic-depressive illness, $NaHCO_3$ (Alka-seltzer) for heartburn, $Al(OH)_3$(Gaviscon) for heartburn, As (melarsoprol) for sleeping sickness, Bi subsalicylate (pepto-	**CSO 3.1:** To make student understand how Li_2CO_3 is used for manic depressive illness. (U, A) **CSO 3.2:** To make student understand how $NaHCO_3$ and	**16**	**24**	

	Bismol) for heartburn and diarrhea, Bi subcitrate (De-nol) peptic ulcer, Zinc oxide with Fe2O3 (Calamine lotion) as antimicrobial agent. Internship to pharmacies in and around the State (Students are to make report of it and submit to the respective Teacher).	$Al(OH)_3$ is used for heartburn. (U, A) **CSO 3.3:** To make student understand some of the medicine and its uses. (U)			

Practicals:

Volumetric titrations:

1. To estimate the acidity of commercially available antacids.
2. To estimate the concentration of Fe in commercially available medicines.
3. To estimate the concentration of Ca in commercially available medicines.
4. To estimate the strength of carbonate in tablets containing $Li2CO_3$
5. To estimate the sodium bicarbonate in synthetic/commercially available drug.
6. To estimate the zinc and iron present in Calamine lotion.
7. To estimate the Mg present in multivitamins.
8. Internship/ Minor Project and submit a hardcopy report to the concerned Teacher.

Suggested Readings:

1. *Metals in Medicine*,John Wiley & Sons Ltd, 2009.
2. J. Stephen, *Lipid, Chapter-9,*
3. Jones, Chris and Thornback, John, *Medicinal applications of coordination chemistry,* Cambridge, UK: Royal Society of Chemistry, 2007.

V- **SEMESTER**

NAME OF THE PAPER (CODE) : CHEMISTY IN DIARY PRODUCTION (CHS-5)

Number of Credit 02

Number of Hours of Lecture 30

COURSE OBJECTIVES (COs):

The following are the course Objectives (Cos) for the paper-**Chemistry in Diary Production:**

CO 1:	Gain skills in dairy product development and hands-on training for the processing of different milk products.
CO 2:	Establish a food industry/start up based on their learning in the subject.
CO 3:	Start providing 3rd party manufacturing to premier dairy-based industries. Work in any dairy based industry.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit	Content	Course Specific Objectives (CSOs)	Lectures Hours	Marks	LOs
UNIT 1 Preparations I	Processing of Flavoured milk Preparation of Dahi Preparation of Ghee Preparation of milk based traditional Indian sweet	**CSO 1.1:** To learn the Processing of Flavoured milk. (A) **CSO 1.2:** To make the student learn how to Prepare Dahi. (A) **CSO 1.3:** To make the student learn how to Prepare Ghee. (A) **CSO 1.4:** To make the student learn the Preparation of milk based traditional Indian sweet. (A)	**8**	**14**	
UNIT 2 Preparations II	Preparation of Ice cream. Preparation of milk based instant mix Preparation of whey based drink	**CSO 2.1:** To learn the preparation of Ice cream. (A) **CSO 2.2:** To learn how milk based instant mix are done.(A) **CSO 2.3:** To learn the Preparation of whey based drink. (A)	**8**	**14**	
UNIT 3 Exercises	Milk based new product development How to plan a startup, budgeting, marketing / case study/ entrepreneur (anyone of the above) Regulations, Licensing and registration of a startup.	**CSO 3.1:** An introduction on the milk based product development. (K) **CSO 3.2:** To learn how to start up own business.(A) **CSO 3.3:** To learn the entrepreneur.(A) **CSO 3.4:** To give an idea on how an individual can get the licensing for making own milk products.(U) **CSO 3.5:** To explain to the	**14**	**22**	

		student on how to get a registration for startup.(U)			

Practicle:

1. Field trip/ Industrial Visit and submit a hardcopy report to the concerned Teacher.

Suggested Readings:

1. De, Sukumar,*Outlines of dairy technology*, Oxford University Press, 2007.
2. B.H. Webb & Alford, *Fundamentals of dairy chemistry*, CBS Publisher, 2005.
3. P.F. Fox, T. Uniacke-Lowe and J.A.O' Mahony (*Dairy Science andTechnology*, Taylor & amp; Francis, 2005.
4. P. Walstra, T.M. Jan,Wouters and J. G. Tom, *Dairy chemistry andBiochemistry*, Springer, 2015.

VI- **SEMESTER**

NAME OF THE PAPER (CODE) : CHEMISTRY AND ITS RELATION TO SOCIETY (CHS-6)

Number of Credit 02

Number of Hours of Lecture 30

COURSE OBJECTIVES (COs)

The following are the course Objectives (Cos) for the paper-**Chemistry and its Relation to Society:**

CO 1:	Increase the literacy of chemistry even in non-science students by learning the heritage of Chemistry
CO 2:	Understand the basic concept, principle and importance ofchemistry in Daily Life.
CO 3:	Realize the importance of chemistry in daily life and futurerequirement.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & title	Unit Contents	Course Specific Objectives (CSOs)	Lectures Hours	Marks	Los
UNIT 1 Chemistry in Heritage	Extraction and uses of metals like iron and stone in ancient times, metals in ornaments, medicines, weapons and chemistry for preservatives, basics of preservation and few examples of preservatives.	**CSO 1.1:** An introduction to how the ancient times extract the metals.(K) **CSO 1.2:** Explain how the metals are used in ornaments, medicines and weapons. (U, A) **CSO 1.3:** To explain how the metal are persevered using the chemical ways. (U,A) **CSO 1.4:** To give the student the basic ideas about preservation. (K) **CSO 1.5:** To give a few example on how the preservations. (U)	**10**	**16**	
UNIT 2 Chemistry in Life	Edible and non- edible molecules, biochemistry of foods and medicine with examples: Aspirin, Paracetamol. Ibuprofen and Penicillin, Cephalosporin, Chemistry for industry: Artificial sweeteners, Soaps and detergents and cosmetics, Polymer and Plastics: Uses and environmental issues.	**CSO 2.1:** An introduction to edible and on- edible molecules. (K) **CSO 2.2:** To explain the biochemistry of foods with example.(U) **CSO 2.3:** To explain the biochemistry of medicine with example. (U) **CSO 2.4:** An introduction to Chemistry of industry.(K) **CSO 2.5:** To make student understand how the artificial sweetener, soap and detergents are made.(U,A) **CSO 2.6:** To make student understand how the cosmetics, Polymer and plastics are manufacture.(U,A) **CSO 2.7:**To make student aware of the issues related to the environment of using artificial	**12**	**20**	

		sweeteners, Soaps and detergents and cosmetics, Polymer and Plastics. (U)			
UNIT 3 Future of chemistry	Basics of green chemistry, Reuse and recycling of by-products, zero waste chemistry and Alternate fuel and energy providing chemicals: biodiesel, natural gas and hydrogen.	**CSO 3.1:** An introduction to green chemistry.(K) **CSO 3.2:**An explanation to the R3. (U) **CSO 3.3:** To make student understand the importance of zero waste. (U) **CSO 3.4:**To make the student understand the importance of using biodiesel, natural gas and hydrogen.(A)	**8**	**14**	

Practicals:

1. Determine the calcium and magnesium contents in water samples using EDTA methods.
2. Determine the organic contents and pH of soil sample.
3. Estimate the food adulterants in edible items
4. Quantify the presence metals by flame test method
5. Demonstrate the conversion of PET into bottle into value added products.
6. Determine the quantitative presence of heavy metals like copper and chromium in natural sample like ore.
7. Demonstrate the exothermic and endothermic reaction in laboratory.
8. Organize a Community Outreach/Extension Activity and submit a hardcopy report to the concerned Teacher.

Suggested Readings:

1. J. D. Lee, *Concise Inorganic Chemistry,* Wiley India Pvt. Ltd., 1991.
2. B. K. Sharma, *Industrial chemistry,* Goel Publishing House, India, 1983.
3. D.Christian, Gary, Dasgupta, K. Purnendu, Schug & A. Kevin, *Analytical chemistry,* Wiley, 2013.
4. V. Subramanian, *A text book of Environmental chemistry,* Wiley, 2011.