

SYLLABUS
for
Choice Based Credit System
(CBCS)
On the basis of
Outcome Based Education
(OBE)

CHEMISTRY HONOURS

PATNA WOMEN'S COLLEGE
PATNA UNIVERSITY

3rd Cycle NAAC Accredited – 'A' Grade with CGPA 3.58/4
'College with Potential for Excellence' (CPE) Status Accorded by UGC

Vision

Rooted in the life, vision, and teachings of Jesus Christ and inspired by Mother Veronica, the foundress of the Apostolic Carmel, Patna Women's College strives to become a centre of academic excellence in higher education, social responsibility, and empowerment of women.

Mission Statement

Patna Women's College, the first college for women in Bihar, is committed to the holistic development of women so as to make an effective contribution to the creation of a better society.

To this end, we strive

- To become a center of excellence in higher education for women in an atmosphere of autonomy.
- To excel in teaching-learning, research, and consultancy.
- To provide education that promotes capacity building and holistic development of a person.
- To offer subjects for competency building and motivate/animate a workforce imbued with human values.
- To promote patriotism, communal harmony and cultural integration to maintain a free and peaceful atmosphere on the campus.
- To train the students in creative arts, social service, critical thinking, and leadership in order to make an effective contribution to the creation of a new and value-based society.
- To create women leaders and to make them agents of social change.
- To develop skill oriented and value-based courses, for the all-round development of individuals.
- To promote academic exchange and academia-industry interface.
- To form young women who are 'always wise' and who will dare to 'go ahead and conquer knowledge' through, competence, commitment, delicate conscience, and compassion.

DEPARTMENT OF CHEMISTRY

Programme Outcomes: B.Sc. Chemistry (Hons.)

After successful completion of the programme, the students will be able to:

- PO1:** Gain the theoretical as well as practical knowledge of handling chemicals.
- PO2:** Demonstrate, solve and an understanding of major concepts in all disciplines of chemistry.
- PO3:** Solve the problem and also think methodically, independently and draw a logical conclusion.
- PO4:** Employ critical thinking and the scientific knowledge to design, carry out, record analyze the results of chemical reactions.
- PO5:** Create an awareness of the impact of chemistry on the environment, society, and development outside the scientific community.
- PO6:** Find out the green route for chemical reaction for sustainable development.
- PO7:** Use modern techniques, decent equipments and Chemistry software's.

Programme Specific Outcomes: B.Sc. Chemistry (Hons.)

After successful completion of the programme, a student will be able to:

- PSO1:** Gain the knowledge of Chemistry through theory and practical's.
- PSO2:** Explain nomenclature, stereochemistry, structures, reactivity, and mechanism of the chemical reactions.
- PSO3:** Identify chemical formulae and solve numerical problems.
- PSO4:** Use modern chemical tools, Models, Chem-draw, Charts and Equipments.
- PSO5:** Know structure-activity relationship.
- PSO6:** Understand good laboratory practices and safety.
- PSO7:** Develop research-oriented skills.
- PSO8:** Comprehend and handle the sophisticated instruments/equipments.

B.Sc. (Honours) Chemistry

Note: 1 credit = 15 hours

- 1. Theory paper: 4credits each.**
- 2. Practical paper: 2 credits each.**
- 3. Practical paper will not have tutorials.**
- 4. Core Course (Theory + Practical): 6 credits each.**

Core Courses (6 credits each)

Core Course: A course, which will compulsorily be studied by a candidate as a core requirement is termed as a Core course.

Semester I

1. Inorganic Chemistry-I + (P)
2. Physical Chemistry – I + (P)

Semester II

3. Organic Chemistry-I + (P)
4. Physical Chemistry-II + (P)

Semester III

5. Inorganic Chemistry- II + (P)
6. Organic Chemistry-II + (P)
7. Physical Chemistry–III + (P)

Semester IV

8. Inorganic Chemistry - III + (P)
9. Organic Chemistry-III + (P)
10. Physical Chemistry-IV + (P)

Semester V

11. Organic Chemistry-IV + (P)
12. Physical Chemistry-V + (P)

Semester VI

13. Inorganic Chemistry -IV + (P)
14. Organic Chemistry-V + (P)

Generic Elective Papers (GE) (6 credits each: Theory-04+Practical 02)

Generic Elective (GE) Course:

An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/ subject and vice versa and such electives may also be referred to as Generic Elective.

Semester I

1. Physical Chemistry, Inorganic Chemistry & Organic Chemistry + (P)

Semester II

2. Physical Chemistry & Functional Group Organic Chemistry – I + (P)

Semester III

3. Physical Chemistry & Functional Group Organic Chemistry – II + (P)

Semester IV

4. Physical Chemistry & Inorganic Chemistry + (P)

Discipline Specific Elective (DSE) (6 credits each)

Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

Semester V

DSE - 1

1. Inorganic Materials of Industrial Importance + (P)

DSE - 2

- Analytical Methods in Chemistry + (P)

Semester VI**DSE - 3**

- Industrial Chemical and Environment + (P)

DSE - 4

- Dissertation

Skill Enhancement Course (SEC) (2Credits)

Skill Enhancement Courses (SEC): These courses may be chosen from a pool of courses designed to provide **value-based and/or skill-based knowledge**.

Semester III

- Inter Religious Studies

Semester IV

- Basic Analytical Chemistry

Chemistry (Hons.) CBCS Syllabus

Sem	Core Course (14) <u>6 Credits each</u>	Ability Enhanceme nt Compulsor y Course AECC (2) <u>2 Credits each</u>	Skill Enhanceme nt Course SEC (2) <u>2 Credits each</u>	Discipline Specific Elective DSE (4) <u>6 Credits each</u>	Generic Elective GE (4) <u>6 Credits each</u>

I	CHE CC101: Inorganic Chemistry-I +(P)	CHE. AECC (English / Hindi)			CHE GE101: Physical Chemistry, Inorganic Chemistry & Organic Chemistry + (P)
	CHE CC102: Physical Chemistry– I +(P)				
II	CHE CC203: Organic Chemistry– I + (P)	CHE. AECC Environment al Science			CHE GE202: Physical Chemistry & Functional Group Organic Chemistry - I + (P)
	CHE CC204: Physical Chemistry– II +(P)				
III	CHE CC305: Inorganic Chemistry-II + (P)		IRS SEC301: Inter religious studies		CHE GE303: Physical Chemistry & Functional Group Organic Chemistry-II + (P)
	CHE CC306: Organic Chemistry – II + (P)				
	CHE CC307: Physical Chemistry– III + (P)				
IV	CHE CC408: Inorganic Chemistry-III		CHE SEC402: Basic		CHE GE404: Physical

	+ (P)		Analytical Chemistry		Chemistry & Inorganic Chemistry + (P)
	CHE CC409: Organic Chemistry- III + (P)				
	CHE CC410: Physical Chemistry- IV + (P)				
V	CHE CC511: Organic Chemistry- IV + (P)			CHE DSE501: Inorganic Materials of Industrial Importance + (P)	
	CHE CC512: Physical Chemistry- V + (P)			CHE DSE502: Analytical Methods in Chemistry + (P)	
VI	CHE CC613: Inorganic Chemistry-IV + (P)			CHE DSE603: Industrial Chemical and Environment + (P)	
	CHE CC614: Organic Chemistry- V + (P)			CHE DSE604: Dissertation	

Course Structure for B.Sc. Chemistry (Hons.)

SEMESTER-I	SEMESTER-II
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CHE CC101: Inorganic Chemistry-I + (P)	CHE CC203: Organic Chemistry-I + (P)
CHE CC102: Physical Chemistry-I + (P)	CHE CC204: Physical Chemistry-II + (P)
ENG AEC101 : English Communication HIN AEC101 : fgUnh O;kdj.k vkSj IEizs"k.k	EVS AEC202 : Environmental Science
CHE GE101: Physical Chemistry, Inorganic Chemistry & Organic Chemistry + (P)	CHE GE202: Physical Chemistry & Functional Group Organic Chemistry - I + (P)
SEMESTER-III	
CHE CC305: Inorganic Chemistry- II + (P)	CHE CC408: Inorganic Chemistry-III + (P)
CHE CC306: Organic Chemistry-II + (P)	CHE CC409: Organic Chemistry-III + (P)
CHE CC307: Physical Chemistry –III + (P)	CHE CC410: Physical Chemistry-IV + (P)
IRS SEC301 : Inter Religious Studies (Value Based)	CHE SEC402: Basic Analytical Chemistry
CHE GE303: Physical Chemistry & Functional Group Organic Chemistry – II + (P)	CHE GE404: Physical Chemistry & Inorganic Chemistry + (P)
SEMESTER-V	
CHE CC511: Organic Chemistry-IV + (P)	CHE CC613: Inorganic Chemistry –IV + (P)
CHE CC512: Physical Chemistry-V (P)	CHE CC614: Organic Chemistry-V
CHE DSE501:	CHE DSE603:

Inorganic Materials of Industrial Importance + (P)	Industrial Chemical and Environment + (P)
CHE DSE502: Analytical Methods in Chemistry + (P)	CHE DSE604: Dissertation

Details of Credits for Courses under B.A., B.Sc., B.Com. Honours

CHEMISTRY

Semester	Course	Theory	Practical	Dissertation	Total Credits
<u>I. Core Course (14 Papers) – 06 credits each</u>					
I	1. Inorganic Chemistry-I	4	2	-	6
	2. Physical Chemistry –I	4	2	-	6
II	3. Organic Chemistry –I	4	2	-	6
	4. Physical Chemistry-II	4	2	-	6
III	5. Inorganic Chemistry- II	4	2	-	6
	6. Organic Chemistry-II	4	2	-	6
	7. Physical Chemistry –III	4	2	-	6
IV	8. Inorganic Chemistry III	4	2	-	6
	9. Organic Chemistry-III	4	2	-	6
	10. Physical Chemistry-IV	4	2	-	6
V	11. Organic Chemistry-IV	4	2	-	6
	12. Physical Chemistry-V	4	2	-	6
VI	13. Inorganic Chemistry -IV	4	2	-	6
	14. Organic Chemistry-V	4	2	-	6
<u>II. Elective Course – 06 credits each</u>					
A. 1. Discipline Specific Elective-DSE(4 papers)					

V	1. Inorganic Materials of Industrial Importance	4	2	-	6
	2. Analytical Methods in Chemistry	4	2	-	6
VI	3. Industrial Chemical and Environment	4	2	-	6
	4. Dissertation	-	-	6	6
B. 1. Generic Elective / Interdisciplinary (4 papers)					
I	1. Physical Chemistry & Organic Chemistry	4	2	-	6
II	2. Physical Chemistry & Functional Group Organic Chemistry - I	4	2	-	6
III	3. Physical Chemistry & Functional Group Organic Chemistry – II	4	2	-	6
IV	4. Physical Chemistry & Inorganic Chemistry	4	2	-	6
III. Ability Enhancement Courses – 02 credits each					
1. Ability Enhancement Compulsory (AECC)					
I	1. (English / Hindi)	2			2
II	2. Environmental Science	2			2
II. Skill Enhancement Course (SEC)					
III	1. Inter religious studies	2	-	-	2
IV	2. Basic Analytical Chemistry	2	-	-	2
TOTAL					140

Institute will evolve a system/policy about ECA / General Interest / Hobby / Sports / NCC / NSS / related courses on its own.

*wherever there is practical there will be no tutorial and vice-versa.

Core Courses (6 credits each)

SEMESTER – I

Core Course: A course, which will compulsorily be studied by a candidate as a core requirement is termed as a Core course.

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand fundamental properties of atoms, molecules, periodicity of elements in the periodic table and the various states of matter with an emphasis on the particulate nature of matter. Quantum mechanical treatments of atoms and molecules.

CO2: Understand Fundamentals of acid/base reactions, redox reactions and precipitation reactions.

CO3: Analysis the structures and important bonding parameters

CO4: Evaluate the idea of a mole and the use of stoichiometry and “gas laws” governing the physical/chemical behaviour of gases.

CHE CC101 : Inorganic Chemistry-1		
PWC (Theory :4 credits + Practical: 2 credit)		
Unit	Topics to be covered	No. of hours
1	Atomic Structure: Recapitulation of Bohr’s theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg’s Uncertainty Principle and its significance. Schrödinger’s wave equation, significance of ψ and ψ^2 . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbital’s. Pauli’s Exclusion Principle, Hund’s rule of	14

	maximum multiplicity, aufbau principle and its limitations.	
2.	<p>Periodicity of Elements: Brief discussion of the following properties of the elements, with reference to s & p-block and the trends shown:</p> <ul style="list-style-type: none"> a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. b) Atomic and ionic radii c) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. d) Electron gain enthalpy and trends in groups and periods. e) Electronegativity, Pauling's/ Allred Rochow's scales. Variation of electro negativity with bond order, partial charge, hybridization, group electro negativity. 	16
3.	<p>Chemical Bonding:</p> <p>(i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.</p> <p>(ii) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N₂, O₂, C₂, B₂, F₂, CO, NO, and their ions; HCl (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H₂O, NH₃, PCl₃, PCl₅, SF₆, ClF₃, I₃⁻, BrF₂⁺, PCl₆⁻, ICl₂⁻, ICl₄⁻ and SO₄²⁻. Multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and</p>	26

	<p>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.</p> <p>(iii) Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.</p> <p>(iv) Weak Chemical Forces: Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of weak chemical forces, melting and boiling points, solubility, energetics of dissolution process.</p>	
4.	<p>Oxidation- Reduction: Introduction of electro chemical cell Recapitulation of Oxidation reduction Concept, Balancing of ionic reaction by ion-electron and Oxidation number method, The principles involed in redox titrations, standard electrode potential and its applications.</p>	4
	<p>Practical</p> <p>(A) Titrimetric Analysis</p> <ol style="list-style-type: none"> I. Calibration and use of apparatus II. Preparation of solutions of titrants of different Molarity/Normality <p>(B) Acid-Base Titrations: Principles of acid-base titrations to be discussed.</p> <ol style="list-style-type: none"> I. Estimation of sodium carbonate using standardized HCl. II. Estimation of carbonate and hydroxide present together in a mixture. III. Estimation of carbonate and bicarbonate present together in a mixture. IV. Estimation of free alkali present in different soaps/detergents <p>(C) Oxidation-Reduction Titrimetry : Principles of oxidation-reduction titrations (electrode potentials) to be discussed.</p> <ol style="list-style-type: none"> I. Estimation of Fe(II) and oxalic acid using standardized KMnO4 solution 	30

	II. Estimation of oxalic acid and sodium oxalate in a given mixture. III. Estimation of Fe(II) with $K_2Cr_2O_7$ using internal indicator (diphenylamine, Nphenylanthranilic acid) and discussion of external indicator.	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Lee J.D., (2010). *Concise Inorganic Chemistry*, Pearson Education
2. Huheey J.E., Keiter E.A., Keiter R.L., Medhi O.K., (2006). *Inorganic Chemistry, Principles of Structure and Reactivity*, Pearson Education.
3. Douglas B.E., Mc Daniel D.H., (1970). *Concepts & Models of Inorganic Chemistry*, Oxford,
4. Shriver D.D., Atkins P., (1994). *Inorganic Chemistry* 2nd Ed., Oxford University Press,.
5. Day M.C., Selbin J., (1962). *Theoretical Inorganic Chemistry*, ACS Publications.
6. Vogel A.I., (2008). *A Textbook of Quantitative Inorganic Analysis*, ELBS.

SEMESTER – I

Course Outcomes:

After completion of these courses, students will be able to:

- CO1:** Understand the structure of solids in its influence on physical-chemical properties, phase relations, chemical synthesis, reaction kinetics as well as characterization methods
- CO2:** Evaluate mathematical expressions for different properties of gas, liquid and solids and understand their physical significance
- CO3:** Understand the crystal structure and calculate related properties of cubic systems
- CO4:** Analysis the concept of ionization of electrolytes with emphasis on weak acid and base and hydrolysis

CHE CC102 : Physical Chemistry-I		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	Gaseous state: Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of ζ from η ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure and temperature for different gases. Causes of deviation from ideal	18

	behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour, calculation of Boyle temperature. 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.	
2	Liquid state: Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.	6
3	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, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl.	16
4	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; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid– base indicators; selection of indicators and their limitations.	20

	<p>Practical</p> <p>1. Surface tension measurements using stalagmometer.</p> <p>a) Determine the surface tension by</p> <p>(i) drop number</p> <p>(ii) drop weight method.</p> <p>b) Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.</p> <p>2. Viscosity measurement using Ostwald's viscometer.</p> <p>a) Determination of co-efficient of viscosity of an unknown aqueous solution.</p> <p>b) Study the variation of co-efficient of viscosity with different concentration of Poly Vinyl Alcohol (PVA) and determine molar of PVA.</p> <p>c) Study the variation of viscosity with different concentration of sugar solutions.</p> <p>3. Molecular weight determination:</p> <p>a) Determination of molecular weight of volatile liquid by Victor Meyer's method.</p> <p>4. pH metry:</p> <p>a) Study the effect of addition of HCl/NaOH on pH to the solutions of acetic acid, sodium acetate and their mixtures.</p> <p>b) Preparation of buffer solutions of different pH values i. Sodium acetate-acetic acid ii. Ammonium chloride-ammonium hydroxide</p> <p>c) pH metric titration of</p> <p>(i) strong acid with strong base,</p> <p>(ii) weak acid with strong base. Determination of dissociation constant of a weak acid.</p> <p>Any other experiment carried out in the class.</p>	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Atkins P., De Paula J., (2006). *Atkins' Physical Chemistry* Ed., Oxford University Press 13
2. Ball D. W., (2007), *Physical Chemistry* Thomson Press, India.
3. Castellan G. W., (2004). *Physical Chemistry* 4th Ed. Narosa.
4. Mortimer R. G., (2009). *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP.
5. Khosla B. D., Garg V. C., Gulati A. (2011). *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi.
6. Garland C. W., Nibler J. W., Shoemaker D. P., (2003). *Experiments in Physical Chemistry* 8th Ed.; McGraw-Hill: New York.
7. Halpern A. M., Mc Bane G. C., (2003). *Experimental Physical Chemistry* 3rd Ed.; W.H. Freeman & Co.: New York.

SEMESTER – II

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand the hybridization and geometry of atoms and the three-dimensional Structure of organic molecules.
- CO2:** The reactivity and stability of an organic molecule based on structure, including conformation stereochemistry and mechanism for organic reactions.
- CO3:** how to design syntheses of organic molecules
- CO4:** how to determine the structure of organic molecules using IR and NMR spectroscopic techniques.

CHE CC203 : Organic Chemistry-I		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of

		hours
1	<p>Recapitulation of basics of Organic Chemistry: Hybridization, Shapes of molecules Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation Dipole moment; Hydrogen bonding (Applications to be discussed with relevant topics) Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Types, shape and relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions: Addition, Elimination and Substitution reactions.</p>	6
2	<p>Stereochemistry: Fischer, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis-trans, syn-anti and E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations.</p>	18
3	<p>Chemistry of Aliphatic Hydrocarbons :</p> <p>A. Carbon-Carbon sigma bonds: General methods of preparation, physical and chemical properties of alkanes: Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.</p> <p>B. Carbon-Carbon pi bonds: General methods of preparation, physical and chemical properties of alkenes and alkynes, Mechanism of SN1 and SN2, E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2- and 1,4-addition reactions in conjugated dienes and Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.</p> <p>Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions.</p>	24

	Hydration to form carbonyl compounds, Alkylation of terminal alkynes. C. Cycloalkanes and Conformational Analysis Conformational analysis of alkanes: Relative stability and Energy diagrams. Types of cycloalkanes and their relative stability, Baeyer strain theory : Chair, Boat and Twist boat forms of cyclohexane with energy diagrams ; Relative stability of mono substituted cycloalkanes.	
4	Aromatic Hydrocarbons: Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution and energy profile diagram of the following reaction: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Effect of substituents on orientation and reactivity of benzene ring.	12
	Practical <ol style="list-style-type: none"> 1. Checking the calibration of the thermometer 2. Purification of organic compounds by crystallization using the following solvents: a. Water b. Alcohol c. Alcohol-Water 3. Determination of the melting points of unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus) 4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds 5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method) 6. Chromatography <ol style="list-style-type: none"> 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 	30

	chromatography c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC) 7. Detection of elements in organic compounds. 8. Organic Preparations (i) Oxidation of toluene, benzaldehyde (ii) Nitration of nitrobenzene / Phenol.	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Morrison R. N., Boyd R. N., (2007). *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar I.L., (2014). *Organic Chemistry (Volume 1)*: Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar I.L., (2014). *Organic Chemistry (Volume 2): Stereochemistry and the Chemistry of Natural Products*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Eliel E. L., Wilen S. H., (1994). *Stereochemistry of Organic Compounds*; Wiley: London,.
5. Kalsi P. S., (2005). *Stereochemistry Conformation and Mechanism*; New Age International,.
6. Mann F.G., Saunders B.C., (2009). *Practical Organic Chemistry*, Pearson Education
7. Furniss B.S., Hannaford A.J., Smith P.W.G., Tatchell A.R., (2012). *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson

SEMESTER – II

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand concepts in thermodynamics, different thermodynamic quantities such as heat and work and how they are measured, related or transformed from one to the other.
- CO2:** Understand states of matter and how they depend on temperature and pressure as well as how they co-exist in phase equilibria.
- CO3:** Understand transport of ions and thermodynamic functions with applications to electron transfer in biological systems
- CO4:** Understand chemical kinetics; how reaction rates are measured and represented in rate laws, and applications of chemical kinetics in studying enzyme mechanisms and the basic (colligative) properties of solutions.

CHE CC204 : Physical Chemistry-II		
PWC (Theory :4 credits +Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	Chemical Thermodynamics: Intensive and extensive properties; state and path functions; isolated, closed and open systems. First law: Concept of heat, Q, work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of Q, W, ΔU and ΔH for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Thermochemistry: Enthalpy of reactions: standard states; enthalpy of formation and enthalpy of combustion and its	36

	<p>applications; effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.</p> <p>Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics. Calculation of entropy change for reversible and irreversible processes.</p> <p>Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.</p>	
2	<p>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.</p>	8
3	<p>Chemical Equilibrium: Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration (Le Chatelier Principle, Quantitatively)). Free energy of mixing and spontaneity. equilibrium between ideal gases and a pure condensed phase.</p>	8
4	<p>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</p> <ol style="list-style-type: none"> 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 	8

	solutes in solution.	
	<p>Practical</p> <p>Thermochemistry:</p> <p>a) Determination of heat capacity of a calorimeter for different volumes using</p> <p>(i) change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization), and</p> <p>(ii) heat gained equal to heat lost by cold water and hot water respectively</p> <p>b) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.</p> <p>c) Determination of the enthalpy of ionization of ethanoic acid.</p> <p>d) Determination of integral enthalpy (endothermic and exothermic) solution of salts.</p> <p>e) Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.</p> <p>f) Determination of enthalpy of hydration of salt.</p> <p>g) Study of the solubility of benzoic acid in water and determination of ΔH.</p> <p>Any other experiment carried out in the class.</p>	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Peter A., De Paula J., (2011). *Physical Chemistry* 9th Ed., Oxford University Press.
2. Castellan G. W., (2004). *Physical Chemistry* 4th Ed., Narosa.
3. Engel T., Reid P., (2012). *Physical Chemistry* 3rd Ed., Prentice-Hall.
4. Mc Quarrie D. A., Simon J. D., (2004). *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi.
5. Assael M. J., Goodwin A. R. H., Stamatoudis M., Wakeham W. A., Will S., (2011). *Commonly Asked Questions in Thermodynamics*. CRC Press: NY.
6. Levine I .N., (2010). *Physical Chemistry* 6th Ed., Tata Mc Graw Hill.
7. Metz C.R., (2006). *2000 solved problems in chemistry*, Schaum Series
8. Khosla B. D., Garg V. C., Gulati A., (2011). *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi.
9. Athawale V. D., Mathur P., (2001). *Experimental Physical Chemistry* New Age International: New Delhi.

SEMESTER – III

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Learn the fundamental principles of metallurgy and understand the importance of recovery of by products during extraction.
- CO2:** Understand the basic and practical applications in various fields of metals and alloy behaviour and their manufacturing processes.
- CO3:** Understand chemistry of s- & p-block elements.
- CO4:** Understand structure, bonding and properties of s- & p-block elements

CHE CC305 : Inorganic Chemistry-II		
PWC (Theory :4 credits +Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	General Principles of Metallurgy: Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, van Arkel-de Boer process and Mond's process, Zone refining.	6
2	Chemistry of s Block Elements: (i) General characteristics: melting point, flame colour, reducing nature, diagonal relationships and anomalous behavior of first member of each group. (ii) Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. (iii) Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates. (iv) Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. (v) Solutions of alkali metals in liquid ammonia and their properties.	22
3	Chemistry of p Block Elements: Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous	6

	behaviour of first member of each group.	
4	<p>Structure, bonding and properties: acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat of the following:</p> <p>a) Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH₃ where E = N, P, As, Sb, Bi), Group 16 and Group 17.</p> <p>b) Oxides: oxides of phosphorus, sulphur and chlorine</p> <p>c) Oxoacids: oxoacids of phosphorus and chlorine; peroxyacids of sulphur</p> <p>d) Halides: halides of silicon and phosphorus</p> <p>Preparation, properties, structure and uses of the following compounds:</p> <p>a) Borazine</p> <p>b) Silicates, silicones,</p> <p>c) Phosphonitrilic halides {(PNCl₂)_n where n = 3 and 4}</p> <p>d) Interhalogen and pseudohalogen compounds</p> <p>e) Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF₂).</p>	26
	<p>Practical</p> <p>(A) Iodo / Iodimetric Titrations</p> <p>i. Estimation of Cu(II) and K₂Cr₂O₇ using sodium thiosulphate solution (Iodometrically).</p> <p>ii. Estimation of antimony in tartar-emetic iodometrically</p> <p>(B) Complexometric titrations using disodium salt of EDTA</p> <p>i. Estimation of Mg²⁺, Zn²⁺</p> <p>ii. Estimation of Ca²⁺ by substitution method</p> <p>(C) Inorganic preparations</p> <p>i. Cuprous Chloride, Cu₂Cl₂</p> <p>ii. Manganese(III) phosphate, MnPO₄.H₂O</p> <p>iii. Aluminium potassium sulphate KAl(SO₄)₂.12H₂O (Potash alum) or Chrome alum.</p>	30

	TOTAL	90
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❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Lee J.D., (2010). *Concise Inorganic Chemistry*, Pearson Education
2. Douglas B.E., Mc Daniel D.H., Alexander J.J., (1994). *Concepts & Models of Inorganic Chemistry* 3rd Ed., John Wiley Sons, N.Y..
3. Greenwood N.N., Earnshaw (1997). *Chemistry of the Elements*, Butterworth-Heinemann.
4. Cotton F.A., Wilkinson G., (1999). *Advanced Inorganic Chemistry*, Wiley, VCH,.
5. Miessler G. L., Donald A. Tarr., (2009). *Inorganic Chemistry* 3rd Ed.(adapted), Pearson.
6. Shriver D.F., Atkins P.W., Langford C.H., (1994). *Inorganic Chemistry* 2nd Ed., Oxford University Press.
7. Vogel A.I., (1978). *A Textbook of Quantitative Inorganic Analysis*, ELBS.
8. Marr G., Rockett R.W., (1972). *Practical Inorganic Chemistry*, Van Nostrand Reinhold..

SEMESTER – III

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand preparation, properties and reactions of haloalkanes, haloarenes

CO2: Learn oxygen containing functional groups.

CO3: Understand the functional group transformations.

CO4: Propose plausible mechanisms for any relevant reaction.

CHE CC306 : Organic Chemistry-II**PWC (Theory :4 credits + Practical: 2 credits)**

Units	Topics to be covered	No. of hours
1	Chemistry of Halogenated Hydrocarbons: Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. Aryl halides: Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; S _N Ar, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.	16
2	Alcohols, Phenols, Ethers and Epoxides: Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, BouvaeltBlancReduction; Oxidation of diols by periodic acid and lead tetraacetate, PinacolPinacolone 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	16
3	Carbonyl Compounds : Structure, reactivity, preparation and properties; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and BenzilBenzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α - substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH ₄ , NaBH ₄ , MPV, PDC). Addition reactions of α , β -unsaturated carbonyl compounds: Michael addition.	16

	Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	
4	<p>Carboxylic Acids and their Derivatives: General methods of preparation, physical properties and reactions of monocarboxylic acids, effect of substituents on acidic strength. Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids.</p> <p>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.</p>	12
	<p>Practical</p> <p>1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.</p> <p>2. Organic preparations:</p> <ol style="list-style-type: none"> i. Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: <ol style="list-style-type: none"> a) Using conventional method. b) Using green approach ii. Benzoylation of one of the following amines (aniline, o-, m-, p-toluidines and o-, m, p-anisidine) and one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction. iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Selective reduction of meta dinitrobenzene to m-nitroaniline. v. Hydrolysis of amides and esters. vi. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. vii. S-Benzylisothiuronium salt of one each of water soluble and 	30

	<p>water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).</p> <p>viii. Aldol condensation using either conventional or green method. The above derivatives will be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.</p>	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Morrison R. T., Boyd R. N., (2007). *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar I. L., (2014). *Organic Chemistry* (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons T.W., *Organic Chemistry*, John Wiley & Sons, Inc.
4. Mann F.G., Saunders B.C.,(2009). *Practical Organic Chemistry*, Pearson Education
5. Furniss B.S., Hannaford A.J., Smith P.W.G., Tatchell A.R., (2012). *Practical Organic Chemistry*, 5th Ed., Pearson
6. Ahluwalia V.K., Aggarwal R., (2000). *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press.
7. Ahluwalia V.K., Dhingra S., (2000). *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press.

SEMESTER – III

Course Outcomes:

After completion of the course, students will be able to:

CO1: Gain the knowledge of different types of cell, their working and applications

CO2: Understand the concept of different types of Phases and their applications

CO3: Learn surface- and interfacial phenomena

CO4: Understand the interactions between colloidal particles and explain colloidal stability and instability.

CHE CC307 : Physical Chemistry III		
PWC (Theory: 4 credits+Practical:2 credits)		
Units	Topics to be covered	No. of hours
1	Phase Equilibria: 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 (H ₂ O and S), with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points. Three component systems: triangular plots, water-chloroform-acetic acid system. Binary solutions: Gibbs-DuhemMargules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.	27
2	Electrochemistry-I: 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.	5
3	Electrochemistry-II: Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction)	22

	<p>potential and its application to different kinds of half-cells. Application of EMF measurements in determining</p> <ol style="list-style-type: none"> i. free energy, enthalpy and entropy of a cell reaction, ii. equilibrium constants, and <p>pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb₂O₃ electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).</p>	
4	<p>Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms (Langmuir and Freundlich). Nature of adsorbed state. Qualitative discussion of BET.</p>	6
	<p>Practical</p> <p>Phase Equilibria:</p> <ol style="list-style-type: none"> I. Determination of critical solution temperature and composition at CST of the phenol-water system and to study the effect of impurities of sodium chloride and succinic acid on it. II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems. III. Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane. IV. Study the equilibrium of at least one of the following reactions by the distribution method: <ol style="list-style-type: none"> i. $I_2(aq) + I^-(aq) \rightarrow I_3^-(aq)$ ii. $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n^{2+}$ <p>Potentiometry:</p> <ol style="list-style-type: none"> V. Perform the following potentiometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Dibasic acid vs. strong base iv. Potassium dichromate vs. Mohr's salt 	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Atkins P., De Paula J., (2010). *Physical Chemistry* 9th Ed., Oxford University Press.
2. Castellan G. W., (2004). *Physical Chemistry*, 4th Ed., Narosa.
3. Mc Quarrie D. A., Simon J. D., (2004). *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi.
4. Engel T., Reid P., (2012). *Physical Chemistry* 3rd Ed., Prentice-Hall.
5. Assael M. J., Goodwin A. R. H., Stamatoudis M., Wakeham W. A., Will S., (2011). *Commonly Asked Questions in Thermodynamics*. CRC Press: NY.
6. Zundhal S.S., (2011). *Chemistry concepts and applications* Cengage India.
7. Ball D. W., (2012). *Physical Chemistry* Cengage India.
8. Mortimer R. G., (2009). *Physical Chemistry* 3rd Ed., Elsevier: NOIDA, UP.
9. Levine I. N., (2011). *Physical Chemistry* 6th Ed., Tata McGraw-Hill.
10. Metz C. R., (2009). *Physical Chemistry* 2nd Ed., Tata McGraw-Hill.
11. Khosla B. D., Garg V. C., Gulati A., (2011). *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi. 25
12. Garland C. W., Nibler J. W., Shoemaker D. P., (2003). *Experiments in Physical Chemistry* 8th Ed.; McGraw-Hill: New York.
13. Halpern A. M., Mc Bane G. C., (2003). *Experimental Physical Chemistry* 3rd Ed.; W.H. Freeman & Co.: New York.

SEMESTER – IV

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand chemistry of d & f-block elements

CO2: Gain Knowledge on the chemistry of coordination compounds and their properties.

CO3: Understand Latimer diagram, VBT and CFT for bonding in coordination compounds and synthesis & characterisation of coordination compounds

CO4: Analysis Inorganic reaction mechanism

CHE CC408 : Inorganic Chemistry III		
PWC (Theory:4 credits+Practical:2 credits)		
Units	Topics to be covered	No. of hours
1	Coordination Chemistry: Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of $10 Dq$ (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of $10 Dq$ (Δ_o , Δ_t). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.	26
2	Transition Elements: General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer diagrams) Different between the first, second and third transition series.	14

	Chemistry of Cr, Mn, Fe and Co in various oxidation states with special reference to the following compounds: peroxo compounds of chromium, potassium dichromate, potassium permanganate, potassium ferrocyanide, potassium ferricyanide, sodium nitroprusside and sodium cobaltinitrite.	
3	Lanthanoids and Actinoids: Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).	6
4	Inorganic Reaction Mechanism: Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect. Thermodynamic and Kinetic stability.	14
	<p>Practical</p> <p>Gravimetric Analysis:</p> <ol style="list-style-type: none"> Estimation of nickel (II) using Dimethylglyoxime (DMG). Estimation of copper as CuSCN Estimation of iron as Fe₂O₃ by precipitating iron as Fe(OH)₃. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)₃ (aluminium oxinate). <p>Inorganic Preparations:</p> <ol style="list-style-type: none"> Tetraamminecopper (II) sulphate, [Cu(NH₃)₄]SO₄.H₂O Acetylacetonate complexes of Cu²⁺/Fe³⁺ Tetraamminecarbonatocobalt (III) nitrate Potassium tri(oxalato)ferrate(III) <p>Properties of Complexes</p> <ol style="list-style-type: none"> Measurement of 10 Dq by spectrophotometric method Verification of spectrochemical series. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetonate, DMG, glycine) by substitution method. 	30

	TOTAL	90
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❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Purcell K.F., Kotz J.C., (1977). *Inorganic Chemistry* W.B. Saunders Co.,
2. Huheey J.E., (1993). *Inorganic Chemistry*, Prentice Hall,.
3. Cotton F.A., Wilkinson G., (1999). *Advanced Inorganic Chemistry* Wiley-VCH,
4. Basolo F., Pearson R.C., (1967). *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY.
5. Greenwood N.N., Earnshaw A., (1997). *Chemistry of the Elements*, Butterworth-Heinemann,.
6. Miessler G. L., Tarr Donald A., (2009). *Inorganic Chemistry* 3rd Ed.(adapted), Pearson,
7. Vogel A.I., (1986). *A text book of Quantitative Analysis*, ELBS.
8. Marr G., Rockett B.W., (1972). *Practical Inorganic Chemistry*, Van Nostrand Reinhold.

SEMESTER – IV

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand structure and properties of different N containing functional groups like amines, nitro, nitriles & isonitries and benzene diazonium chloride and the synthetic application of benzene diazonium chloride.
- CO2:** Comprehend the Polynuclear Hydrocarbon Structure elucidation and properties of different polynuclear hydrocarbons like naphthalene and anthracene.

CO3: Analysis the Different synthetic methods of synthesis of different heterocyclic compounds and the mechanism of different chemical reactions.

CO4: Synthesis and structure of different alkaloids and terpenes and their medicinal importance.

CHE CC409 : Organic Chemistry III		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Nitrogen Containing Functional Groups: Preparation and important reactions of nitro compounds, nitriles and isonitriles.</p> <p>Amines: Preparation and properties: Effect of substituent and solvent on basicity; 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.</p> <p>Diazonium Salts: Preparation and their synthetic applications.</p>	18
2	<p>Polynuclear Hydrocarbons: Aromaticity of polynuclear hydrocarbons, structure elucidation of naphthalene; Preparation and properties of naphthalene, phenanthrene and anthracene.</p>	8
3	<p>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), Indole(Fischer indole synthesis and Madelung synthesis), Quinoline and isoquinoline, (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner- Miller synthesis, Bischler-Napieralski reaction, PictetSpengler reaction, Pomeranz-Fritsch reaction)</p>	22
4	<p>a) Alkaloids: Natural occurrence, General structural features, Isolation and their physiological action,Hoffmann's exhaustive</p>	12

	<p>methylation, Emde's modification; Structure elucidation and synthesis of Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.</p> <p>b) Terpenes: Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral.</p>	
	<p>Practical</p> <p>1. Functional group test for nitro, amine and amide groups.</p> <p>2. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols, carbonyl compounds and esters)</p>	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Morrison R. T., Boyd R. N., (2007). *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar I. L., (2014). *Organic Chemistry* (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar I. L., (2014). *Organic Chemistry* (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Acheson R.M., (1976). *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons.
5. Graham Solomons T.W., *Organic Chemistry*, John Wiley & Sons, Inc.
6. Kalsi P. S., (2010). *Textbook of Organic Chemistry* 1st Ed., New Age International (P) Ltd. Pub.

7. Clayden J., Greeves N., Warren S., Wothers P., (2014). *Organic Chemistry*, Oxford University Press.
8. Singh J., Ali S.M., Singh, J., (2010). *Natural Product Chemistry*, PrajatiParakashan.
9. Mann F.G., Saunders B.C., (2009). *Practical Organic Chemistry*, Pearson Education
10. Furniss B.S., Hannaford A.J., Smith P.W.G., Tatchell A.R., (2012). *Practical Organic Chemistry*, 5th Ed., Pearson
11. Ahluwalia V.K., Aggarwal R., (2000). *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press.
12. Ahluwalia V.K., Dhingra S., (2000). *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press.

SEMESTER – IV

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand chemistry of conductance and its variation with dilution, migration of ions in solutions
- CO2:** Understand different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- CO3:** Rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatics.
- CO4:** Gain the knowledge of photochemical reactions.

<u>CHE CC410</u> : Physical Chemistry IV		
PWC (Theory :4 credits + Practical:2credits)		
Units	Topics to be covered	No. of hours
1	Conductance: Quantitative aspects of Faraday's laws of electrolysis Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and	18

	<p>strong electrolytes. Molar conductivity at 29 infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. 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:</p> <ol style="list-style-type: none"> 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 hydrolysis constants of salts. 	
2	<p>Chemical Kinetics: Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only):</p> <ol style="list-style-type: none"> i. Opposing reactions ii. parallel reactions and iii. consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) <p>chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.</p>	22
3	<p>Catalysis: Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.</p>	8
4	<p>Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, 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,</p>	12

	photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence	34
	<p>Practical</p> <p>Conductometry:</p> <ol style="list-style-type: none"> I. Determination of cell constant II. Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid. III. Perform the following conductometric titrations: <ol style="list-style-type: none"> i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Mixture of strong acid and weak acid vs. strong base iv. Strong acid vs. weak base <p>Chemical Kinetics:</p> <ol style="list-style-type: none"> IV. Study the kinetics of the following reactions. <ol style="list-style-type: none"> 1. Iodide-persulphate reaction <ol style="list-style-type: none"> (i) Initial rate method; (ii) Integrated rate method 2. Acid hydrolysis of methyl acetate with hydrochloric acid. 3. Saponification of ethyl acetate. 4. Comparison of the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate. 	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Atkins P.W., De Paula J., (2011). *Physical Chemistry*, 9th Ed., Oxford University Press.
2. Castellan G. W., (2004). *Physical Chemistry* 4th Ed., Narosa.

3. Mortimer R. G., (2009). *Physical Chemistry* 3rd Ed., Elsevier: NOIDA, UP.
4. Barrow G. M., (2006). *Physical Chemistry* 5th Ed., Tata McGraw Hill: New Delhi.
5. Engel T., Reid P., (2012). *Physical Chemistry* 3rd Ed., Prentice-Hall.
6. Rogers D. W., (2010). *Concise Physical Chemistry* Wiley.
7. Silbey R. J., Alberty R. A., Bawendi M. G., (2005). *Physical Chemistry* 4th Ed., John Wiley & Sons, Inc..
8. Khosla B. D., Garg V. C., Gulati A., (2011). *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi.
9. Garland C. W., Nibler J. W., Shoemaker D. P., (2003). *Experiments in Physical Chemistry* 8th Ed.; McGraw-Hill: New York.
10. Halpern A. M., Mc Bane G. C., (2003). *Experimental Physical Chemistry* 3rd Ed.; W.H. Freeman & Co.: New York.

SEMESTER – V

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand the biosynthesis of lipids, amino acids and nucleic acids, regulation of pathways, structure and function of biosynthetic enzymes, mechanisms of action of biosynthetic enzymes
- CO2:** Understand the nucleic acid structure – building blocks of both DNA and RNA, secondary structures, tertiary structures.
- CO3:** Understand the Concept of Bioenergetics, role of ATP in cellular reaction and free energy change, catabolic and anabolic reactions in biological system. Electron transfer agents in biological redox system. Pathways of carbohydrate catabolism Calorific values of food
- CO4:** Analysis the classification of pharmaceutical compound and the synthesis and uses of antipyretics antibiotics, antacids, & medicinal properties of haldi & neem.

CHE CC511 : Organic Chemistry IV		
PWC (Theory :4 credits + Practical:2credits)		
Units	Topics to be covered	No. of hours
1	<p>Amino Acids, Peptides and Proteins: Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups, Solid-phase synthesis; primary, secondary and tertiary structures of proteins, Denaturation</p> <p>Nucleic Acids: Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides (DNA and RNA).</p>	27
2	<p>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.</p> <p>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, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance.</p>	14
3	<p>Concept of Energy in Biosystems: Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism).</p> <p>ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD⁺, FAD.</p> <p>Conversion of food to energy: Outline of catabolic pathways of</p>	7

	carbohydrate- glycolysis, fermentation, Krebs cycle. Caloric value of food, standard caloric content of food types.	
4	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).	12
	Practical <ol style="list-style-type: none"> 1. Estimation of glycine by Sorenson's formalin method. 2. Study of the titration curve of glycine. 3. Estimation of proteins by Lowry's method. 4. Study of the action of salivary amylase on starch at optimum conditions. 5. Effect of temperature on the action of salivary amylase. 6. Saponification value of an oil or a fat. 7. Determination of Iodine number of an oil/ fat. 8. Isolation and characterization of DNA from onion/ cauliflower/peas. 	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Berg J.M., Tymoczko J.L., Stryer L., (2006). *Biochemistry*. VIth Edition. W.H. Freeman and Co.
2. Nelson D.L., Cox M.M., Lehninger A.L., (2009). *Principles of Biochemistry*. IV Edition. W.H. Freeman and Co.

3. Murray R.K., Granner D.K., Mayes P.A., Rodwell V.W., (2009). *Harper's Illustrated Biochemistry*. XXVIII edition .Lange Medical Books/ McGraw-Hill.
4. *Manual of Biochemistry Workshop*, (2012). Department of Chemistry, University of Delhi.
5. Arthur I. V.,(2014). *Quantitative Organic Analysis*, Pearson.

SEMESTER – V

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand limitations of classical mechanics and solution in terms of quantum mechanics for atomic and molecular systems.
- CO2:** Apply quantum mechanics operator, quantization, probability distribution.
- CO3:** Understand uncertainty principle and application of quantization to spectroscopy.
- CO4:** Interpret various types of spectra and their application in structure elucidation.

CHE CC512 : Physical Chemistry IV		
PWC (Theory :4credits + Practical:2credits)		
Units	Topics to be covered	No. of hours
1	<p>Quantum Chemistry: Postulates of quantum mechanics, quantum mechanical operators and commutation rules, Schrödinger equation and its application to free particle and —particle-in-a-box (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.</p> <p>Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation in Cartesian and spherical polar (Derivation not required). Separation of variables. Spherical harmonics. Discussion of solution (Qualitative).</p> <p>Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).</p>	20
2	<p>Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAOMO treatment of H₂ +. Bonding and antibonding orbitals. Qualitative extension to H₂. Comparison of LCAOMO and VB treatments of H₂ (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches</p>	10

	(Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH).	
3	<p>Molecular Spectroscopy: Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.</p> <p>Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.</p> <p>Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.</p> <p>Vibration-rotation spectroscopy: Diatomic vibrating rotator, P, Q, R branches.</p>	15
4	<p>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.</p> <p>Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.</p> <p>Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales (δ and T), spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.</p> <p>Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.</p>	15
	<p>Practical</p> <p>Colorimetry:</p>	30

	<p>I. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration</p> <p>II. Determine the concentrations of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture.</p> <p>III. Study the kinetics of iodination of propanone in acidic medium.</p> <p>IV. Determine the amount of iron present in a sample using 1, 10-phenanthroline.</p> <p>V. Determine the dissociation constant of an indicator (phenolphthalein).</p> <p>VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.</p> <p>VII. Analysis of the given vibration-rotation spectrum of $\text{HCl}(\text{g})$</p> <p>Adsorption</p> <p>VIII. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.</p> <p>UV/Visible spectroscopy:</p> <p>I. Study the 200-500 nm absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).</p> <p>II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $\text{K}_2\text{Cr}_2\text{O}_7$.</p> <p>III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.</p>	
TOTAL		90

❖ Two Practical Classes be treated as one (30 x 2=60 Hours)

Reading List:

1. Banwell C. N., Mc Cash E. M., (2006). *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi.
2. Chandra A. K., (2001). *Introductory Quantum Chemistry* Tata McGraw-Hill.
3. House J. E., (2004). *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA.
4. Lowe J. P., Peterson K., (2005). *Quantum Chemistry*, Academic Press.
5. Kakkar R., (2015). *Atomic & Molecular Spectroscopy*, Cambridge University Press.
6. Khosla B. D., Garg V. C., Gulati A., (2011). *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi.
7. Garland C. W., Nibler J. W., Shoemaker D. P., (2003). *Experiments in Physical Chemistry* 8th Ed.; McGraw-Hill: New York.
8. Halpern A. M., Mc Bane G. C., (2003). *Experimental Physical Chemistry* 3rd Ed.; W.H. Freeman & Co.: New York.

SEMESTER – VI

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand the classification based on nature of metal-carbon bond.

CO2: Understand chemistry and applications of 3d elements including their oxidation states and important properties of the familiar compounds potassium dichromate, potassium permanganate and potassium ferrocyanide.

CO3: Analysis the toxicity of metal ions through the study of Hg^{2+} and Cd^{2+} in the physiological system.

CO4: Apply the methods to catalyze the reaction by organometallic compounds.

CHE CC613 : Inorganic Chemistry IV		
PWC (Theory :4 credits+Practical:2credits)		
Units	Topics to be covered	No. of hours
1	Theoretical Principles in Qualitative Analysis (H₂S Scheme): Basic principles involved in analysis of cations and anions. Solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.	12
2	Organometallic Compounds: Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.	26

3	<p>Bioinorganic Chemistry: Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine, Cisplatin as an anti-cancer drug.</p> <p>Iron and its application in bio-systems, Haemoglobin, Myoglobin; Storage and transfer of iron.</p>	14
4	<p>Catalysis by Organometallic Compound: Study of the following industrial processes and their mechanism:</p> <ol style="list-style-type: none"> 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Synthetic gasoline (Fischer Tropsch reaction) <p>Polymerisation of ethene using Ziegler-Natta catalyst</p>	8
	<p>Practical</p> <p>Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis will 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-}, $\text{S}_2\text{O}_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}</p> <p>Mixtures will preferably contain one interfering anion, or insoluble component (BaSO_4, SrSO_4, PbSO_4, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^-, NO_3^- and I^-.</p> <p>Spot tests will be done whenever possible.</p> <p>Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:</p> <ol style="list-style-type: none"> i. Ni (II) and Co (II) ii. Cu(II) and Cd(II) 	30

	TOTAL	90
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❖ Two Practical Classes be treated as one (30 x 2=60 Hours)

Reading List:

1. Vogel A.I., (1972). *Qualitative Inorganic Analysis*, Longman,
2. Svehla G., (1996-03-07). *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall,.
3. Lippard S.J., Berg J.M., (1994). *Principles of Bioinorganic Chemistry* Panima Publishing Company.
4. Cotton F.A., Wilkinson G., Gaus P.L., (2007). *Basic Inorganic Chemistry* 3rd Ed.; Wiley India,
5. Huheey J. E., Keiter E.A., Keiter R.L., (2006). *Inorganic Chemistry, Principles of Structure and Reactivity* 4th Ed., Harper Collins 1993, Pearson,.
6. Sharpe A.G., (2005). *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education)
7. Douglas B. E., McDaniel D.H., Alexander J.J., (1994). *Concepts and Models in Inorganic Chemistry* 3rd Ed., John Wiley and Sons, NY.
8. Greenwood N.N., Earnshaw A., (1997). *Chemistry of the Elements* 2nd Ed, Elsevier, (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
9. Lee J.D., (2008). *Concise Inorganic Chemistry* 5th Ed., John Wiley and sons.
10. Powell P., (1988). *Principles of Organometallic Chemistry*, Chapman and Hall,.
11. Shriver D.D., Atkins P., Langford C.H., (1994). *Inorganic Chemistry* 2nd Ed., Oxford University Press,.
12. Purcell K.F., Kotz J.C., (1977). *Inorganic Chemistry*, W.B. Saunders Co.
13. Miessler G. L., Tarr Donald A., (2010). *Inorganic Chemistry* 4th Ed., Pearson,.
14. Collman James P. et al., (1987). *Principles and Applications of Organotransition Metal Chemistry*. Mill Valley, CA: University Science Books,.
15. Crabtree Robert H., (2000). *The Organometallic Chemistry of the Transition Metals*. John Wiley New York, NY,.

16. Spessard Gary O., Miessler Gary L., (1996). *Organometallic Chemistry*. Upper Saddle River, NJ: Prentice-Hall,.
17. Vogel's (2014). *Qualitative Inorganic Analysis*, Revised by G. Svehla.
18. Vogel A.I., (1986). *A Textbook of Quantitative Analysis*, ELBS.

SEMESTER – VI

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand general principal of UV, IR and NMR Spectroscopy and its application in the identification of organic molecules.

CO2: Understand Biological importance of carbohydrates and structure of different monosaccharides, disaccharides and polysaccharides.

CO3: Analysis different types of dyes, their synthesis and application in textile.

CO4: Apply different types of polymerization reaction and their application in the preparation of various polymers and their usefulness in different industries like automotive, packaging, aerospace etc.

CHE CC614 : Organic Chemistry V		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Organic Spectroscopy: General principles Introduction to absorption and emission spectroscopy.</p> <p>UV Spectroscopy: Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ_{max} for the following systems: α,β-unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes:</p>	24

	<p>alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.</p> <p>IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.</p> <p>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.</p> <p>Applications of IR, UV and NMR for identification of simple organic molecules.</p>	
2	<p>Carbohydrates: Occurrence, classification and their biological importance.</p> <p>Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.</p>	16
3	<p>Dyes: Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl orange; Triphenyl methane dyes Malachite green and Rosaniline ; Phthalein Dyes – Phenolphthalein; Natural dyes – structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.</p>	8

4	<p>Polymers: Introduction and classification including di-block, tri-block and amphiphilic polymers; Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to; Biodegradable and conducting polymers with examples.</p>	12
	<p>Practical</p> <ol style="list-style-type: none"> 1. Extraction of caffeine from tea leaves. 2. Preparation of urea formaldehyde resin. 3. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, e.g. salicylic acid, cinnamic acid, nitrophenols etc. 4. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided). <p>Preparation of methyl orange.</p>	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Kalsi P. S., (2010). *Textbook of Organic Chemistry* 1st Ed., New Age International (P) Ltd. Pub.

2. Morrison R. T., Boyd R. N., (2007). *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Billmeyer F. W., (2013). *Textbook of Polymer Science*, John Wiley & Sons, Inc.
4. Gowariker V. R., Viswanathan N. V., Sreedhar J., *Polymer Science*, New Age International (P) Ltd. Pub.
5. Finar I. L.,(2014). *Organic Chemistry* (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons T.W., *Organic Chemistry*, John Wiley & Sons, Inc.
7. Clayden J., Greeves N., Warren S., Wothers P., (2014). *Organic Chemistry*, Oxford University Press.
8. Singh J., Ali S.M., Singh, J., (2010). *Natural Product Chemistry*, PrajatiPrakashan.
9. Kemp W., *Organic Spectroscopy*, Palgrave
10. Vogel A.I., (2012). *Quantitative Organic Analysis*, Part 3, Pearson.
11. Mann F.G., Saunders B.C., (2009). *Practical Organic Chemistry*, Pearson Education
12. Furniss B.S., Hannaford A.J., Smith P.W.G., Tatchell A.R., (2012). *Practical Organic Chemistry*, 5th Ed., Pearson
13. Ahluwalia V.K., Agarwal R., (2000). *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press.
14. Ahluwalia V.K., Dhingra S., (2000). *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press.

Generic Elective Papers (GE) (6 credits each: Theory-04+Practical 02)

SEMESTER – I

Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/ subject and vice versa and such electives may also be referred to as Generic Elective.

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand the basic quantum chemistry and atomic structures of atoms.

CO2: Understand the chemical bonding from the valence bond model and molecular orbital theory.

CO3: Understand the fundamentals of electronic structure and bonding in conjugated and aromatic system.

CO4: Analysis the reactivity patterns of conjugated and aromatic molecules

CHE GE101 : Physical Chemistry & Organic Chemistry		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Physical Chemistry</p> <p>Atomic Structure: Review of Bohr's theory and its limitations, Heisenberg Uncertainty principle. Dual behaviour of matter and radiation, de-Broglie's relation. Hydrogen atom spectra. Need of a new approach to Atomic structure.</p> <p>What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special</p>	14

	<p>reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).</p> <p>Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.</p>	
2	<p>Inorganic Chemistry</p> <p>Chemical Bonding and Molecular Structure</p> <p>Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy (no derivation), Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.</p> <p>Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR (H_2O, NH_3, PCl_5, SF_6, ClF_3, SF_4) 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 of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+.</p>	16
3	<p>Organic Chemistry</p> <p>Fundamentals of Organic Chemistry: Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and</p>	18

	<p>Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Reaction intermediates: Carbocations, Carbanions and free radicals. Electrophiles and nucleophiles</p> <p>Aromaticity: Benzenoids and Hückel's rule.</p> <p>Stereochemistry: Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).</p>	
4	<p>Aliphatic Hydrocarbons: Functional group approach for the following reactions (preparations physical property & chemical reactions) to be studied with mechanism in context to their structure.</p> <p>Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, Grignard reagent. Reactions: Free radical Substitution: Halogenation.</p> <p>Alkenes: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO₄) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.</p> <p>Alkynes: Preparation: Acetylene from CaC₂ and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides and acidity of alkynes, addition of bromine and alkaline KMnO₄, ozonolysis and oxidation with hot alk. KMnO₄. Hydration to form carbonyl compounds</p>	12
	<p>Practical</p> <p>Inorganic Chemistry - Volumetric Analysis</p>	30

	<ol style="list-style-type: none"> 1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. 2. Estimation of oxalic acid by titrating it with KMnO_4. 3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4. 4. Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator. 5. Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$. <p>Organic Chemistry</p> <ol style="list-style-type: none"> 1. Purification of OC by crystallisation (from water and alcohol) and distillation. 2. Criteria of purity: Determination of Mpt/Bpt 3. Detection of extra elements (N, S, Cl, Br, I) in organic compounds 4. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given) <ol style="list-style-type: none"> a) 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 b) Identify and separate the sugars present in the given mixture by paper chromatography 	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Lee J. D., (2010). *A new Concise Inorganic Chemistry*, E L. B. S.17

2. Cotton F. A., Wilkinson G., (2007). *Basic Inorganic Chemistry*, John Wiley.
3. Douglas Mc Daniel, Alexander (1970). *Concepts and Models in Inorganic Chemistry*, John Wiley.
4. Huheey James E., Keiter Ellen, Keiter Richard (2006). *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Publication.
5. Graham Solomon T. W., *Organic Chemistry*, John Wiley and Sons.
6. Sykes Peter (2011). *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
7. Eliel E. L., (2005). *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
8. Finar I. L., (2014). *Organic Chemistry (Vol. I & II)*, E. L. B. S.
9. Morrison R. T., Boyd R. N., (2007). *Organic Chemistry*, Prentice Hall.
10. Bahl Arun, Bahl B. S., (2012). *Advanced Organic Chemistry*, S. Chand
11. Atkins Overton, Rourke Weller, Armstrong Shriver, Atkins, (1994). *Inorganic Chemistry*, Oxford
12. Vogel A.I., (2014). *Vogel's Qualitative Inorganic Analysis*, Prentice Hall, 7th Edition.
13. Vogel A.I., (2014). *Vogel's Quantitative Chemical Analysis*, Prentice Hall, 6th Edition.
14. Vogel A.I., (2014). *Textbook of Practical Organic Chemistry*, Prentice Hall, 5th edition.
15. Mann F. G., Saunders B. C., (1960). *Practical Organic Chemistry*, Orient Longman,.

SEMESTER – II

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand application of mathematical tools to calculate thermodynamic properties and physical phenomena associated to chemical thermodynamics and its relationship with thermo dynamic quantities.
- CO2:** Understand relationship between microscopic properties of molecules with

macroscopic thermodynamic observables and derivation of rate equations from mechanistic data.

CO3: Analysis how to predict the outcome of organic reactions using a basic understanding of the general reactivity of functional groups and mechanism.

CO4: Design the nucleophilic substitution reactions.

CHE GE202 : Physical Chemistry & Functional Group Organic Chemistry - I		
PWC (Theory : 4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Physical Chemistry</p> <p>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.</p> <p>Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.</p>	10
2	<p>Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G_0, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.</p> <p>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</p>	20

	<p>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.</p>	
3	<p>Organic Chemistry-I</p> <p>Functional group approach for the following reactions (preparations physical properties and Chemical reactions) to be studied in context to their structure with mechanism.</p> <p>Aromatic hydrocarbons</p> <p>Preparation (benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.</p> <p>Reactions: (benzene): Electrophilic substitution reactions: nitration, halogenation sulphonation. Friedel-Craft's reaction (alkylation and acylation) Side chain oxidation of alkyl benzenes.</p> <p>Organic Chemistry-2</p> <p>Functional group approach for the following reactions (preparations physical properties and Chemical reactions) to be studied in context to their structure with mechanism.</p> <p>Aromatic hydrocarbons</p> <p>Preparation (benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.</p> <p>Reactions: (benzene): Electrophilic substitution reactions: nitration, halogenation sulphonation. Friedel-Craft's reaction (alkylation and acylation) Side chain oxidation of alkyl benzenes.</p>	8
4	<p>Alkyl and Aryl Halides</p> <p>Alkyl Halides .</p> <p>Preparation: from alkenes and alcohols.</p> <p>Reactions: Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions, hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.</p>	22

Aryl Halides Preparation:(Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic electrophilic and nucleophilic substitution (replacement by – OHgroup) and effect of nitro substituent.

Benzyne Mechanism: KNH_2/NH_3 (or $\text{NaNH}_2/\text{NH}_3$).

Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards Nucleophilic substitution reactions.

(Alcohols, Phenols and Ethers)

Alcohols:

Preparation:Preparation of 1o, 2o and 3o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO_4 , acidic dichromate, conc. HNO_3), factors affecting acidity, Oppeneauer oxidation

Diols: 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, Houben–Hoesch Condensation, Schotten – Baumann Reaction. acidity and factors affecting

Ethers (aliphatic and aromatic).

Preparation : Williamson ether synthesis.

Reactions: Cleavage of ethers with HI

Aldehydes and ketones (aliphatic and aromatic):

Preparation: from acid chlorides and from nitriles.

Reactions: Nucleophilic addition, Nucleophilic addition – elimination

	<p>reaction including Reaction with HCN, ROH, NaHSO₃, NH₂-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.</p>	
	<p>Practical</p> <p>Physical Chemistry</p> <p>Thermochemistry</p> <ol style="list-style-type: none"> 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 H. <p>Ionic equilibria pH measurements</p> <ol style="list-style-type: none"> 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: <ol style="list-style-type: none"> (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values. <p>Organic Chemistry</p> <ol style="list-style-type: none"> 1. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done. <ol style="list-style-type: none"> (a) Nitration of Phenol/Aniline 	30

	(b) Benzoylation of amines/phenols (c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone 2. Systematic Qualitative organic analyses of organic compounds possessing monofunctional groups (Alcohols, Phenols, Carbonyl,- COOH) and preparation of one suitable derivative.	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Graham Solomons T. W., *Organic Chemistry*, John Wiley and Sons.
2. Peter Sykes, (2011). *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
3. Finar I.L., (2014). *Organic Chemistry* (Vol. I & II), E. L. B. S.
4. Morrison R. T., Boyd R. N., (2007). *Organic Chemistry*, Prentice Hall.
5. Arun Bahl, Bahl B. S., (2012). *Advanced Organic Chemistry*, S. Chand.
6. Barrow G. M., (2007). *Physical Chemistry* Tata McGraw Hill.
7. Castellan G. W., (2004). *Physical Chemistry* 4th Edn. Narosa.
8. Kotz J. C., Treichel P. M., Townsend J. R., (2009). *General Chemistry* Cengage Lening India Pvt. Ltd., New Delhi.
9. Mahan B. H., (1998). *University Chemistry* 3rd Ed. Narosa.
10. Petrucci R. H., (1985). *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York.
11. Vogel A.I., (2014). *Textbook of Practical Organic Chemistry*, 5th edition, Prentice-Hall.
12. Mann F. G., Saunders B. C., (1960). *Practical Organic Chemistry*, Orient Longman.
13. Khosla B.D., *Senior Practical Physical Chemistry*, Chand R. & Co.

SEMESTER – III

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Explain the concepts of different types of binary solutions-miscible, partially miscible and immiscible along with their applications.
- CO2:** Explain the thermodynamic aspects of equilibria between phases and draw phase diagrams of simple one component and two component systems.
- CO3:** Explain the factors that affect conductance, migration of ions, different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties.
- CO4:** Understand and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biosynthesis of carbohydrates, amino acids and nucleic acids.

CHE GE303 : Physical Chemistry & Functional Group Organic Chemistry-II		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Physical Chemistry</p> <p>Solutions: Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature- composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.</p> <p>Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.</p> <p>Phase Equilibrium: Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its</p>	30

	<p>thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, FeCl₃-H₂O and Na-K only).</p> <p>Conductance: Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.</p> <p>Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).</p> <p>Electrochemistry: Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.</p> <p>pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).</p>	
2	<p>Functional Group Organic Chemistry – II</p> <p>Carboxylic acids and their derivatives: Carboxylic acids (aliphatic and aromatic)</p> <p>Preparation: Acidic and Alkaline hydrolysis of esters.</p> <p>Reactions: Hell - Vohlard - Zelinsky Reaction, Acidity of carboxylic</p>	12

	<p>acid, effect of substitution on acid strength.</p> <p>Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion claisen condensation . Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky Reaction, Perkin condensation.</p> <p>Amines and Diazonium Salts Amines (Aliphatic and Aromatic): Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, reaction with HNO₂, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation basic character of amines. .</p> <p>Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.</p>	
3	<p>Amino Acids, Peptides and Proteins: Zwitterion, Isoelectric point and Electrophoresis Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Reactions of Amino acids: ester of –COOH group, acetylation of –NH₂ group, complexation with Cu²⁺ ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N- terminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.</p>	10
4	<p>Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of</p>	8

	<p>configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.</p>	
	<p>Practical</p> <p>Physical Chemistry</p> <p>Distribution: Study of the equilibrium of one of the following reactions by the distribution method:</p> <p>$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$</p> <p>$Cu^{2+}(aq) + xNH_3(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$</p> <p>Phase equilibria</p> <ol style="list-style-type: none"> a. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves. b. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it. c. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature. <p>Conductance</p> <ol style="list-style-type: none"> 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: <ol style="list-style-type: none"> i. Strong acid vs. strong base ii. Weak acid vs. strong base <p>Potentiometry</p> <p>Perform the following potentiometric titrations:</p> <ol style="list-style-type: none"> i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Potassium dichromate vs. Mohr's salt 	30

	<p>Organic Chemistry- I</p> <p>Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (amide, nitro, amines, Hydrocarbons, Halo Hydrocarbons) and preparation of one derivative.</p> <p>II</p> <p>1) Determination of the concentration of glycine solution by formylation method</p> <p>2) Action of salivary amylase on starch</p> <p>3) Differentiation between a reducing and nonreducing sugar</p>	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. G. M., (2007). *Physical Chemistry* Tata McGraw Hill.
2. Barrow Castellan G. W., (2004). *Physical Chemistry* 4th Ed. Narosa.
3. Kotz J. C., Treichel P. M., Townsend J. R., (2009). *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi.
4. Mahan B. H., (1998). *University Chemistry*, 3rd Edn. Narosa.
5. Petrucci R. H., (1985). *General Chemistry*, 5th Edn., Macmillan Publishing Co.: New York.
6. Morrison R. T., Boyd R. N., (2007). *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar I. L., (2014). *Organic Chemistry* (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar I. L., (2014). *Organic Chemistry* (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Nelson D. L., Cox M., Lehninger's M., *Principles of Biochemistry* 7th Ed., W. H. Freeman.
10. Berg J. M., Tymoczko J. L., Stryer L., *Biochemistry* 7th Ed., W. H. Freeman

11. Vogel A.I., (2014). *Textbook of Practical Organic Chemistry*, Prentice Hall, 5th Edn.
12. Mann F. G., Saunders B. C., (1960). *Practical Organic Chemistry*, Orient Longman,.
13. Khosla B.D., *Senior Practical Physical Chemistry*, R. Chand & Co.
14. Ahluwalia V.K., Aggarwal R., *Comprehensive Practical Organic Chemistry*, Universities Press.

SEMESTER – IV

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand chemistry of s- and p-block elements.

CO2: Understand chemical kinetics; how reaction rates are measured and represented in rate laws, and applications of chemical kinetics in studying enzyme mechanisms.

CO3: Analysis Chemistry of different types of phases such as solid and liquid phase.

CO4: Analysis the basic (colligative) properties of solutions.

CHE GE404 : Physical Chemistry & Inorganic Chemistry		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Inorganic Chemistry</p> <p>Principles of Metallurgy: Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.</p> <p>Hydrometallurgy with reference to cyanide process for silver and gold, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, van Arkel-de Boer process and Mond's process.</p>	4
2	<p>s- and p-Block Elements: Periodicity in s- and p-block elements with</p>	26

	<p>respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred-Rochow scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.</p> <p>Compounds of s- and p-Block Elements: Diborane and concept of multicentre bonding Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial and environmental chemistry.</p> <p>Hydrides of nitrogen (NH₃, N₂H₄, N₃H, NH₂OH) Oxoacids of P, S and Cl. Halides and oxohalides: XPCl₃, PCI₅, SOCl₂ and SO₂Cl₂</p>	
3	<p>Physical Chemistry</p> <p>Kinetic Theory of Gases: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.</p> <p>Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO₂.</p> <p>Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.</p> <p>Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).</p> <p>Liquids: Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and</p>	22

	<p>coefficient of viscosity of a liquid (qualitative treatment only)</p> <p>Solids: Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals.</p> <p>Glasses and liquid crystals.</p>	
4	<p>Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.</p> <p>Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).</p>	8
	<p>Practical</p> <p>Inorganic Chemistry: Semi-micro qualitative analysis of mixtures using H₂S or any other scheme- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:</p> <p>Cations :</p> <p>NH₄⁺ , Pb²⁺ , Bi³⁺ , Cu²⁺ , Fe³⁺ , Al³⁺ , Co²⁺ , Ni²⁺ , Mn²⁺ , Zn²⁺ , Ba²⁺ , Sr²⁺ , Ca²⁺ , K⁺</p> <p>Anions :</p>	30

	<p>CO₃²⁻, S²⁻, SO₃²⁻, NO₃⁻, CH₃COO⁻, Cl⁻, Br⁻, I⁻, NO₃⁻, SO₄²⁻, PO₄³⁻, BO₃³⁻, C₂O₄²⁻, F⁻ (Spot tests will be carried out wherever feasible)</p> <p>Physical Chemistry</p> <p>1) Surface tension measurement (use of organic solvents excluded).</p> <p>a. Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.</p> <p>b. Study of the variation of surface tension of a detergent solution with concentration.</p> <p>(II) Viscosity measurement (use of organic solvents excluded).</p> <p>a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.</p> <p>b) Study of the variation of viscosity of an aqueous solution with concentration of solute.</p> <p>(III) Chemical Kinetics</p> <p>Study the kinetics of the following reactions.</p> <p>1. Initial rate method: Iodide-persulphate reaction</p> <p>2. Integrated rate method:</p> <p>a. Acid hydrolysis of methyl acetate with hydrochloric acid.</p> <p>b. Saponification of ethyl acetate.</p> <p>Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetates</p>	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Barrow G. M., (2007). *Physical Chemistry* Tata McGraw Hill.
2. Castellan G.W., (2004). *Physical Chemistry* 4th Edn. Narosa.
3. Kotz J. C., Treichel P. M., Townsend J. R., *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan B. H., (1998). *University Chemistry* 3rd Ed. Narosa.

5. Petrucci R. H., (1985). *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York.
6. Lee J. D., (2010). *A New Concise Inorganic Chemistry*, E.L.B.S.
7. Cotton F.A., Wilkinson G., (2007). *Basic Inorganic Chemistry*, John Wiley.
8. Shriver D. F., Atkins P. W., *Inorganic Chemistry*, Oxford University Press.
9. Gary Wulfsberg, *Inorganic Chemistry*, Viva Books Pvt. Ltd.
10. Miessler G. L., Donald Tarr. A., (2009). *Inorganic Chemistry* 3rd Ed.(adapted), Pearson, ISBN 978-81-31718858.
11. Vogel A.I., (2014). *Qualitative Inorganic Analysis*, Prentice Hall, 7th Edn.
12. Vogel A.I., (2014). *Quantitative Chemical Analysis*, Prentice Hall, 6th Edn.
13. B.D. Khosla, *Senior Practical Physical Chemistry*, R. Chand & Co.

Discipline Specific Elective (DSE) (6 credits each)

SEMESTER – V

Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Understand composition and applications of the different kinds of glass, glazing of ceramics and the factors affecting their porosity.
- CO2:** Understand suitability of fertilizers for different kinds of crops and soil.
- CO3:** Apply process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
- CO4:** Analysis principle, working and applications of different batteries and synthesis and properties of nano-dimensional materials, various semiconductor and superconductor oxides.

CHE DSE501 : Inorganic Materials Of Industrial Importance		
PWC (Theory :4 credits+ Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Silicate Industries:</p> <p>Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.</p> <p>Ceramics: Brief introduction to types of ceramics. Superconducting and semiconducting oxides, fullerenes, carbon nanotubes and carbon fibre.</p> <p>Cements: Manufacture of cement and the setting process, quick setting cements.</p>	16
2	<p>Fertilizers: Different types of fertilizers (N, P and K). Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, super phosphate of lime.</p> <p>Surface Coatings: Brief introduction to and classification of surface coatings. Paints and pigments - formulation, composition and related properties. Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.</p>	12
3	<p>Batteries: Working of the following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.</p>	10
4	<p>Catalysis: General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.</p>	12

	Application of zeolites as catalysts. Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.	
	Practical 1. Determination of free acidity in ammonium sulphate fertilizer. 2. Estimation of Calcium in Calcium ammonium nitrate fertilizer. 3. Estimation of phosphoric acid in superphosphate fertilizer. 4. Electroless metallic coatings on ceramic and plastic material. 5. Determination of composition of dolomite (by complexometric titration). 6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples. 7. Analysis of Cement. 8. Preparation of pigment (zinc oxide).	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Stocchi E., (1990). *Industrial Chemistry*, Vol I, Ellis Horwood Ltd. UK,
2. Felder R. M., Rousseau R.W., (2005). *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi,.
3. Kingery W. D., Bowen H. K., Uhlmann D. R., (1976). *Introduction to Ceramics*, Wiley Publishers, New Delhi,.
4. Kent J. A., (ed) Riegel's (1997). *Handbook of Industrial Chemistry*, 9th Ed., CBS Publishers, New Delhi,
5. Jain P. C., Jain M., (2005). *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi
6. Gopalan R., Venkappayya D., Nagarajan S., (2004). *Engineering Chemistry*, Vikas Publications, New Delhi,.
7. Sharma B. K., (2006). *Engineering Chemistry*, Goel Publishing House, Meerut,

SEMESTER – V

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand how to perform experiment with accuracy and precision.

CO2: Understand how to test contaminated water samples.

CO3: Gain the knowledge of geometrical isomers and keto-enol tautomers to analysis.

CO4: Analysis how to determine composition of soil and macronutrients using Flame photometry and UV-vis spectrophotometer.

CHE DSE502 : Analytical Methods In Chemistry		
PWC (Credits: Theory-04, Practicals-02)		
Units	Topics to be covered	No. of hours
1	Qualitative and quantitative aspects of analysis: Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals	5
2	Optical methods of analysis: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. 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	25

	quantitative estimation of trace level of metal ions from water samples.	
3	<p>Thermal methods of analysis: Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.</p> <p>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</p>	15
4	<p>Separation techniques:</p> <p>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.</p> <p>Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.</p> <p>Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.</p>	15
	<p>Practical</p> <p>ANALYTICAL METHODS IN CHEMISTRY</p> <p>I. Separation Techniques</p> <p>Chromatography:</p> <p>(a) Separation of mixtures</p> <p>(i) Paper chromatographic separation of Co^{2+} and Ni^{2+}.</p> <p>(ii) Analysis of soil:</p> <p>Separation and identification of the amino acids present in the given mixture by paper chromatography. Reporting the R_f values.</p> <p>II. Solvent Extractions:</p> <p>(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and</p>	30

	<p>extracting the Ni²⁺- DMG complex in chloroform, and determine its concentration by spectrophotometry.</p> <p>(i) Determination of pH of soil. (ii) Total soluble salt (iii) Estimation of calcium, magnesium (iv) Qualitative detection of nitrate, phosphate</p> <p>Ion exchange:</p> <p>(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.</p> <p>(ii) Separation of amino acids from organic acids by ion exchange chromatography.</p> <p>III Spectrophotometry</p> <p>Verification of Lambert-Beer's law and determination of concentration of a coloured species (CuSO₄, KMnO₄)</p>	
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Vogel Arthur, (2014). *A Text book of Quantitative Inorganic Analysis* (Rev. by G.H. Jeffery and others) 5th Ed. The English Language Book Society of Longman .
2. Willard Hobart H. et al., (1988). *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,.
3. Christian Gary D., (2004). *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, .
4. Harris Daniel C., (2001). *Exploring Chemical Analysis*, Ed. New York, W.H. Freeman,.
5. Khopkar S.M., (2009). *Basic Concepts of Analytical Chemistry*. New Age, International Publisher,.
6. Skoog D. A., Holler F.J., Nieman T.A., (1998). *Principles of Instrumental Analysis*, Thomson Asia Pvt. Ltd. Singapore,.

7. Mikes O., Chalmers R.A., Ed. *Laboratory Hand Book of Chromatographic and Allied Methods*, Elles Horwood Ltd. London.
8. Dilts R.V., (1974). *Analytical Chemistry – Methods of separation* Van Nostrand.

SEMESTER – VI

Course Outcomes:

After completion of the course, students will be able to:

CO1: Understand Different sources of energy The different toxic gases and their toxicity hazards.

CO2: Analysis the Manufacturing processes, handling and storage of inorganic chemicals and hazardous effects of the inorganic chemicals on human beings and vegetation.

CO3: Understand the Composition of air, various air pollutants, effects and control measures of air pollutants.

CO4: Gain the knowledge of Different sources of water, water quality parameters, impacts of water pollution, water treatment.

CHE DSE603 : Industrial Chemicals And Environment		
PWC (Theory :4 credits + Practical: 2 credits)		
Units	Topics to be covered	No. of hours
1	<p>Industrial Gases and Inorganic Chemicals</p> <p>Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene. Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt,</p>	10

	borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate	
2	Industrial Metallurgy: Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.	4
3	<p>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, NO_x, H₂S and other foul smelling gases. Methods of estimation of CO, NO_x, SO_x 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. Control of particulates.</p> <p>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, agro, fertilizer, etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.</p>	30
4	<p>Energy & Environment Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.</p> <p>Biocatalysis Introduction to biocatalysis: Importance in —Green</p>	16

	Chemistryll and Chemical Industry.	
	<p>Practical</p> <ol style="list-style-type: none"> 1. Determination of dissolved oxygen 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 (CO₃²⁻, HCO₃⁻) 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. 	30
	TOTAL	90

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Stocchi E., *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. Felder R.M., Rousseau R.W., *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. Kent J. A., *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. Dara S. S., *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. De K., *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. Khopkar S. M., *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
7. Manahan S.E., (2005). *Environmental Chemistry*, CRC Press.
8. Miller G.T., (2006). *Environmental Science 11th edition*. Brooks/ Cole.

9. Mishra A., (2005). *Environmental Studies*. Selective and Scientific Books, New Delhi.

SEMESTER – VI

Course Outcomes:

After completion of the course, students will be able to:

CO1: Do survey, study and cite published literature on a particular area of interest.

CO2: Correlate the experimental observations with theoretical understanding.

CO3: Interpret results, write a report and submit to the supervisor.

CO4: Develop scientific writing skills

CHE DSE604 : Dissertation (6 Credits)		
PWC		
Unit	Topics to be covered	No. of hours
1	<p>Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester.</p> <p>Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.</p> <p>Project work/Dissertation is considered as a special course involving application of knowledge involving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper</p>	
	TOTAL	90

Skill Enhancement Course (SEC)(2Credits)

SEMESTER – III

Skill Enhancement Courses (SEC): These courses may be chosen from a pool of courses designed to provide **value-based and/or skill-based knowledge**.

Course Outcomes:

After completion of the course, students will be able to:

CO1:

CO2:

CO3:

CO4:

IRS SEC301 : Inter-Religious Studies (Value Based) (02credits)		
PWC		
Unit	Topics to be covered	No. of hours
1	Nature and Need of Inter-Religious study, Scope of Comparative Religion.	05
2	Salient Features of Hinduism, Jainism and Buddhism, Salient Features of Christianity, Islam and Sikhism.	10
3	Similarities and Differences among Religions, Conflicting Truth claims of different religions and inter-religious Harmony.	10
4	Religious Tolerance, Secularism.	05
	TOTAL	30

Reading List :

1. Chaudhary, C. Neeraj (1979). "Hinduism", B.I. Publication, New Delhi.
2. Devraj, N.K., (1917)-"Hinduism and Christianity" Asian Publishing House.
3. Gordh, George, -"Christian Faith and its Cultural Exoperssion", Printed in USA.
4. Hick, John,- "Philosophy of Religion", Prentice Hall of India.
5. Hopfe, M.Lewis(1983)- "Religion of the World", Macmillan Publishing Co. Inc, New York
6. Masih, Y. (1990)- "Comparitive study of Relgion", Motilal Banarasidass.
7. Sethi, S. Arijit, Pummer, Reinhard, (1979)-"Comparitive Religion", Vikas Publishing House pvt. ltd, Delhi.
8. Singh, B.N.,(1994)-"Vishwa Dharma Darshan ki Samasyain", Ratna Printing Works.
9. Tiwari, Nath Kedar,(1983)-"Comparative Religion", Motilal Banarasidass.
10. Ward, CHS (1998) – 'Early Buddhism", Caxton Publication, Delhi.

SEMESTER – IV

Course Outcomes:

After completion of the course, students will be able to:

- CO1:** Handle analytical data and determine composition and pH of soil, which can be useful in agriculture.
- CO2:** Do quantitative analysis of metal ions in water.
- CO3:** Separate mixtures using separation techniques.
- CO4:** Estimate macro nutrients using Flame photometry.

CHE SEC402 : Basic Analytical Chemistry		
PWC (Credit: 02 each)		
Units	Topics to be covered	No. of hours
1	Introduction: Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.	15
2	Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators a) Determination of pH of soil samples. b) Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.	15
3	Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. Determination of pH, acidity and alkalinity of a water sample. Determination of dissolved oxygen (DO) of a water sample.	15
4	Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc. Paper chromatographic separation of mixture of metal ion (Ni^{2+} and Co^{2+}). Ion-exchange: Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible). Suggested Applications (Any one): a) To study the use of phenolphthalein in trap cases. b) To analyze arson accelerants. c) To carry out analysis of gasoline. Suggested Instrumental demonstrations: a) Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.	15

	b) Spectrophotometric determination of Iron in Vitamin / Dietary Tablets. c) Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.	
	TOTAL	60

❖ **Two Practical Classes be treated as one (30 x 2=60 Hours)**

Reading List:

1. Willard H. H., (1988). *Instrumental Methods of Analysis*, CBS Publishers,.
2. Skoog D.A., Leary J.J., (1992). *Instrumental Methods of Analysis*, Saunders College Publications, New York,
3. Skoog D.A., West D.M., Holler F.J., (1992). *Fundamentals of Analytical Chemistry* 6th Ed., Saunders College Publishing, Fort Worth,
4. Harris D. C., (2007). *Quantitative Chemical Analysis* 7th Ed., W. H. Freeman and Co., New York,
5. Dean J. A., (2007). *Analytical Chemistry Handbook*, McGraw Hill,
6. Day R. A., Underwood A. L., (1991). *Quantitative Analysis*, Prentice Hall of India,
7. Freifelder D., (1982). *Physical Biochemistry* 2nd Ed., W.H. Freeman and Co., N.Y.
8. Cooper T.G., (Ed.) (1977). *The Tools of Biochemistry*, John Wiley and Sons, N.Y.
9. Svehla G., (1996). *Vogel's Qualitative Inorganic Analysis* 7th Ed., Prentice Hall,
10. Mendham J., Denney R.C., Barnes J.D., Thomas M.J.K., (2007). *Vogel's Quantitative Chemical Analysis* 6th Ed., Prentice Hall,.
11. Robinson J.W., (1995). *Undergraduate Instrumental Analysis* 5th Ed., Marcel Dekker, Inc., New York