COURSES OF STUDIES

FOR

THREE YEAR DEGREE COURSE

IN

SCIENCE HONOURS

DEPARTMENT OF CHEMISTRY

Choice Based Credit System (CBCS)

First & Second Semester Examination – 2023-24

Third & Fourth Semester Examination – 2024-25

Fifth & Sixth Semester Examination – 2025-26

GOVERNMENT AUTONOMOUS COLLEGE,
PHULBANI, KANDHAMAL

DISTRIBUTION OF MARKS

Paper with Practical	
Mid Sem (15 Marks)	
Two questions to be answered carrying 1 mark each	2X1 mark = 2 marks
Two questions to be answered carrying 1.5 marks each	2X1.5 marks = 3 marks
Two questions to be answered carrying 2 marks each	2X2 marks = 4 marks
One question to be answered carrying 6 marks each	1X6 marks = 6 marks
End Sem (60 Marks)	
Eight questions to be answered carrying 1 mark each	8X1 mark = 8 marks
Eight questions to be answered carrying 1.5 marks each	8X1.5 marks = 12 marks
Eight questions to be answered carrying 2 marks each	8X2 marks = 16 marks
Four questions to be answered carrying 6 marks each	4X6 marks = 24 marks

Paper without Practical	
Mid Sem (20 Marks)	
Three questions to be answered carrying 1 mark each	3X1 mark = 3 marks
Two questions to be answered carrying 2 marks each	2X2 marks = 4 marks
Two questions to be answered carrying 3 marks each	2X3 marks = 6 marks
One question to be answered carrying 7 marks each	1X7 marks = 7 marks
End Sem (80 Marks)	
Twelve questions to be answered carrying 1 mark each	12X1 mark = 12 marks
Eight questions to be answered carrying 2 marks each	8X2 marks = 16 marks
Eight questions to be answered carrying 3 marks each	8X3 marks = 24 marks
Four questions to be answered carrying 7 marks each	4X7 marks = 28 marks

SYLLABI FOR CBCS COURSE

Sem	CORE COURESE (14)	Ability Enhancement Compulsory Course (AECC) (2)	Ability Enhancement Elective Course (AEEC) (2) (Skill Based)	Elective: Discipline Specific DSE (4)	Elective: Generic (GE) (4)
I	CORE-I	AECC-I AECC-III(EV-I)			GE-IA
	CORE-II				
II	CORE-III	AECC-II AECC-III(EV-II)			GE-1B
	CORE -IV				
III	CORE-V	AECC-III(EV-III)	SEC-I		GE-2A
	CORE-VI				
	CORE-VII				
IV	CORE-VIII	AECC-III(EV-IV)	SEC-II		GE-2B
	CORE-IX				
	CORE-X				
V	CORE-XI	AECC-III(EV-V)		DSE-I	
	CORE-XII			DSE-II	
VI	CORE-XIII	AECC-III(EV-VI)		DSE-III	
	CORE-XIV			DSE-IV / Project	

YEAR & SEMESTER-WISE PAPERS & CREDITS AT A GLANCE

		Three-Year (6-Semester) CBCS Programme (B.Sc. Hons.) (Chemistry Department)			
Yr.	Sl. No.	**Course Structure**	**Code**	**Credit Points**	**Page No.**
FIRST YEAR		**SEMESTER-I**			
	1	Inorganic Chemistry-I	C-1.1	4+2	2
	2	Physical Chemistry-I	C-1.2	4+2	4
	3	Atomic Structure, Bonding, General Organic Chemistry & AliphaticHydrocarbons	GE-1.3	4+2	6
	4				
	5	Ethics & Values (Unit-I)	AECC-1.5	1	9
		SEMESTER-II			
	6	Organic Chemistry-I	C-2.1	4+2	10
	7	Physical Chemistry-II	C-2.2	4+2	12
	8	Atomic Structure, Bonding, General Organic Chemistry & AliphaticHydrocarbons	GE-2.3	4+2	14
	9	Environmental Studies & Disaster Management (For Arts)	AECC-2.4	4	17
	10	Ethics & Values (Unit-II)	AECC-2.5	1	19
SECOND YEAR		**SEMESTER-III**			
	11	Inorganic Chemistry-II	C-3.1	4+2	20
	12	Organic Chemistry-II	C-3.2	4+2	21
	13	Physical Chemistry-III	C-3.3	4+2	24
	14	Chemical Energetics, Equilibria & Functional Organic Chemistry	GE-3.4	4+2	26
	15				
	16	Ethics & Values (Unit-III)	AECC-3.6	1	28
		SEMESTER-IV			
	17	Inorganic Chemistry-III	C-4.1	4+2	30
	18	Organic Chemistry-III	C-4.2	4+2	32
	19	Physical Chemistry-IV	C-4.3	4+2	33
	20	Chemical Energetics, Equilibria & Functional Organic Chemistry	GE-4.4	4+2	35
	21				
	22	Ethics & Values (Unit-IV)	AECC-4.6	1	38
FINAL YEAR		**SEMESTER-V**			
	23	Organic Chemistry-IV	C-5.1	4+2	39
	24	Physical Chemistry-V	C-5.2	4+2	41
	25	Polymer Chemistry	DSE-5.3	4+2	43
	26	Industrial Chemicals and Environment	DSE-5.4	4+2	45
	27	Ethics & Values (Unit-V)	AECC-5.5	1	
		SEMESTER-VI			
	28	Inorganic Chemistry-IV	C-6.1	4+2	47
	29	Organic Chemistry-V	C-6.2	4+2	49
	30	Inorganic Materials of Industrial Importance	DSE-6.3	4+2	51
	31	Green Chemistry	DSE-6.4	4+2	53
	32	Analytical Methods in Chemistry	DSE-6.5	4+2	55
	33	Novel Inorganic Solids	DSE-6.6	4+2	58
	34	Dissertation/Project Work	DSE-6.7	6	59
	32	Ethics & Values (Unit-VI)	AECC-6.5	1	60

Notes:

- C- Core Course
- GE- Generic Elective Course
- DSE- Discipline Specific Elective Course
- AECC- Ability Enhancement Compulsory Course
- SECC- Skill Enhancement Compulsory Course (Skill Based)

For a 6-credit course, the total teaching hours are: Minimum- 50 Hours, Maximum-65 Hours

Programme Outcome (PO)

Under-Graduate Programme in Science (B.Sc.)

Over the past decades the higher education system of our country has undergone substantial structural and functional changes resulting in both quantitative and qualitative development of the beneficiaries. Such changes have gained momentum with the introduction of Choice Based Credit System (CBCS) which further expects learning outcome-based curriculum in order to maximize the benefits of the newly designed curriculum. The learning outcome-based curriculum in general and in Chemistry in particular will help the teachers of the discipline to visualize the curriculum more specifically in terms of the learning outcomes expected from the students at the end of the instructional process. It is pertinent to mention here that the purpose of education is to develop an integrated personality of the individual and the educational system provides all knowledge and skills to the learner for this. The Learning outcome-based curriculum framework (LOCF) has been prepared to support designing uniform, advanced and effective Chemistry curriculum for undergraduate studies in Chemistry. The recommendations related to curriculum development is applicable for college/university education system which includes heads of schools/departments, practicing teachers, parents, employers, academics from tertiary institutions, professionals from related fields or related bodies and representatives from university/college examinations authorities. The LOCF guides are based on the consultation documents on curriculum framework of University Grants Commission and MOOCs. The concerns, needs and interests of students, teachers as well as societal expectations have been taken into consideration while developing this framework structure. Each subject content aims to present a curriculum framework, specifying the curriculum aims, learning targets and objectives, and thus providing suggestions regarding curriculum planning, learning and teaching strategies, assessment and resources. In addition, the curriculum framework also provides examples of effective learning, teaching and assessment practices. A coherent understanding of the whole-undergraduate chemistry (major and pass) curriculum planning and the planning of student learning ability at subject levels can be established. Curriculum development is a collaborative and an on-going enhancement process; therefore, the same shall be updated and improved from time to time to meet new needs of students, teachers, and society at large.

The template as developed has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards core courses, discipline specific courses, generic elective courses, ability enhancement courses and skill enhancement courses with special focus on technical, communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills. The template of learning outcome-based curriculum has categorically mentioned very well-defined expected outcomes for the programme like core competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness and so on along with very specific learning course outcomes at the starting of each course. Therefore, this template on Learning Outcomes based Curriculum Framework (LOCF) for B.Sc. with Chemistry/Chemistry Honours will be a landmark in the field of outcome-based curriculum construction.

Introduction Academics and research in India is a priority which depends upon the quality of education. Quality higher education includes innovations that can be useful for efficient governance of higher education institutions, systems and society at large. Thus, fundamental approach to learning outcome-based curriculum framework emphasizes upon demonstration of understanding, knowledge, skills, attitudes and values in particular programme of study. The LOCF based programme intended tofollow flexibility and innovation in design of the programme, its assessment, and expect graduate attributes demonstrating the level of learning outcome. It is further expected to provide effective teaching — learning strategies including periodic review of the programme and its academic standard. The learning outcome-based curriculum framework for B.Sc. degree in Chemistry is intended to provide a broad framework and hence designed to

address the needs of the students with chemistry as the core subject of study. The framework is expected to assist in the maintenance of the standard of chemistry degrees/programmes across the country and periodic programme review within a broad framework of agreed/expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The framework is intended to allow flexibility and innovation in programme design, syllabi development, teaching-learning process and quality assessment of students learning levels. This curriculum framework for the bachelor-level program in Chemistry is developed keeping in view of the student centric learning pedagogy, which is entirely outcome-oriented and curiosity-driven. To avoid rote-learning approach and foster

imagination, the curriculum is more leaned towards self-discovery of concepts. The curriculum framework focuses on pragmatist approach whereby practical application of theoretical concepts is taught with substantial coverage of practical and field works. The platform aims at equipping the graduates with necessary skills for Chemistry-related careers, careers with general graduate-level aptitude and for higher education in Chemistry and allied subjects. Augmented in this framework are graduate attributes including critical thinking, basic psychology, scientific reasoning, moral ethical reasoningand so on, qualification descriptors that are specific outcomes pertinent to the discipline of chemistry, learning outcomes for the two programmes these frameworks have been developed, learning outcomes for individual courses, pedagogical methods and assessment methods. While designing these frameworks, emphasis is given on the objectively measurable teaching-learning outcomes to ensure employability of the graduates. In line with recent trends in education section, these frameworks foster implementation of modern pedagogical tools and concepts such as flip-class, hybrid learning, MOOCs and other e-learning platforms. In addition, the framework pragmatic to the core; it is designed such a way to enable the learners implementing the concepts to address the real-world problems. A major emphasis of these frameworks is that the curriculum focuses on issues pertinent to India and of the west; for example, green chemistry and biomaterials etc. Above all, these frameworks are holistic and aim to mould responsible Indian citizen to have reflective thinking, scientific temper, and digital literacy in order to acquire requisite skill to be self-employed entrepreneurial.

Aims:

- To transform curriculum into outcome-oriented scenario.
- To develop the curriculum for fostering discovery-learning.
- To equip the students in solving the practical problems pertinent to India.
- To adopt recent pedagogical trends in education including e-learning,flipped class, hybrid learning and MOOCs.
- To mould responsible citizen for nation-building and transforming thecountry towards the future.

Programme Specific Outcomes (PSO) of

Bachelor's Degree Programme in Chemistry.

The broad aims of bachelors degree programme in Chemistry are:

I. Broad and balance knowledge in chemistry in addition to understanding of key chemical concepts, principles, and theories.

II. To develop students' ability and skill to acquire expertise over solving boththeoretical and applied chemistry problems.

III. To provide knowledge and skill to the students' thus enabling them to undertake further studies in chemistry in related areas or multidisciplinary areas that can be helpful for self-employment/entrepreneurship.

IV. To provide an environment that ensures cognitive development of students in a holistic manner. A complete dialogue about chemistry, chemical equations and its significance is fostered in this framework, rather than mere theoretical aspects

V. To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A chemistry graduate as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

VI. To mould a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.

VII. To enable the graduate, prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination.

SEMESTER-I

C-1.1: INORGANIC CHEMISTRY-I

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To study different models of atom and to understand quantum mechanical approach to atom.
- To understand periodic properties of elements with reference to modern periodic table.
- To explain different types of bond formation (ionic and covalent). To predict geometry of covalent molecule based on hybridisation and VSEPR theory.
- To understand the nature of bonding in metals
- To develop skills in titration and theory behind Acid-Base and Redox titration.

THEORY

UNIT		HOURS REQUIRED
I	**Atomic structure** Bohr's theory, its limitations and atomic spectrum of hydrogen atom, Sommerfeld's modification. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle, Schrodinger's wave equation (time independent) and its significance, Derivation of Schrodinger's wave equation (for hydrogen atom) in Cartesian coordinate, significance of ψ and ψ^2. Normalized and orthogonal wave functions. Sign of wave functions; Setting of Schrodinger's equation in polar coordinates (derivation not required), radial and angular wave functions for hydrogen atom. Radial and angular distribution curves; Shapes of s, p, d and f orbitals; Quantum numbers and their significance. Pauli's Exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations.	**15**
II	**Periodicity of elements** Periodicity of Elements: s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-blocks. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling's/ Mulliken's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization. Sanderson's electron density ratio.	**15**
III	**Chemical bonding-I** Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Lande equation with derivation. Madelung constant, Solvation energy. (ii) Covalent bond: Valence Bond theory (Heitler-London approach). Hybridization with	**15**

	suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements, equivalent and non-equivalent hybrid orbitals. VSEPR theory, shapes of simple molecules and ions containing lone and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.	
IV	**Chemical bonding-II** Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions (CO^+, NO^+, NO^-). LCAO MO treatment of H^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Localized and non-localized molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. *Metallic Bond*: Qualitative idea of valence bond and band theories. Semiconductors and insulators. (ii) Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process. **Oxidation-reduction**: Redox equations, standard electrode potential and its applications to inorganic reactions. Principles involved in some volumetric analyses (iron and copper).	**15**

Recommended Textbooks:

1. Lee J. D., Concise Inorganic Chemistry Wiley India, 5th Edn., 2008.
2. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017
4. Malik, Tuli, Madan Selected Topic in Inorganic Chemistry, S. Chand, New Delhi, 17th Ed., 2010.

Reference Books:

- Das Asim K., Fundamentals of Inorganic Chemistry, Vol. I, CBS Publications, 2nd Ed. 2010.
- Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.

PRACTICAL

Students are required to learn the followings:

i. Calibration and use of apparatus

ii. Preparation of solutions of different Molarity/Normality of titrants.

Sl. No.	Name of the Experiment
1	*Acid-Base Titrations* i. Estimation of carbonate and hydroxide present together in mixture. ii. Estimation of carbonate and bicarbonate present together in a mixture. iii. Estimation of free alkali present in different soaps/detergents

2	*Oxidation-Reduction Titrimetry* i. Standardization of $KMnO_4$ with standard sodium oxalate and estimation of Fe (II) using standardized $KMnO_4$ solution. ii. Estimation of percentage of oxalic acid and sodium oxalate in a given mixture. iii. Estimation of Fe (II) and Fe (III) in a mixture by standard $K_2Cr_2O_7$ solution.

Reference text Books:

- J. Mendham, A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- Gulati Shikha, Sharma Gulati JL and Manocha, Shagun, Practical Inorganic Chemistry, 1st Edn., CBS Publishers & Distributors Pvt Ltd., (2017).

C-1.2: PHYSICAL CHEMISTRY- I

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To understand the properties of gaseous state and liquid state of matter on the basis of Kinetic Theory and to study structure of different types of solid.
- To study ionic equilibrium with reference to salt hydrolysis, buffer solution andtheories of acid and base, and theories of indicator.
- To develop skills for determination of viscosity and surface tension of liquid by using simple equipment.

THEORY

UNIT		HOURS REQUIRED
I	**Gaseous state-I** Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waal's equation of state, its derivation and application in explaining real gas behaviour. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.	**17**
II	**Liquid state** Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and	**15**

	their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water. **Ionic equilibria- I** Strong, moderate and weak electrolytes, 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; dissociation constants of mono- and diprotic acids.	
III	**Solid state** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analyses of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals (stoichiometric and non- stoichiometric). Glasses and liquid crystals.	**13**
IV	**Ionic equilibria - II** Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts –applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants	**15**

Recommended Textbooks:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn. 2017.
3. Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017
4. Castellan G. W. Physical Chemistry 4th Edn. Narosa (2004).

Reference Books:

- Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications
- Mortimer R. G., Physical Chemistry, Elsevier (Academic Press), 3rd Ed (2008).
- Ball D. W. Physical Chemistry Thomson Press, India (2007).
- Engel T. & Reid P., Physical Chemistry, 3rd Ed. Pearson (2013)

PRACTICAL

Sl. No.	Name of the Experiment
1	*Surface tension measurements.* 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.
2	*Viscosity measurement using Ostwald's viscometer.*

	a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature. b. Study the variation of viscosity of sucrose solution with the concentration of solute.
3	*pH- metry* a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. b. Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii) Ammonium chloride- ammonium hydroxide. c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base. d. Determination of dissociation constant of a weak acid.
4	*Ionic equilibria* a. Determination of solubility product of PbI_2 by titrimetric method.

Reference Books:

- Khosla, B. D. Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
- Garland, C. W., Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed.; McGraw-Hill, New York (2003).
- Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry, Viva Books (2009).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co., New York (2003).

GE-1.3: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To understand the concept of atomic structure, chemical bonding, and to get a preliminary idea about fundamentals of organic chemistry and aliphatic hydrocarbons.
- To develop skills in volumetric analysis and organic chemistry particularly in the field of chromatography by using suitable equipment.

THEORY

UNIT		HOURS REQUIRED
SECTION A: INORGANIC CHEMISTRY-I		
I	**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. Quantum mechanics: Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrodinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals	**15**

	(Only graphical representation). Quantum numbers and their significance, shapes of s, p and d atomic orbitals, nodal planes. 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 orbital, Anomalous electronic configurations.	
II	**Chemical Bonding and Molecular Structure** Ionic Bonding: General characteristics, energy considerations. Lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Lande equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules and its applications. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal 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 (N_2, O_2) and heteronuclear diatomic molecules (CO, NO). Comparison of VB and MO approaches.	**15**
	SECTION B: ORGANIC CHEMISTRY-I	
III	**Fundamentals of Organic Chemistry** Physical Effects, Electronic Displacements: Inductive effect, Electrometric effect, Resonance and 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 affecting pK values. Aromaticity: Huckel's rule. *Stereochemistry* Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (up to two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). D and L; cis-trans nomenclature; CIP Rules: R / S (for one chiral carbon atoms) and E / Z Nomenclature (for up to two C=C systems).	**15**
IV	**Aliphatic Hydrocarbons** Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. *Alkanes*: (Up to 5 Carbons) Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.	**15**

	Alkenes: (Up to 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis-alkenes (Partial catalytic hydrogenation) and trans-alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis. *Alkynes:* (Up to 5 Carbons) Preparation: Acetylene from CaC_2 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.	

Recommended Textbooks:

1. Lee J. D., Concise Inorganic Chemistry, Wiley India, 5th Edn., 2008.
2. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd Ed., 2017.
3. Shriver D. E., Atkins P. W., Inorganic Chemistry, Oxford University Press, 5th Edn.
4. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
5. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Bhal Arun & Bhal B S., Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.
7. Kalsi, P. S. Stereochemistry Conformation and Mechanism; 8th Edn, New Age International, 2015.

Reference Books:

- Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
- Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.
- Mallick, Madan and Tuli, S. Chand Selected Topic in Inorganic Chemistry, 17th Edn. 2010.
- Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications.

PRACTICAL

Sl. No.	Name of the Experiment
	SECTION A: INORGANIC CHEMISTRY
1	Volumetric Analysis a. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. b. Estimation of oxalic acid by titrating it with $KMnO_4$. c. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$. d. Estimation of Fe(II) ions by titrating it with $K2Cr_2O_7$ using internal indicator. e. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.
	SECTION B: ORGANIC CHEMISTRY
1	a. Detection of extra elements (N, S, Cl) in organic compounds (containing up to two extra elements) b. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given) i. Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography. ii. Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).

AECC-1.5 (EV-I): ETHICS & VALUES

Full Marks – 25	Credits: 1	End Sem Theory – 25/1 hr.	Hours Required: 15

Course Outcome

- To acquire the ideas of ethics and values in relation to women and family, women and work and women, community and society for maintaining a healthy societal balance.

UNIT-I: Issues Relating to Women

UNIT		HOURS REQUIRED
I	**Introduction:** General introduction on Ethics and Values, Gender equality as an essential precursor to social progress, the present scenario, Desirable gender related values	3
II	**Women and Family:** Pre-natal sex selection, Gendered practices in the family, Gender based division of labour in the family, Marriage and women, Marriage and women's consent, Child marriage, Practice of dowry, Women and family violence	4
III	**Women and Work:** Women's work: The Invisible hands, Exploitation of women at work, Gender Stereotyping at work, Glass Ceiling, Women and pay gap, Sexual Harassment of women at work, Working women and role conflict	4
IV	**Women, Community and Society:** Violence against women in public spaces, Gender sensitive language and communication, Gendered language, Sexist Language, Gender neutral language, Women and property Rights, Women's property Rights in Indian Laws, The functionality of Women's Property Rights	4

SEMESTER-II

C-2.1: ORGANIC CHEMISTRY-I

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To understand the basics of organic chemistry and stereochemistry withreference to conformational and configurational isomerism.
- To understand the chemistry (preparation and properties) of alkanes, alkenes, alkynes, and cycloalkanes.
- To understand aromaticity and peculiar aromatic compounds.
- To develop the skills required for separation and purification of compounds.

THEORY

UNIT		HOURS REQUIRED
I	**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; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. Carbon-carbon sigma bonds Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.	**15**
II	**Stereochemistry** Fischer Projection, Newmann and Sawhorse Projection formulae; Geometrical isomerism: cis–trans and, syn-anti isomerism, E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with one and two chiral-centers, Distereoisomers, meso-structures, Racemic mixture and resolution, inversion. Relative and absolute configuration: D/L and R/S designations.	**15**
III	**Chemistry of aliphatic hydrocarbons Carbon-Carbon pi bonds:** Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration- demercuration, hydroboration oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2- and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Reactions of alkynes: Acidity,	**20**

	Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. Cycloalkanes and Conformational Analysis Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of alkanes (ethane and n-butane): Relative stability with energy diagrams. Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.	
IV	**Aromatic hydrocarbons** Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/ carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups	**10**

Recommended Textbooks:

1. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Bhal and Bhal, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.
3. Kalsi, P. S., Stereochemistry Conformation and Mechanism; 8th Edn., New Age International, 2015.

Reference Books:

- Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013)
- Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.

Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

PRACTICAL

Sl. No.	Name of the Experiment
Students are required to learn the followings: ➢ Checking the calibration of the thermometer ➢ Determination of melting point, effect of impurities on the melting point – mixed melting point of two unknown organic compounds ➢ Determination of boiling point of liquid compounds [boiling point lower than and more than 100°C (up to 160°C) by distillation and capillary method respectively] (e.g., ethanol, cyclohexane, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide etc.).	
1	Functional group tests for alcohols, phenols, carbonyl and carboxylic acid groups and identification of unknown organic compounds of CHO system (without element detection).
2	Separation and purification of any one component of following binary solid mixture based on the solubility in common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, etc. and determination of melting point. Benzoic acid/p-Toluidine; p-Nitrobenzoic acid/p-Aminobenzoic acid; p-Nitrotolune/p-Anisidine etc.
3	Chromatography a. Separation of a mixture of two amino acids by ascending and horizontal paper

	chromatography b. Separation of a mixture of two sugars by ascending paper chromatography c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Reference Books:

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

C-2.2: PHYSICAL CHEMISTRY II

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To understand the concepts of thermodynamics with reference to Enthalpy,Entropy, Free energy, Chemical potential.
- To understand the concept of chemical equilibrium and it`s conditions andcharacteristics.
- To understand the theories relating to dilute solution and colligative properties.
- To develop skills for use of equipment like pH meter and conductivity meter andto perform thermal experiments using calorimeter

THEORY

UNIT		HOURS REQUIRED
I	**Chemical thermodynamics** Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat(q), work(w), internal energy(U) and statement of first law; enthalpy(H), relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.	**16**
II	Carnot cycle, efficiency of heat engine, Carnot theorem Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters, inversion	**14**

	temperature, Gibbs-Helmholtz equation, Maxwell relations, thermodynamic equation of state	
III	**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 in mixing of ideal gases. *Chemical equilibrium* Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient (Vant Hoff's reaction). Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment) and its applications.	**17**
IV	**Solutions and Colligative Properties** Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.	**13**

Recommended Textbooks:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
3. K. L. Kapoor, Text Book of Physical Chemistry, Mac Grow Hill, 3rd Edn. 2017
4. Castellan G. W. Physical Chemistry 4th Ed. Narosa (2004).

Reference Books:

- Engel T. & Reid P., Physical Chemistry 3rd Ed. Pearson (2013).
- McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
- Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.

PRACTICAL

Sl. No.	Name of the Experiment
	THERMOCHEMISTRY
1.	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 or enthalpy of neutralization).
2.	Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3.	Calculation of the enthalpy of ionization of ethanoic acid.
4.	Determination of heat capacity of the calorimeter and integral enthalpy (endothermic

	and exothermic) solution of salts.
5.	Determination of basicity/ proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6.	Determination of enthalpy of hydration of copper sulphate.
7.	Determination of heat of solution (ΔH) of oxalic acid/benzoic acid from solubility measurement.
8.	Kinetics of pseudo-unimolecular reaction to determine the pseudo first order hydrolysis rate constant of Methyl acetate at room temperature in 0.5N H2S4 & 0.5N HCl media.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, New Age International: New Delhi (2001).
- Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry, Viva Books (2009)

GE-2.3: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To understand the concept of atomic structure, chemical bonding, and to get a preliminary ide about fundamentals of organic chemistry and aliphatic hydrocarbons.
- To develop skills in volumetric analysis and organic chemistry particularly in the field of chromatography by using suitable equipment.

THEORY

UNIT		HOURS REQUIRED
	SECTION A: INORGANIC CHEMISTRY-I	
I	**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. Quantum mechanics: Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ2, Schrodinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Quantum numbers and their significance,	**15**

	shapes of s, p and d atomic orbitals, nodal planes. 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 orbital, Anomalous electronic configurations.	
II	**Chemical Bonding and Molecular Structure** Ionic Bonding: General characteristics, energy considerations. Lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Lande equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules and its applications. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal 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 (N2, O2) and heteronuclear diatomic molecules (CO, NO). Comparison of VB and MO approaches.	**15**
	ORGANIC CHEMISTRY-I	
III	**Fundamentals of Organic Chemistry** Physical Effects, Electronic Displacements: Inductive effect, Electrometric effect, Resonance and 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 affecting pK values. Aromaticity: Huckel's rule. *Stereochemistry* Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (up to two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). D and L; cis-trans nomenclature; CIP Rules: R / S (for one chiral carbon atoms) and E / Z Nomenclature (for up to two C=C systems).	**15**
IV	**Aliphatic Hydrocarbons** Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. *Alkanes:* (Up to 5 Carbons) Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation. *Alkenes:* (Up to 5 Carbons) Preparation: Elimination reactions:	**15**

	Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis-alkenes (Partial catalytic hydrogenation) and trans-alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis. *Alkynes:* (Up to 5 Carbons) Preparation: Acetylene from CaC_2 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.	

Recommended Textbooks:

1. Lee J. D., Concise Inorganic Chemistry, Wiley India, 5th Edn., 2008.
2. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd Edn., 2017.
3. Shriver D. E., Atkins P. W., Inorganic Chemistry, Oxford University Press, 5th Edn.
4. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
5. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Bhal Arun & Bhal B S., Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.
7. Kalsi, P. S. Stereochemistry Conformation and Mechanism; 8th Edn, New Age International, 2015.

Reference Books:

- Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
- Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.
- Mallick, Madan and Tuli, S. Chand Selected Topic in Inorganic Chemistry, 17th Edn. 2010.
- Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications.

PRACTICAL

Sl. No.	Name of the Experiment
	SECTION A: INORGANIC CHEMISTRY
1	Volumetric Analysis a. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. b. Estimation of oxalic acid by titrating it with KMnO4. c. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4. d. Estimation of Fe(II) ions by titrating it with K2Cr2O7 using internal indicator. e. Estimation of Cu(II) ions iodometrically using Na2S2O3.
	SECTION B: ORGANIC CHEMISTRY
1	a. Detection of extra elements (N, S, Cl) in organic compounds (containing up to two extra elements)
2	b. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given) i. Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography. ii. Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education 2009.
- Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press 2005.

AECC-2.4: ENVIRONMENTAL STUDIES & DISASTER MANAGEMENT (FOR ARTS STREAM)

Full Marks – 100	Mid Sem – 20/1hr	End Sem Theory – 80/3 hrs.	Hours Required: 60
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes:

- To educate the students about the importance of the environment
- To aware the situations leading to climate change and the sustainable development
- To educate the students about ways and steps of disaster management
- To give a brief idea on epidemics and pandemics

UNIT		HOURS REQUIRED
I	**Environment** The Environment: The Atmosphere, Lithosphere, Hydrosphere, Biosphere Ecosystem: Energy flow in the ecosystem Biogeochemical Cycle: Water Cycle, Carbon Cycle, Nitrogen Cycle Pollution: Water Pollution, Air Pollution, Soil Pollution, Radiation Pollution, Industrial Pollution, Light Pollution, Sound Pollution Environmental Laws: Water Act 1974, Air Act 1981, The Wildlife Protection Act 1972, The Environment Protection Act 1986, The Forest Conservation Act 1980	**15**
II	**Climate Change & Sustainable Development** Population Ecology: Individuals, Species, Population, Community Human Population Growth, Population Control Methods Urbanization and its effects on Society Climate Change: Causes, effect, Global Warming, Carbon footprint and environmental protection Steps taken towards sustainable development: Ban of single-use plastics, Automobile Scrapping Policy, Promotion of Electrical Vehicles Brief idea on Sustainable Development: Goals (SDGs), Agenda 21 of Rio Earth Summit	**15**
III	**Disaster Management** Disaster Management: Types of disasters (Natural and Man-made) and their causes and effect Vulnerability Assessment and Risk Analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves and Lightning) Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), District Disaster Management	**15**

	Authority (DDMA), National Disaster Response Force (NDRF) and Odisha Disaster Rapid Action Force (ODRAF) Preparedness Measures: Disaster Management Cycle, Early warning System, Pre-Disaster and Post-Disaster Preparedness, Strengthening of SDMA and DDMA, Community Preparedness, Stakeholder participation, Corporate Social Responsibility (CSR) Survival Skills: Survival Skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone, Lightening)	
IV	**Brief idea on Epidemics and Pandemics** Non-communicable diseases with special reference to Cardiovascular diseases, Cancer, Diabetes, Hypertension and Obesity and their prevention Communicable diseases with special reference to Covid-19, Flu, Hepatitis, AIDS and Tuberculosis and their transmission Dynamics of Disease Transmission: Mode of transmission (Direct/Indirect), Events after infection: Immunity (Active vrs Passive, Innate vrs Acquired, Herd Immunity), Incubation Period Prevention of Epidemics/Pandemics Diseases: Preventing Measures (Quarantine, Sanitization, Personal Protective measures such as hand washing and use of protective devices, Vaccination); Control Measures (Surveillance, Isolation, Contact Tracing) Life Style management: Diet, Physical Exercise, Yoga and sleeping habit Role of Different Sectors in Managing Health Disaster: Role of Government (Centre and State), Community, Civil Society, Student mass, NGOs	**15**

Books Recommended:

1. Asthana DK and Asthana M: A Text Book of Environmental Studies, S. Chand, New Delhi.
2. Bharucha E: A Text Book of Environmental Studies, New Delhi, UGC.
3. Dash MC and Mishra PC: Man and Environment, McMillan, London.
4. Disaster Management and Mitigation Plan, 2013 of Dept. of Health & Family Welfare, Govt. of Odisha*
5. Mishra DD: Fundamental Concept in Environmental Studies, S. Chand, New Delhi.
6. National Policy on Disaster Management, 2009*
7. National Disaster Management Plan, 2019*
8. Odeem EP, Fundamentals of Ecology, Natraj Publications.
9. State Disaster Management Plan, 2019 of Government of Odisha*
10. Standard Operating Procedure (SOP) issued by Govt. of India and Govt. of Odisha on Public Health Managements in the websites www.mohfw.gov.in and health.odisha.gov.in*
11. The Disaster Management Act. 2005 of Government of India*

[Note: Star (*) marked Reference, published by the State as well as Central Government are available in the open sources]

AECC-2.5 (EV-II): ETHICS & VALUES

Full Marks – 25	Credits: 1	End Sem Theory – 25/ hrs.	Hours Required: 15

Course Outcome

- To understand the vivid idea about Indian Constitution, Patriotism, Voluntarism and Work Ethics.

UNIT-II: Values and Good Citizenship

UNIT		HOURS REQUIRED
I	**Indian Constitution:** Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity	**3**
II	**Patriotism:** Patriotic value and ingredients of nation building, Concept of Good citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens	**4**
III	**Volunteerism:** Concept of facets of Volunteerism and Leadership, building a better society through Volunteerism, Blood Donation, Social Work, Helping the Aged, Environmental Protection	**4**
IV	**Work Ethics:** Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper	**4**

SEMESTER-III

C-3.1: INORGANIC CHEMISTRY-II

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To understand the general principles of metallurgy and theories of acid and base.
- To understand chemistry of s and p block elements including noble gases.
- To understand preparation and properties and uses of inorganic polymers.
- To develop skills for preparation of inorganic compounds and their characterization.
- To understand the skills of iodometric/iodimetric titrations

THEORY

UNIT		HOURS REQUIRED
I	**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. Methods of purification of metals: Electrolytic process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining. **Acids and Bases** Bronsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) application of HSAB principle.	**20**
II	**Chemistry of s and p Block Elements – I** General characteristics and chemistry of s- and p-block elements. Hydrides, halides, and oxides of nitrogen, phosphorous, oxygen, sulphur and halogen	**15**
III	**Chemistry of s and p Block Elements - II** Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes. Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens. **Inorganic Polymers**: Structural aspects and applications of silicones, borazines, silicates and phosphazenes.	**15**
IV	**Noble Gases** Occurrence and uses, rationalization of inertness of noble gases, clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for	**10**

	XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).	

Recommended Textbooks:

1. Lee J. D., Concise Inorganic Chemistry Wiley India, 5th Edn., 2008.
2. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd Ed., 2017.
4. Shriver D. E., Atkins P. W., Inorganic Chemistry, Oxford University Press, 5th Edn.(2010).

Reference Books:

- Das Asim K., Fundamentals of Inorganic Chemistry, Vol. I, CBS Publications, 2nd Ed. 2010.
- Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.

PRACTICAL

Sl. No.	Name of the Experiment
Iodometric / Iodimetric titrations	
1.	Standardization of sodium thiosulphate solution by standard of K2Cr2O7 solution. (ii) Estimation of Cu(II) using standard sodium thiosulphate solution (Iodimetrically).
2.	Estimation of available chlorine in bleaching powder iodometrically.
Inorganic preparations	
1.	Cuprous oxide (Cu_2O)
2.	Cuprous chloride (Cu_2Cl_2)
3.	Manganese(III) phosphate($MnPO_4 \cdot H_2O$)
4.	Aluminium potassium sulphate ($K_2SO_4 \cdot Al_2(SO_4)_2 \cdot 24H_2O$ - Potash alum).
5.	Lead chromate ($PbCrO_4$)

Reference Books:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson, 2009.
- Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).
- Gulati Shikha, Sharma Gulati JL and Manocha, Shagun, Practical Inorganic Chemistry, 1st Edn., CBS Publishers & Distributors Pvt. Ltd., (2017).

C-3.2: ORGANIC CHEMISTRY-II

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

- To understand preparation and properties of organic compounds like Alcohols,Phenols, Ethers, Epoxies, Aldehydes, Ketones and Carboxylic acids.
- To understand the preparation properties and synthetic application of active methylene compounds.
- To understand the chemistry Sulphur containing organic compounds.
- To develop the skills for preparation of different organic molecules and their characterization.

THEORY

UNIT		HOURS REQUIRED
I	**Chemistry of Halogenated Hydrocarbons** Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic substitution; S_NAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.	**15**
II	**Alcohols, Phenols, Ethers and Epoxides** **Alcohols**: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement; **Phenols:** Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism; **Ethers and Epoxides**: Preparation and reactions with acids. Reactions of epoxides with alcohols, Ammonia derivatives and $LiAlH_4$.	**15**
III	**Carbonyl Compounds** Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann rearrangements, α halo form reaction and Baeyer Villiger oxidation, -substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV.; Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	**15**
IV	**Carboxylic Acids and their Derivatives** Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic, lactic, tartaric, citric, and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement. Sulphur containing compounds: Preparation and reactions of thiols and thioethers.	**15**

Recommended Textbooks:

1. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson

Education).
2. Bhal and Bhal, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.
3. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson, 2009.

Reference Books:

- Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013)
- Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.
- Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

PRACTICAL

Sl. No.	Name of the Experiment
	Organic Preparations
1.	Acetylation of one of the following compounds: amines (aniline, o-, m-, ptoluidines and o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: a. Using conventional method. b. Using green approach
2.	Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
3.	Bromination of any one of the following: a. Acetanilide by conventional methods b. Acetanilide using green approach (Bromate-bromide method)
4.	Nitration of any one of the following: a. Acetanilide/nitrobenzene by conventional method b. Salicylic acid by green approach (using ceric ammonium nitrate).
The above derivatives should be prepared using 0.5-1g of the organic compound. Calculate percentage yield, based upon isolated yield (crude) and theoretical yield. Purification of the crude product by recrystallisation from water/alcohol, or sublimation, whichever is applicable and determination of melting point.	

Reference Books:

- Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, Pearson (2011)
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

C-3.3: PHYSICAL CHEMISTRY-III

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome

- To understand concepts like phase, component, degrees of freedom and phaserule. Application of phase rule to different types of system.
- To understand Nernst distribution law and it`s applications.
- To understand speed of reaction and factors influencing speed of reaction andmechanism of reaction with reference to catalysis.
- To understand theories of reaction rate.
- To develop the skills to study kinetics of first order reaction and determination ofpartition coefficient.

THEORY

UNIT		HOURS REQUIRED
I	**Phase Equilibria-I** Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive 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 (H_2O and sulphur system). Phase diagrams for systems of solid-liquid equilibria involving eutectic (Pb-Ag system, desilverisation of lead), congruent (ferric chloride-water) and incongruent (sodium sulphate water) melting points, completely miscible solid solutions (intermediate, medium, maximum freezing points).	**20**
II	**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 non-ideal), azeotropes, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.	**10**
III	**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 orders. Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions (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. Collision theory of reaction rates, qualitative treatment of the theory of absolute reaction rates.	**20**

IV	**Catalysis** Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis. Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms (Langmuir, Freundlich and Gibb's isotherms), nature of adsorbed state.	**10**

Recommended Textbooks:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
3. Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017
4. Castellan G. W. Physical Chemistry 4th Edn. Narosa (2004).

Reference Books:

- Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Ball D. W. Physical Chemistry Thomson Press, India (2007).
- Engel T. & Reid P., Physical Chemistry 3rd Ed. Pearson (2013)

PRACTICAL

Sl. No.	Name of the Experiment
1	Determination of distribution coefficients of: (a) Iodine between water and carbon tetrachloride. (b) Acetic/ benzoic acid between water and cyclohexane.
2	Study the equilibrium of at least one of the following reactions by the distribution method: • $I_{2(aq)} + I^- \rightarrow I_3^-(aq)$ • $Cu^{2+}_{(aq)} + nNH_3 \rightarrow Cu(NH_3)_n$
3	Study the kinetics of the following reactions. (i) Integrated rate method: a) Acid hydrolysis of methyl acetate with hydrochloric acid. b) Saponification of ethyl acetate. (ii) Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.
4	Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

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

GE-3.4: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required:60 (Theory) + 60 (Practical)	

Course Outcome

- To understand the concept of chemical energetic, chemical equilibrium, ionic equilibria, aromatic hydrocarbons, alkyl and aryl halides.
- To understand about alcohols, phenols and ethers.
- To develop the skill for determination of heat capacity of calorimeter for different volumes and for preparation of Buffer solution and measurement of pH of buffer solution by pH meter and comparison of the values with the theoretical values.
- To develop the skill of purification of organic compounds by crystallization and determination of melting point.
- To acquire the skill of preparation, recrystallisation, determination of melting point and calculation of quantitative yield of different compounds namely bromination of phenol/ aniline, benzoylation of phenol/aniline and of oximes.

THEORY

UNIT		HOURS REQUIRED
	SECTION A: PHYSICAL CHEMISTRY-I	
I	**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. 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. **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.	**17**
II	**Ionic Equilibria** Strong, moderate and weak electrolytes, 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. 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.	**13**
	SECTION B: ORGANIC CHEMISTRY-II	
III	Functional group approach for the following reactions (preparations &	**15**

	reactions) to be studied in context to their structure. **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) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene). **Alkyl and Aryl Halides** Alkyl Halides (Up to 5 Carbons) Types of Nucleophilic Substitution (S_N^1, S_N^2 and S_N^i) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).	
IV	**Alcohols, Phenols and Ethers** (Up to 5 Carbons) **Alcohols:** Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes and 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: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. **Phenols:** (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer Tiemann Reaction, Gattermann - Koch Reaction, Ethers (aliphatic and aromatic): Cleavage of ethers with HI. **Aldehydes and ketones** (aliphatic and aromatic): Formaldehyde, 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, Benzoin condensation. Clemensen reduction and Wolff-Kishner reduction.	**15**

Recommended Textbooks:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co, 47th Edn., 2017.
3. K. L. Kapoor, Text Book of Physical Chemistry, Mac Grow Hill, 3rd Edn. 2017.
4. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Arun Bahl & B S Bahl, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.

Reference Books:

- Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.
- Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

PRACTICAL

Sl. No.	Name of the Experiment
	Section A: Physical Chemistry
1	**Thermochemistry** (any three) 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 (KNO3, NH4Cl). 5. Determination of enthalpy of hydration of copper sulphate. 6. Study of the solubility of benzoic acid in water and determination of ΔH.
2	**Ionic equilibria** pH measurements a. 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. b. Preparation of buffer solutions: • Sodium acetate-acetic acid • Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
	Section B: Organic Chemistry
1	Purification of organic compounds by crystallization (from water) and determination of melting.
2	Preparations, recrystallisation, determination of melting point and calculation of quantitative yields of the followings: a. Bromination of Phenol/Aniline b. Benzoylation of amines/phenols c. Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books:

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Khosla, B.D.; Garg, V.C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
- Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).

AECC-3.6 (EV-III): ETHICS & VALUE

Full Marks – 100	Credits: 1	End Sem Theory – 25/1 hr.	Hours Required: 15

Course Outcomes

- To understand and create awareness about the menace of drug and tobacco addiction and alcoholism in India and its impact on socio-economic aspects.

- To understand the laws to address these problems and the role of stakeholders including students for active participation for a tobacco free campus

UNIT-III: Issues of Drug, Tobacco and Alcohol Addiction

UNIT		HOURS REQUIRED
I	**Extent of the Problem:** Extent of Drug and Tobacco addiction and alcoholism in India, Myths associated with them, Health hazards associated with them and how they have become silent killers	**3**
II	**Socio-economic impact:** Socio-economic impact of Drug and Tobacco addiction and alcoholism: Loss of physical and mental strength, Loss of character, Loss of family ties and relationship, Loss of earning and livelihood potentials, Loss of societal respect and dignity etc.	**4**
III	**Laws to Address this Problem:** Silent features of social legislation such as NDPS Act, 1985 and COTPA Act, 2003, Mechanism and Government Schemes for prevention, deaddiction and rehabilitation	**4**
IV	**Role of Stake - holders:** Provision of Tobacco free campus and role of students, Role of students in their family and immediate surroundings, Role of NGOs and other agencies	**4**

SEMESTER-IV

C-4.1: INORGANIC CHEMISTRY-III

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- To understand the properties of transition and inner transition elements.
- To understand nature of bonding in coordinate compounds (VBT and CFT)
- To understand role of metal ions in biological systems Na/K pump and toxicity of metals.
- To develop the skills for preparation and characterization of some complexcompounds.
- To develop the skills of complex- metric titration.

THEORY

UNIT		HOURS REQUIRED
I	**Coordination Chemistry** Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, Labile and inert complexes. Crystal field theory, measurement of CFSE weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq in octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of ligand field and MO Theory.	**20**
II	**Transition Elements-I** 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 and e.m.f. (Latimer & Ebsworth diagrams). Difference between the first, second and third transition series.	**10**
III	**Transition Elements-II** Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy). **Lanthanoids and Actinoids** Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). General features of actinoids, separation of Np, Pm, Am from U.	**13**
IV	**Bioinorganic Chemistry** Metal ions present in biological systems, classification of elements according to their action in biological system. Na/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace	**17**

	metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin and myoglobin.	

Recommended Textbooks:

1. Lee J. D., Concise Inorganic Chemistry, Wiley India, 5th Edn., 2008.
2. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
4. Shriver D. E. Atkins P. W., Inorganic Chemistry, Oxford University Press, 5th Edn.

Reference Books:

- Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
- Bioinorganic Chemistry, Asim Kumar Das, Books & Allied (P) Ltd. 1st Ed. 2015.
- Selected Topic in Inorganic Chemistry, Mallick, Madan and Tuli, S. Chand Publisher. 17th Ed. 2010.
- Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.

PRACTICAL

Sl. No.	Name of the Experiment
	Inorganic preparations
1	**Preparation of complexes:** i. Hexamine nickel(II), $[Ni(NH_3)_6]Cl_2$ ii. Potassium trioxalatoferrate (III) trihydrate iii. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$ iv. Tetraamminecarbonatocobalt (III) nitrate
2	**Complexometric titration** i. Estimation of Ca by EDTA ii. Estimation of Mg by EDTA
3	**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).
	Chromatography of metal ions
4	Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions: i. Ni(II) and Co(II) ii. Fe(III) and Al(III)

Reference Books:

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS (1978).
- Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).
- Gulati Shikha, Sharma Gulati JL and Manocha, Shagun, Practical Inorganic Chemistry, 1st Edn., CBS Publishers & Distributors Pvt Ltd., (2017).

C-4.2: ORGANIC CHEMISTRY-III

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- To understand the chemistry of organic compounds containing Nitrogen such as: amines, diazonium salt.
- To understand the chemistry of poly nuclear hydrocarbons like naphthalene andanthracene.
- To understand the chemistry of Heterocyclic compounds likeFuran , Pyrole &Thiophene.
- To understand the chemistry of and alkaloids and terpinoids.
- To develop the skills to identify unknown organic compound.

THEORY

UNIT		HOURS REQUIRED
I	**Nitrogen Containing Functional Groups** Preparation and important reactions of nitro and compounds, nitriles. **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.	**20**
II	**Diazonium Salts** Preparation and their synthetic applications. Polynuclear Hydrocarbons Reactions of naphthalene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene. Polynuclear hydrocarbons.	**10**
III	**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 (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine. Fischer indole synthesis and Madelung synthesis, Derivatives of furan: Furfural and furoic acid (preparation only).	**15**
IV	**Alkaloids** Natural occurrence, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. **Terpenes** Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α- terpineol.	**15**

Recommended Textbooks:

1. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Advanced Organic Chemistry, 2nd Edition, Arun Bahl & B S Bahl, S. Chand Publisher, 2012.

Reference Books:

- Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013)
- Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.
- Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

PRACTICAL

Sl. No.	Name of the Experiment
	Qualitative organic analysis of organic compounds
1	Detection of extra elements (N, X, S) in organic compounds by Lassaigne's test.
2	Qualitative analysis of unknown organic compounds containing simple functional groups under CHN system (amine, nitro, amide and imide), determination of melting/ boiling point, and preparation of their derivative.

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).
- Ghoshal, A., Mahapatra, B., Nad, A. K. An Advanced Course in Practical Chemistry, New Central Book Agency (2007).

C-4.3: PHYSICAL CHEMISTRY-IV

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- To understand concepts like theories of conductance and principles of electrochemistry.
- To understand, how to determine different physical quantities using conductance measurement methods.
- To understand construction and functioning of different types of electro chemicalcells.
- To develop the skills to work with conductivity meter and potentiometer.

THEORY

UNIT		HOURS REQUIRED
I	**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	**15**

	independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.	
II	**Conductance-II** Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.	**15**
III	**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. Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes.	**15**
IV	**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). Electrical properties of atoms and molecules Basic ideas of electrostatics, Electrostatics of dielectric media. Clausius-Mosotti equation and Lorenz-Laurentz equation (no derivation), Dipole moment and molecular polarizabilities and their measurements.	**15**

Recommended Textbooks:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
3. Kapoor, K. L., Text Book of Physical Chemistry, Mac Grow Hill, 3rd Edn., 2017
4. Castellan G. W. Physical Chemistry 4th Ed. Narosa (2004).

Reference Books:

- Engel T. & Reid P., Physical Chemistry 3rd Ed. Pearson (2013).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
- Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.

PRACTICAL

Sl. No.	Name of the Experiment
	Conductometry
1	Determination of cell constant.
2	Determination of equivalent conductance, degree of dissociation and dissociation

	constant of a weak acid.
3	Perform the following conductometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Strong acid vs. weak base
Potentiometry	
4	Perform the following potentiometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Dibasic acid vs. strong base
5	Determination of distribution coefficient of I_2 between H_2O & CCl_4.

Reference Books:

- Khosla, B. D., Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
- Garland, C. W. Nibler, J. W. & Shoemaker, D. P., Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C., Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co., New York (2003).
- Viswanathan, B., Raghavan, P.S., Practical Physical Chemistry, Viva Books (2009).

GE-4.4: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required:60 (Theory) + 60 (Practical)	

Course Outcomes

- To understand the concept of chemical energetic, chemical equilibrium, ionic equilibria, aromatic hydrocarbons, alkyl and aryl halides.
- To understand about alcohols, phenols and ethers.
- To develop the skill for determination of heat capacity of calorimeter for different volumes and for preparation of Buffer solution and measurement of pH of buffer solution by pH meter and comparison of the values with the theoretical values.
- To develop the skill of purification of organic compounds by crystallization and determination of melting point.
- To acquire the skill of preparation, recrystallisation, determination of melting point and calculation of quantitative yield of different compounds namely bromination of phenol/ aniline, benzoylation of phenol/aniline and of oximes.

THEORY

UNIT		HOURS REQUIRED
SECTION A: PHYSICAL CHEMISTRY-I		
I	**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	**17**

	differential enthalpies of solution and dilution. 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. **Chemical Equilibrium** Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔGo, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.	
II	**Ionic Equilibria** Strong, moderate and weak electrolytes, 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. 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.	**13**
SECTION B: ORGANIC CHEMISTRY-II		
III	Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. **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) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene). **Alkyl and Aryl Halides** Alkyl Halides (Up to 5 Carbons) Types of Nucleophilic Substitution (S_N^1, S_N^2 and S_N^i) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).	**15**
IV	**Alcohols, Phenols and Ethers (Up to 5 Carbons)** Alcohols: Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes and 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: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer Tiemann Reaction, Gattermann -	**15**

	Koch Reaction, Ethers (aliphatic and aromatic): Cleavage of ethers with HI. **Aldehydes and ketones** (aliphatic and aromatic): Formaldehyde, 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, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction.	

Recommended Textbooks:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Principles of Physical Chemistry, Puri, Sharma & Pathania, Vishal Publishing Co, 47th Edn., 2017.
3. K. L. Kapoor, Text Book of Physical Chemistry, Mac Grow Hill, 3rd Edn. 2017.
4. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Arun Bahl & B S Bahl, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.

Reference Books:

- Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.
- Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications.

PRACTICAL

Sl. No.	Name of the Experiment
	Section A: Physical Chemistry
1	**Thermochemistry** (any three) 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 (KNO3, NH4Cl). 5. Determination of enthalpy of hydration of copper sulphate. 6. Study of the solubility of benzoic acid in water and determination of ΔH.
2	**Ionic equilibria** pH measurements a. 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. b. Preparation of buffer solutions: • Sodium acetate-acetic acid • Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
	Section B: Organic Chemistry
1	Purification of organic compounds by crystallization (from water) and determination of melting.
2	Preparations, recrystallisation, determination of melting point and calculation of quantitative yields of the followings:

	a. Bromination of Phenol/Aniline b. Benzoylation of amines/phenols c. Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books:

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Khosla, B.D.; Garg, V.C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
- Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).

AECC-4.6 (EV-IV): ETHICS & VALUES

Full Marks – 25	End Sem – 25/1 hrs.	Credits: 1	Hours Required: 15

Course Outcomes

- To create an awareness about unethical practices in academics.
- To understand the core values of academic goals of education.
- To contribute to develop a positive social environment through active participation and cooperation with others.
- To give respectful treatment to others in an organizational context.

UNIT-IV: Ethical Values for Student Life

UNIT		HOURS REQUIRED
I	**Meaning and Objectives of Education:** Knowledge is power and quest for knowledge is the real meaning of education, not quest for Degree and qualifications; Real education builds character: Difference between Academic Qualification and Ability, Academic failure could be failure within the classroom, but not outside (i.e., Failed in exam, passed in life!)	**3**
II	**Challenges for Ethical Practices in Institutions of Higher Education** Ragging, Suicide and Need for Educational Counselling, Violence vs. Peaceful Protest, Conflict resolution, Plagiarism and Violation of Intellectual Property Rights, Cheating in Examination and Other Fraudulent Practices	**4**
III	**Inter-Personal Relation and Community life in HEI:** Green Preacher and conservation of energy, Community life in Campus including Hostels, local common area, Inter-personal relations (Student-Teacher, Students-student and Man-Woman, Positive Friendship)	**4**
IV	**Ethical leadership in Academic Institutions:** Concept and Traits of leadership to provide solution, everyone has leadership Role (not limited to position), Concept of Ethical leadership, Scope of leadership in college and Universities for Student, Teachers and Administrators, Importance of Co-curricular and extra-curricular activities.	**4**

SEMESTER-V

C-5.1: ORGANIC CHEMISTRY-IV

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- To understand the basic principles and instrumentation UV-Visible spectroscopy,IR spectroscopy and NMR spectroscopy.
- To understand the interpretation of spectrum in relation to the structure of organic molecule.
- To understand the chemistry of carbohydrates in relation to structure andproperties.
- To develop the skills to identify organic compounds including carbohydrates andalso to estimate organic compounds quantitatively.

THEORY

UNIT		HOURS REQUIRED
I	**Organic Spectroscopy-I** *UV Spectroscopy*: Types of electronic transitions, λmax, Lambert-Beer's law and its limitations, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward rules for calculation of λmax for the following systems: α, β the unsaturated aldehydes: ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.	**12**
II	**Organic Spectroscopy-II** *IR Spectroscopy*: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O and N containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in simple functional group analysis.	**12**
III	**Organic Spectroscopy-III** *NMR Spectroscopy*: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin- spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics; Interpretation of NMR spectra of simple compounds. *Mass Spectroscopy*- Basic principle, Fragmentation pattern, instrumentation, determination of m/e ratio. Application of mass spectroscopy on CH_4, C_2H_6, n-butane and neo-pentane. Applications of IR, UV & NMR for identification of simple organic molecules.	**26**
IV	**Carbohydrates** Occurrence, classification and their biological importance. Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of	**10**

	glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose; Polysaccharides – Elementary treatment of starch, cellulose.	

Recommended Textbooks:

1. Kemp William, Organic Spectroscopy, 3rd Edition, Palgrave Publisher, 1991.
2. Davis, B. G., Fairbanks, A. J., Carbohydrate Chemistry, Oxford Chemistry Primer, Oxford University Press.
3. Kalsi P. S., Spectroscopy of Organic Compounds, 5th Edition, New Age International Publishers, 2016.
4. Advanced Organic Chemistry, 2nd Edition, Arun Bahl & B S Bahl, S. Chand Publisher, 2012.

Reference Books:

- Y R Sharma, Elementary Organic Spectroscopy, 5th Edition, S. Chand & Company, 2013.
- Jag Mohan, Organic Spectroscopy and Applications, Narosa Publishers, 2012.
- Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013).
- Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.
- Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

PRACTICAL

Sl. No.	Name of the Experiment
1.	Qualitative analysis of carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
2.	Qualitative analysis of unknown organic compounds containing simple bifunctional groups, for e.g., salicylic acid, cinnamic acid, nitrophenols etc.
3.	Quantitative estimation of sugars: (a) Estimation glucose by titration with Fehling's solution. (b) Estimation of sucrose by titration with Fehling's solution. (c) Estimation glucose and sucrose in a given mixture.
4.	Identification of labelled peaks in the 1H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.
5.	Identification of labelled peaks in the IR spectrum of the same compound explaining 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).

Reference Books:

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

C-5.2: PHYSICAL CHEMISTRY-V

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- To understand the basis of quantum mechanics and its application to simpleproblems.
- To understand the nature of covalent bond with quantum mechanical approach.
- To understand rotational spectra of linear diatomic and triatomic molecule and its applications.
- To explain Hooks law (Harmonic oscillator) and to explain IR spectra of diatomic molecule.
- To explain energy levels and selection rules for vibrating rotator.
- To understand basic principles of photochemistry and photochemical reactions.
- To develop the skill of using UV –Visible spectrophotometer to solve differentproblems.

THEORY

UNIT		HOURS REQUIRED
I	**Quantum Chemistry** Quantum mechanical operators, Postulates of quantum mechanics, Schrodinger equation and its application to particle in one-dimensional box (complete solution) - quantization of energy levels, zero-point energy, normalization of wave functions, probability distribution functions, nodal properties. Extension to three- dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrodinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule: Schrodinger equation, transformation to spherical polar coordinates. Separation of variables (Preliminary treatment).	**20**
II	**Molecular Spectroscopy-I** Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. *Rotational spectroscopy*: Selection rules, intensities of spectral lines, determination of bond 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. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.	**15**
III	**Molecular Spectroscopy-II**	**15**

	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 pre-dissociation.	
IV	**Photochemistry** Characteristics of electromagnetic radiation, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching, chemiluminescence.	**10**

Recommended Textbooks:

1. McQuarie D., Quantum Chemistry, University Science Publishers, 2007
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2010).
4. Prasad R K., Quantum Chemistry, New Age International Publishers, 4th Edn, 2010.
5. Rohatagi Mukherjee K. K., Fundamentals of Photochemistry, Wiley Eastern Ltd., 1992.

Reference Books:

- Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
- Kapoor, K. L., Text Book of Physical Chemistry, McGraw Hill, Vol. II, IV.
- Levine, I. N. Quantum Chemistry, PHI.

PRACTICAL

Sl. No.	Name of the Experiment
Spectroscopy/Colorimetry	
1.	Study of absorption spectra (visible range) of $KMnO_4$ and determine the λ_{max} value. Calculate the energies of the transitions in kJ mol^{-1}, cm^{-1}, and eV.
2.	Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration.
3.	Determine the dissociation constant of an indicator (phenolphthalein).
Spectrophotometric titration	
4.	Determine the concentration of HCl against 0.1 N NaOH spectrophotometrically.
5.	To find the strength of given ferric ammonium sulfate solution of (0.05 M) by using EDTA spectrophotometrically.
6.	To find out the strength of $CuSO_4$ solution by titrating with EDTA spectrophotometrically.
7.	To determine the concentration of Cu(II) and Fe(III) solution photometrically by titrating with EDTA.
8.	Estimation of Ca & Mg in a mixture by EDTA titration method.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.:

New Delhi (2011).
- Garland, C. W., Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A.M. & McBane, G.C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
- J. N. Gurtu, R. Kapoor, Experimental Physical Chemistry.

DSE-5.3: POLYMER CHEMISTRY

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes
- The mechanism of polymer material formation
- Molecular weight and structure property relationship.
- Polymerization procedure and Zeigler Natta Catalyst.
- Characterization of polymer.

THEORY

UNIT		HOURS REQUIRED
I	**Introduction and history of polymeric materials:** Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems.	**12**
II	**Mechanism & Kinetics of Polymerization:** Polymerization reactions – addition and condensation, mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques. Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.	**17**
III	**Molecular weight of polymers and their determination** (Mn, Mw, Mv, Mz) by end group analysis, viscometry and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Glass transition temperature (Tg) and it determination: WLF equation, Outlines of factors affecting glass transition temperature (Tg).	**13**
IV	**Properties of polymers** (physical, thermal and mechanical properties) Preparation, structure, properties and applications of the following polymers: polyolefins (polyethylene, polypropylene), polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon), polyamides (nylon-6 and nylon 6, 6). Thermosetting polymers - phenol formaldehyde resins (Bakelite, Novalac), polyurethanes,	**18**

	conducting polymers (polyacetylene, polyaniline). Brief outline of biodegradable polymers.	

Recommended Textbooks:

1. V. R. Gowarikar, Jayadev Sreedhar, N. V. Viswanathan, Polymer Science 1st Edition, New Age International Publishers, 1986.
2. Premamoy Ghosh, Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rd Edition, McGraw Hill Education, 2010.
3. P. Bahadur & N.V. Sastry, Principles of polymer science, Narosa Publishing house, New Delhi 2002.
4. Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley- Interscience (1984)

Reference Books:

- L.H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).
- Nayak P.L., Polymer Chemistry, Kalyani Publisher (2017).

PRACTICAL

Sl. No.	Name of the Experiment
Polymer synthesis (At least three experiments)	
1.	Preparation of nylon-6,6 / Polyaniline.
2.	Preparations of phenol-formaldehyde resin-novalac/ phenol-formaldehyde resin resold.
3.	Preparation of urea-formaldehyde resin.
4.	Free radical solution polymerization of styrene (St)/Methyl Methacrylate (MMA)/Methyl Acrylate (MA)/ Acrylic acid (AA). a. Purification of monomer. b. Polymerization using benzoyl peroxide (BPO)/2,2'-azo-bis-isobutylonitrile (AIBN).
5.	Redox polymerization of acrylamide.
6.	Precipitation polymerization of acrylonitrile.
Polymer characterization/analysis (At least two different experiments)	
1	Determination of molecular weight by viscometry: a. Polyacrylamide / Polystyrene b. Polyvinyl pyrolidine (PVP)
2	Determination of acid value/ saponification value of a resin.
3	Determination of hydroxyl number of a polymer using colorimetric method.
4	Estimation of the amount of HCHO in the given solution by sodium sulphite method
5	Analysis of some IR spectra of polymers – Identification of labelled peaks in IR spectra of known polymer.

Reference Books:

- Hundiwale G.D., Athawale V.D., Kapadi U.R. and Gite V. V., Experiments in Polymer Science, New Age Publications (2009).
- Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
- Joel R. Fried, Polymer Science and Technology, 2nd Ed. Prentice-Hall (2003).
- Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd Ed. John Wiley & Sons (2002).

- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005).

DSE-5.4: INDUSTRIAL CHEMICALS AND ENVIRONMENT

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcome:

- After completion of this course the learner can able to understand about some hazardous and toxic chemicals used in different industries and how to handle these chemicals.
- Different components of environment and the relationship between them.
- Different types of environmental pollution and remedies.
- Different energy sources and pollution.

THEORY

UNIT		HOURS REQUIRED
I	**Industrial Gases and Inorganic Chemicals** Industrial Gases: Large scale production uses storage and hazards in handling of the following gases: oxygen, nitrogen, argon, hydrogen, acetylene, carbon monoxide, chlorine, sulphur dioxide. Inorganic Chemicals: Manufacture, application and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, potassium dichromate and potassium permanganate. Industrial Metallurgy Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.	**15**
II	**Environment and its segments** Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone. Major sources of air pollution. Pollution by SO2, CO2, CO, NOx, and H2S and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal.	**15**
III	**Water Pollution:** Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, fertilizer. Sludge disposal. Industrial	**15**

	waste management: incineration of waste. Water treatment and purification (reverse osmosis, ion exchange). Water quality parameters for wastewater, industrial water and domestic water.	
IV	**Energy and Environment** Sources of energy: Coal, petrol and natural gas. Nuclear fusion/fission, solar energy, hydrogen, geothermal, tidal and hydel. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management. Biocatalysis Introduction to biocatalysis: Importance in green chemistry and chemical industry.	**15**

Recommended Textbooks:

1. De, A. K. Environmental Chemistry: New Age International Pvt., Ltd, New Delhi, 2010.
2. Stocchi E., Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

Reference Books:

- Felder R.M. and Rousseau R.W., Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- Dara S. S., A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
- Miller G.T., Environmental Science, 11th edition. Brooks/ Cole (2006).
- Mishra, Environmental Studies, Selective and Scientific Books, New Delhi (2005).

PRACTICAL

Sl. No.	Name of the Experiment
1.	Determination of Dissolved Oxygen (DO) in water.
2.	Determination of Chemical Oxygen Demand (COD)
3.	Determination of Biological Oxygen Demand (BOD)
4.	Percentage of available chlorine in bleaching powder.
5.	Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO3 and potassium chromate)
6.	Estimation of total alkalinity of water samples (CO 2-, HCO -) using double titration method.
7.	Measurement of dissolved CO2.
8.	Study of some of the common bio-indicators of pollution.
9.	Estimation of SPM in air samples.
10.	Preparation of borax/ boric acid.

Reference Books:

Dara S. S., A Textbook on Experiments and Calculations in Engineering Chemistry S Chand & Company; 9th revised edition (2015).

E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.

R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.

A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.

S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

SEMESTER-VI

C-6.1: INORGANIC CHEMISTRY-IV

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- To understand structure and bonding in carbonyls and their reactions.
- To understand structure some organometallic compound and their application ascatalysts.
- To understand inorganic reaction mechanism, trans effect and ligand substitution reactions.
- To develop the skills to identify the cations and anions in a salt mixture.

THEORY

UNIT		HOURS REQUIRED
I	**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), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.	**15**
II	**Organometallic Compounds-II** Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethyl aluminium 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, Mannich Condensation), structure and aromaticity, comparison of aromaticity and reactivity with that of benzene.	**15**
III	**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) Theoretical Principles in Qualitative Analysis (H2S 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 and	**13**

	phosphate) and need to remove them after Group II.	
IV	**Thermodynamic & kinetic aspects and reaction mechanism of metal complexes** Thermodynamic and kinetic stability, Stepwise and overall formation constants and their relationship, factors affecting stability. Introduction to inorganic reaction mechanisms-types of reaction and classification of substitution reaction. Substitution reaction of square planar complexes, Trans effect and its applications, theories of trans-effect (electrostatic polarization and Static π-Bonding Theory). Kinetics of octahedral substitution (classification of metal ions based on water exchange rate), General mechanism of ligand substitution reactions in octahedral complexes (D, I, I_d, I_a).	**17**

Recommended Textbooks:

1. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
2. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd Ed., 2017.
3. Shriver D. E. Atkins P. W., Inorganic Chemistry, Oxford University Press, 5th Edn.
4. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996-0307.

Reference Books:

- Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
- Selected Topic in Inorganic Chemistry, Mallick, Madan and Tuli, S. Chand Publisher. 17th Ed. 2010.
- Mehrotra R.C. and Singh, A. Organometallic Chemistry, New Age International Publishers, 2nd Edn, 2000.
- Gupta B. D. and Elias A. J., Basic Organometallic Chemistry, 2nd Edn., University Press (2013).

PRACTICAL

Sl. No.	Name of the Experiment
1	Qualitative analysis of mixtures containing 4 radicals (2 anions and 2 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-}, F^-, Cl^-, Br^-, I^-, NO_3^-, 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+}.
2	Mixtures may contain one insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of interfering 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 and Br^-, NO and I^-.
3	Spot tests should be done whenever possible.

Reference Books:

- Vogel's Qualitative Inorganic Analysis, 7th Ed, Revised by G. Svehela, 4th Ed., Person (2007).
- Gulati Shikha, Sharma Gulati JL and Manocha, Shagun, Practical Inorganic Chemistry, 1st Edn., CBS Publishers & Distributors Pvt Ltd., (2017).

C-6.2: ORGANIC CHEMISTRY-V

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

To understand the chemistry of amino acids vis-a-vis proteins in relation to thestructure, physical, chemical and biological characteristics.

To understand structure and function of enzymes, nucleic acids and lipids inrelation to their biological importance.

To understand and appreciate the concepts of bioenergetics.

To understand and appreciate the applications of chemistry in forms of medicines& dyes.

To develop the skill of preparation of simple drugs like Paracetamol, Vitamin C,Aspirin etc. and some dyes like methyl orange.

THEORY

UNIT		HOURS REQUIRED
I	**Amino Acids, Peptides and Proteins** Amino acids: Classification; α-Amino acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis. Peptides: Classification, Determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, CORE PAPER protecting and CORE PAPER activating groups - Solid-phase synthesis. Proteins: Structure of proteins, protein denaturation and renaturation	**15**
II	**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 stereo specificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition). Nucleic Acids Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.	**15**
III	**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. Concept of Energy in Biosystems Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism and anabolism). Overview of catabolic pathways of fat and protein. Interrelationship in the	**15**

	metabolic pathways of protein, fat and carbohydrate. Caloric value of food, standard caloric content of food types.	
IV	**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). **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); Triphenylmethane dyes - Malachite Green, and crystal violet; Phthalein dyes –Phenolphthalein and Fluorescein.	**15**

Recommended Textbooks:

1. Nelson, D.L., Cox, M.M. and Lehninger, A.L. Principles of Biochemistry. 6th Edn. W.H. Freeman and Co. (2013).
2. Kar Ashutosh, Medicinal chemistry, New Age International (P) Ltd., (2007)
3. Debojyoti Das, Biochemistry, (Part-I) Academic Publishers (1979)

Reference Books:

1. Talwar, G.P. & Srivastava, M. Textbook of Biochemistry and Human Biology, 3rd Ed. PHI Learning.
2. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry, 6th Edition. W.H. Freeman and Co. (2002).
5. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).
6. The Tools of Biochemistry (1977; Reprint 2011) Cooper, T.G., Wiley India Pvt. Ltd. (New Delhi), ISBN: 978- 81-265-3016-8.

PRACTICAL

Sl. No.	Name of the Experiment
1.	Preparations of the following compounds i. Aspirin ii. Methyl orange
2.	Estimation of phenol and aniline by bromination method.
3.	Saponification value of an oil/ fat/ ester.
4.	Estimation of glycine by Sorenson's formalin method.
5.	Estimation formaldehyde (formalin).
6.	Estimation of ascorbic acid in fruit juices/Vitamin C tablet (Iodometric method)
7.	Determination of Iodine number of an oil/ fat.

Reference Books:

1. Arthur, I. Vogel, Elementary Practical Organic Chemistry, Part-1 Small scale preparations, Indian Edition, Pearson (2011).

2. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
3. Arthur, I. Vogel, Quantitative Organic Analysis, Pearson.
4. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).

DSE-6.3: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60	

Course Outcome:

- The manufacturing of glasses, Ceramics and cements.
- The manufacturing of fertilizer.
- The components of battery and their role.
- The objective of coating surfaces and classification of surface coatings.
- The manufacturing of Alloys and chemical explosive.

THEORY

UNIT		HOURS REQUIRED
I	**Silicate Industries** Glass: Glassy state and its properties, classification (silicate and nonsilicate glasses). Manufacturing and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass. Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre. Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.	**15**
II	**Fertilizers:** Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate. Batteries: Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.	**15**
III	**Surface Coatings:** Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.	**15**

IV	**Alloys:** Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon, decarbonization, demanganization, desulphurization, dephosphorisation) and surface treatment (argon treatment, heat treatment nitriding, carburizing). Composition and properties of different types of steels. Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.	**15**

Recommended Textbooks:

1. Stocchi E., Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
3. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.

Reference Books:

- Felder R.M. and Rousseau R.W., Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- Dara S. S., A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
- A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.

PRACTICAL

Sl. No.	Name of the Experiment
1.	Determination of free acidity in ammonium sulphate fertilizer.
2.	Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3.	Estimation of phosphoric acid in superphosphate fertilizer.
4.	Determination of composition of dolomite (by complexometric titration).
5.	Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
6.	Analysis of Cement.
7.	Estimation of Iron from Cement Volumetrically
8.	Preparation of pigment (zinc oxide).

Reference Books:

1. Dara S. S., A Textbook on Experiments and Calculations in Engineering Chemistry S Chand & Company; 9th revised edition (2015).
2. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
3. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
4. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
5. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
6. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
7. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.

DSE-6.4: GREEN CHEMISTRY

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- Learn an interdisciplinary approach to the scientific and social issues arising from pollution of environment and green approach for its solution.
- To understand the basic principles of Green Chemistry.
- To understand the green synthetic methods of different compounds
- To understand the scope of green chemistry.

THEORY

UNIT		HOURS REQUIRED
I	**Introduction to Green Chemistry** What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry. Principles of Green Chemistry and Designing a Chemical synthesis- I Twelve principles of Green Chemistry. Explanations of principle with special emphasis on - Designing green synthesis processes: Prevention of Waste/ by-products; maximize the incorporation of the materials used in the process into the final products (Atom Economy) with reference to rearrangement, addition, substitution and elimination reactions; Prevention/minimization of hazardous/ toxic products; Designing safer chemicals; Use of safer solvents and auxiliaries (e.g. separating agent) - green solvents (supercritical CO2, water, ionic liquids), solvent less processes, immobilized solvents.	**15**
II	**Principles of Green Chemistry and Designing a Chemical synthesis-II** Explanation of green chemistry principles with special emphasis on: Energy efficient processes for synthesis - use of microwaves and ultrasonic energy. Selection of starting materials (use of renewable feedstock); avoidance of unnecessary derivatization (e.g. blocking group, protection groups, deprotection); Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products use of chemically safer substances for prevention of chemical accidents, inherent safer design greener – alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol); real-time, in-process monitoring and control to prevent the formation of hazardous substances; development of green analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.	**15**
III	**Examples of Green Synthesis/ Reactions and some real world cases-I** Green Synthesis of the following compounds: adipic acid, catechol, methyl methacrylate, urethane, disodium iminodiacetate (alternative to Strecker synthesis), paracetamol, furfural. Microwave assisted reactions: Applications to reactions (i) in water: Hofmann Elimination, hydrolysis (of	**15**

	benzyl chloride, methyl benzoate to benzoic acid), Oxidation (of toluene, alcohols); (ii) reactions in organic solvents: Diels-Alder reaction and Decarboxylation reaction. Ultrasound assisted reactions: Applications to esterification, saponification, Simmons- Smith Reaction (Ultrasonic alternative to Iodine).	
IV	**Examples of Green Synthesis/ Reactions and some real world cases- II** Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments; Designing of Environmentally safe marine antifoulant; Right fit pigment: synthetic azopigments to replace toxic organic and inorganic pigments; Synthesis of a compostable and widely applicable plastic (poly lactic acid) from corn; Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting Future Trends in Green Chemistry Oxidizing and reducing reagents and catalysts; multifunctional reagents; Combinatorial green chemistry; Proliferation of solvent less reactions; Green chemistry in sustainable development. (Bio-diesel, bio-ethanol and biogas).	**15**

Recommended Textbooks:

1. Anastas P.T. & Warner J.K.: Green Chemistry- Theory and Practical, Oxford University Press (2000).
2. Ahluwalia V.K. & Kidwai M.: New Trends in Green Chemistry, Anamalaya Publishers, New Delhi (2004).
3. Kumar V., An Introduction to Green Chemistry, Vishal Publishing Co., (2015).

Reference Books:

1. Matlack A.S. Introduction to Green Chemistry, Marcel Dekker (2001).
2. Das Asim K. amd Das Mahua, Environment Chemistry with Green Chemistry, Books and Allied (P) Ltd. (2010)

PRACTICAL

Sl. No.	Name of the Experiment
At least five experiments should be done:	
1.	Acetylation of primary amine (Aniline to N-phenylacetamide) using Zn dust.
2.	Nitration of salicylic acid by green method (Using calcium nitrate and acetic acid).
3.	Bromination of acetanilide using ceric ammonium nitrate/KBr.
4.	Microwave assisted nitration of Phenols using $Cu(NO_3)_2$.
5.	Detection of elements in organic compounds by green method (Sodium carbonate fusion).
6.	Base catalyzed Aldol condensation (Synthesis of dibenzalpropanone).
7.	Vitamin C clock reaction using vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch. Effect of concentration on clock reaction.
8.	Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
9.	Diels Alder reaction in water: Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.
10.	Preparation and characterization of nanoparticles (Cu, Ag) using plant extract.

11.	Preparation of propene by following two methods or any other reactions like addition, elimination, substitution showing atomic economy can be studied a. Triethylamine ion + OH^- → Propene + Trimethylpropene + water b. 1-propanol ⟶ propene + water

Reference Books:

1. Monograph on Green Chemistry Laboratory Experiments, edited and published by Green Chemistry Task Force Committee, DST Govt. of India, p. 1-79.
2. Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
3. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN978-93-81141-55-7 (2013).

DSE-6.5: ANALYTICAL METHODS IN CHEMISTRY

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- Learn the basics of the various methods of analysis of the chemical samples
- Learn the theories behind the various spectra and the origin of the peaks in the spectra
- Learn the principles behind the thermal and electroanalytical methods of analysis
- Get a knowledge of the separation techniques and the chemical principles governing them.

THEORY

UNIT		HOURS REQUIRED
I	**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. **Optical methods of analysis-I:** 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.	**15**
II	**Optical methods of analysis-II** **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,	**15**

	Effect and importance 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.	
III	**Thermal methods of analysis:** Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. **Electroanalytical methods:** Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.	**10**
IV	**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. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition 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.	**20**

Recommended Textbooks:

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988. 27
3. Christian, G.D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

Reference Books:

- Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

PRACTICAL

Sl. No.	Name of the Experiment
I. Separation Techniques	
1.	Chromatography: (a) Separation of mixtures (i) Paper chromatographic separation of Fe3+, Al3+, and Cr3+. (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values. (b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values. (c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC
II. Solvent Extractions:	
2.	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.
3.	Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.
4.	Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
5.	Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
6.	Analysis of soil: (i) Determination of pH of soil. (ii) Total soluble salt 28 (iii) Estimation of calcium, magnesium, phosphate, nitrate
7.	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.
III Spectrophotometry	
8.	Determination of pK_a values of indicator using spectrophotometry.
9.	Structural characterization of compounds by infrared spectroscopy.
10.	Determination of dissolved oxygen in water.
11.	Determination of chemical oxygen demand (COD).
12.	Determination of Biological oxygen demand (BOD).
13.	Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Reference Books:

- Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

- Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

DSE-6.6: NOVEL INORGANIC SOLIDS

Full Marks – 100	Mid Sem – 15/1hr	End Sem Theory – 60/3 hrs.	End Sem Practical – 25/3 hrs.
Credits: 4		Hours Required: 60 (Theory) + 60 (Practical)	

Course Outcomes

- Learn the basics of the inorganic solids and expose the students to the field of inorganic solids of technological importance.
- Introduce students to the field of nanomaterials and their structure-property relationships.
- Learn the basis of engineering materials and composite materials.
- Learn about the synthesis and applications of speciaity polymers

THEORY

UNIT		HOURS REQUIRED
I	**Synthesis and modification of inorganic solids:** Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods. **Inorganic solids of technological importance:** Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments. Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.	**20**
II	**Nanomaterials:** Overview of nanostructures and nanomaterials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisical nanomaterials, bionano composites.	**10**
III	**Introduction to engineering materials for mechanical construction:** Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminium and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials. **Composite materials:** Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.	**20**

IV	**Speciality polymers:** Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers, Ion-exchange resins and their applications. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.	**10**

Recommended Textbooks:

1. Shriver & Atkins. Inorganic Chemistry, Peter Alkins, Tina Overton, Jonathan Rourke, 32 Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press (2011-2012)
2. Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry. John Wiley & Sons, 1974.

Reference Books:

- Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley & Sons, 2003.
- Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

PRACTICAL

Sl. No.	Name of the Experiment
1.	Determination of cation exchange method
2.	Determination of total difference of solids.
3.	Synthesis of hydrogel by co-precipitation method.
4.	Synthesis of silver and gold metal nanoparticles.

Reference Books:

- Fahlman, B.D. Materials Chemistry, Springer, 2004.

DSE-6.7: DISSERTATION / PROJECT WORK

Full Marks – 100	Credits: 6	End Sem Project – 100	Hours Required: 300

Course Outcomes

- To get an initial idea about project/dissertation work, how to report a project work in a standard format to be submitted a presented for evaluation under the guidance of the departmental teachers.
- To understand how to identify a problem, review of literature, methodology, findings and analysis of a project work in different fields like Physiochemical studies (pH, Conductivity, turbidity etc) of different wetlands (ponds, river, lake etc.).
- To analyse hardness of water samples, detection of adulteration in food stocks and other edible items, extraction and preliminary characterization of useful chemicals from plants, pollution related activities, nutrition related activities and small synthetical work (inorganic/organic and polymeric compounds).

A project work is to be carried out by the student in consultation with the teachers of the department. The report of work (dissertation) in a standard format is to be submitted and presented for evaluation.

Distribution of marks

a. Project Report/Dissertation (Proper documentation of literature, data, discussion etc. and logical

flow of work undertaken): 50 Marks
b. Seminar/Presentation: 30 marks
c. Viva voce: 20 marks

Brief Guidelines to Project Work:

1. Students shall undertake the project work (experimental/theoretical) related to any branch of chemistry/Chemical science under the guidance of teacher(s) from the department or jointly with teachers/research personnel of other institutes.
2. The following activities have been outlined as guidelines (not exhaustive):

• Physiochemical studies (pH, conductivity, turbidity, etc.) of different wetlands (ponds, lakes, river etc.)
• Analysis of iron in pond / tube well / river water.
• Analysis of Hardness of water samples.
• Adulteration detection activities in food stuff and other edible items.
• Extraction and preliminary characterization of useful chemicals (as far as possible) from plants.
• Solubility, surface tension, and viscosity measurements of some solution of practical relevance, (cough syrup, soap solution, pesticides, fertilizers. etc.)
• Pollution related activities (Industrial/Agricultural/Municipal etc.)
• Nutrition related activities, (essential metal detection in food, cereals, pulses, fruits etc.).
• Small synthetical work (inorganic/Organic/Polymeric compounds)

3. The UG level project work is a group activity, maximum number of students being limited to three. HOD to notify the name of teacher(s) for supervising the project work of each group. A teacher can guide more than one group, if necessary.
4. No two groups in the same institution are permitted to do project work on the same problem.
5. Each student shall prepare and submit the project report separately for evaluation. Two copies of project report are required to be submitted in bound form (spiral/paperback).
6. The project report shall be divided as:

Chapter I: Introduction (Introduction on the topic, review of literature, objective and scope of the work)
Chapter II: Materials and methods
Chapter II: Results and discussion
Chapter IV: Conclusions and Scope of future studies Chapter V: References

Reference Books:

1. M. A. Malati, An Investigative, Integrated Approach to Practical Project Work; Mid-Kent College of Higher/Further Education, UK (October 1999); Imprint: Woodhead Publishing; ISBN: 978-1-898563-47-1.
2. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed., Prentice-Hall, Harlow.

AECC-6.5 (EV-VI): ETHICS & VALUES

Full Marks – 100	Credits: 4	End Sem. – 25/1 hr.	Hours Required: 15

Course Outcomes

- To develop an understanding of environmental ethics nd work towards sustainable development.

- Commitment to green technology for sustainable future.
- To understand ethical issues relating to the use of digital medium.

UNIT-VI: Environmental & Techno Ethics

UNIT		HOURS REQUIRED
I	Environmental Ethics: Types of Ecological Values, Environmental Values & Valuing Nature, Equitable use of Resources, Role of Individual in the conservation of resources for future generation, Bio-Ethics-Genetic manipulation in plants and animals for benefits of society and cruelty against animal.	
II	Promotion of Green Technology: Goal of Green Technology: Reduce recycling, Renew (removal of chemicals), Refuse and Responsibility. Green Technology in relation to:- Energy and Construction.	
III	Ethics and Technology: Ethics and Technology with reference to Science, gadget, machine etc. and interaction with each other, Agricultural, Industrial, Digital, Globalized Age etc	
IV	Judicious Use of Technology: Judicious use of Mobile Phones, Electrical machines, Plastics, Television, Computers and their harmful effects Ethics and Use of Digital Technology: Cyber ethics- Crimes and Ethical hacking, Ethics of social media: WhatsApp, Facebook, Twitter and others	