FACULTY OF SCIENCES

SYLLABUS FOR THE

SUBJECT: CHEMISTRY

for the award of the Degree in

BACHELOR OF ARTS/ BACHELOR OF SCIENCE/ HONOURS

(Offered under 4-year UG Degree Programme)

(Credit Based Grading System)
under NEP 2020

Batch: 2024–28

GURU NANAK DEV UNIVERSITY AMRITSAR

(ii) Syllabi are subject to change at the discretion of the authority.
Please visit the University website from time to time.

Bachelor of Arts /Bachelor of Science/Honours Chemistry (CBGS)
(under NEP 2020) *(Batch 2024-28) (Semester I-VIII)*
(Faculty of Sciences)

SCHEME

CHEMISTRY

FIRST SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Inorganic Chemistry-I: Atomic structure and periodic table	4-0-0
2.		Inorganic Chemistry-I: Lab qualitative analysis	0-0-1

SECOND SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Organic Chemistry-I: Hydrocarbons and alkyl halides	4-0-0
2.		Organic Chemistry-I: Lab Functional group analysis	0-0-1

THIRD SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Physical Chemistry-I: States of matter and electrochemistry	4-0-0
2.		Physical Chemistry-I: Lab	0-0-1

FOURTH SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Inorganic Chemistry-II: Periodic table and coordination chemistry	4-0-0
2.		Inorganic Chemistry-II: Lab Volumetric/Gravimetric analysis and preparations	0-0-1

Bachelor of Arts /Bachelor of Science/Honours Chemistry (CBGS)
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FIFTH SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Organic Chemistry-II: Chemistry of O/N containing compounds	4-0-0
2.		Organic Chemistry-II: Lab Preparations-I	0-0-1
		Summer Internship	
3.		Summer Internship (02 Weeks)	0-0-2

SIXTH SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Physical Chemistry-II: Thermodynamics and equilibrium	4-0-0
2.		Physical Chemistry-II: Lab	0-0-1

SEVENTH SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Physical Chemistry-III: Chemical kinetics	3-0-0
2.		Organic Chemistry-IV: Structure-reactivity relationship	3-0-0
3.		Inorganic Chemistry-III: Organometallics	3-0-0
4.		Physical Chemistry-IV: Thermodynamics of biopolymer solution	3-0-0
5.		Organic Chemistry-III: Lab Preparations-II	0-0-2
6.		Physical Chemistry-III: Lab	0-0-2
		Minor Stream Courses	
7.		Synthesis and characterization of materials	4-0-0
		Summer Internship	
8.		Summer Internship (02 Weeks)	0-0-2

Bachelor of Arts /Bachelor of Science/Honours Chemistry (CBGS)
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(Faculty of Sciences)

EIGHTH SEMESTER

Sr. No.	Course Code	Course Title	Credits
		Major Core Course	
1.		Inorganic Chemistry-IV: Cluster and cage compounds	4-0-0
2.		Organic Chemistry-V: Organic synthesis-I	4-0-0
3.		Inorganic Chemistry-V: Nuclear chemistry	3-0-0
4.		Physical Chemistry-V: Electroanalytical techniques	3-0-0
5.		Inorganic Chemistry-III: Lab	0-0-2
		Minor Stream Courses	
6.		Atomic and molecular spectroscopy	4-0-0

*** Note : Students Opting for Chemistry subject in Bachelor of Arts/Bachelor of Science/ Honours may choose any one of the following Skill Enhancement Course (SEC) in his/her degree Programme during Ist, IInd and IIIrd Year.**

1. ORGANIC CHEMISTRY-III : SPECTROSCOPIC METHODS

SEMESTER–I

CHEMISTRY

INORGANIC CHEMISTRY – I: Atomic structure and Periodic table

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section

SECTION-A **(15 Hrs.)**

Atomic Structure- Idea of de Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrodinger wave equation, Quantum numbers, Shapes of s, p, d and f orbitals. Aufbau's and Pauli's Exclusion principle, Hund's multiplicity rule. Electronic configurations of the elements and ions.

Periodic Properties- Position of elements in the periodic table; effective nuclear charge and its calculations. Details of atomic and ionic radii, ionization energy, electron affinity and electronegativity.

SECTION-B **(15 Hrs.)**

Ionic Solids: Concept of close packing, Ionic structures, radius ratio rule and coordination number, limitation of radius ratio rule, lattice defects, semiconductors, lattice energy and Born–Haber cycle. Fajan's rule, Weak Interactions –Hydrogen bonding, van der Waals forces.

Chemical Bonding-I: Covalent Bond–Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, Valence shell electron pair repulsion (VSEPR) theory, homonuclear and heteronuclear diatomic molecules. Multicentre bonding in boranes, Percentage ionic character from dipole moment and electronegativity difference.

SECTION-C **(15 Hrs.)**

s- and p-block elements and their comparative study: General remarks about each group (I-VIII), trends in electronic configuration, atomic and ionic radii, ionization potential, electron affinity, electronegativity, oxidation states, Melting and boiling point, density, electropositive or metallic character, flame colouration. Lattice energies. Photoelectric effect, inert pair effect, catenation and hetero catenation. Anomalies in first and second row elements. Chemical properties in details.

Acids and Bases: Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concepts of acids and bases.

SECTION-D **(15 Hrs.)**

p-Block Elements: Group 13: General characteristics, Atomic and ionic radii, melting and boiling point, Ionisation energies, Oxidation states, Electropositive character, Tendency to form covalent compounds. **Compounds of group 13**: Hydrides, Oxides and hydroxides, Oxoacid; Structure and Properties of Boric acid, Preparation, properties and structure of Diborane, Borazine, Boron halides: Boron hydrides ($LiBH_4$, $NaBH_4$), Anomalous behaviour of Boron and its diagonal relationship with Silicon.

Group 14: General characteristics; Atomic radii, Ionisation energies, Melting and boiling point, oxidation state, metallic character, catenation, Allotropy, Tendency to form multiple bonding. **Compounds of group 14**: Hydrides of silicon: preparation and properties, toxic nature of CO, Dioxide of carbon and silicon. Comparison of carbon tetrachloride and silicon tetrachloride. Chemistry of Fullerenes.

Course Outcome:

- Develop understanding for the concepts of structure and bonding
- Enrich the knowledge of chemistry related to ionic and covalent compounds

Books Suggested

1. Cotton, F.A., Wilkinson, G., Gaus, P.L., Basic Inorganic Chemistry; 3rd edition, Pubs: John Wiley Sons. 1995.
2. Lee, J.D., Concise Inorganic Chemistry; 4th edition, Pubs: Chapman Hall Ltd., 1991.
3. Shriver, D.E., Alkins, P.W., Langford, C.H., Inorganic Chemistry; 4th edition, Oxford Publisher: Oxford University Press, 2006.
4. Douglas, B. McDamiel, D., Alexander, J., Concepts and Models of Inorganic Chemistry; 3rd edition, Pubs: John Wiley and Sons Inc., 1994.
5. Miessler, G.L., Larr, D.A., Inorganic Chemistry; 3rd edition, Pubs: Pearson Education Inc., 2004.
6. Jolly, W.L., Modern Inorganic Chemistry; 2nd edition, Pubs: McGraw-Hill Publishing Company Limited, 1991.
7. Purcell, K.F., Kotz, J.C., Inorganic Chemistry; Pubs: W.B. Saunders Company, 1977.
8. Puri, B.R., Sharma, L.R., Kalia, K.C., Principles of Inorganic Chemistry; 30th edition, Pubs: Milestones Publisher, 2006-07.

SEMESTER -I

INORGANIC CHEMISTRY-I: Lab Qualitative Analysis

(PRACTICAL)

Time: 2 Hrs **Marks: 25**

Credits: 0-0-1 **15 Hrs.**

Semi Micro analysis. Cation analysis, Separation and identification of ions from groups I, II, III, IV, V, and VI. Anionic analysis. Four ions with no interference.

Volumetric titrations

1. Determination of strength of Na_2CO_3 solution by titrating it against a standard solution of HCl.
2. Determination of molarity of $KMnO_4$ solution by titrating it against a standard solution of Oxalic acid.
3. Standardise the given $K_2Cr_2O_7$ solution by titrating it against a standard solution of Mohr's Salt.
4. Estimation of free alkali present in different soaps/detergents
5. Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
6. Estimation of available chlorine in bleaching powder iodometrically

Course Outcome

To develop technical skills relevant to quantitative analysis.

Practical Examination

1) Detection of Salt	12
2) Volumetric titration	05
3) Viva-Voce	06
4) Note Book	2

Books Suggested

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

SEMESTER–II

CHEMISTRY

ORGANIC CHEMISTRY – I: Hydrocarbons and Alkyl Halides

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(15 Hrs.)**

Hybridization, localized and delocalized chemical bond, Electron displacement, Use of arrows, Types of reagents, Reactive Intermediates: Carbocations, Carbanions, Free radicals Carbenes, arenes and Nitrenes. Stereochemistry: Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions, Geometrical isomerism, E/Z notations with C.I.P rules, Optical Activity, enantiomeric and diastereomeric excess, Chirality/Asymmetry, Enantiomers, Diastereoisomers, Racemic mixture and resolution, optical activity in absence of chiral carbon, Relative and absolute configuration: D/L and R/S designations,

SECTION-B **(15 Hrs.)**

Chemistry of alkanes: methods of formation of alkanes, Free radical substitutions: Halogenation -relative reactivity and selectivity. Cycloalkanes and Conformational Analysis: Baeyer strain theory, Conformation analysis, relative stability and energy diagrams of ethane, propane, butane, cyclohexane and Chair, Boat and Twist boat forms of cyclohexane.

Chemistry of alkenes/alkynes: Nomenclature and Formation of alkenes and alkynes, Mechanism of E1 and E2 reactions, Saytzeff and Hofmann eliminations. Mechanisms and Reactions of alkenes, reduction, syn and anti-hydroxylation (oxidation), 1,2- and 1,4-addition reactions in conjugated dienes and Diels-Alder reaction, mechanism of allylic and benzylic bromination. Reactions of alkynes.

SECTION-C **(15 Hrs.)**

Aromaticity: Huckel's rule, aromatic ions. Nomenclature of benzene derivatives. The aryl group, Aromatic nucleus and side chain. Structure of benzene: Molecular formula and Kekule structure. Stability and C-C bond lengths of benzene, resonance structure.

Aromatic electrophilic substitution–general pattern of the mechanism, role of σ and π complexes. Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, reactivity and orientation of disubstitution. Side chain reactions of benzene derivatives. Methods of formation and chemical reactions of alkylbenzenes.

SECTION-D **(15 Hrs.)**

Alkyl halides: Methods of preparation, details of nucleophilic substitution reactions – SN1, SN_2 and SNi mechanisms with stereochemical aspects and effect of solvent, nucleophilic substitution vs. elimination. Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic substitution in details; SNAr, Benzyne mechanism. Relative reactivity and mechanism of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions in details.

Course Outcome:

The students will learn about the basic chemistry of organic compounds along with methods of formation and reactions of alkanes, cycloalkanes, alkenes, alkynes, aromatic compounds, alkyl halides and their derivatives.

Books suggested

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Solomons, T. W., Fryhle, C.B., Organic Chemistry; 9th edition, Pubs: Wiley India, 2007.
4. Wade Jr., L.G., Singh, M.S., Organic Chemistry; 6th edition, Pubs: Pearson Education, 2008.
5. Fundamentals of Organic Chemistry, Solomons, John Wiley.
6. Introduction to Organic Chemistry, Sireitwieser, Heathcock and Kosover, Macmilan.

7. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
8. McMurry, J. E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
9. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.

SEMESTER -II

ORGANIC CHEMISTRY-I: Lab Functional Group Analysis

(PRACTICAL)

Time: 2 Hrs **Marks: 25**

Credits: 0-0-1 **15 Hrs.**

Basic techniques on purification of organic compounds. Determination of melting point and boiling point of organic compounds. Detection of nitrogen, halogens and sulphur in organic compounds. Qualitative analysis of unknown organic compounds containing simple functional groups.

Course Outcome

The objective of this course is to familiarize the students with the basic techniques and to learn methods for qualitative analysis of functional groups present in the organic compounds.

Practical Examination

1) Detection of Elements	5
2) Detection of functional group, melting point & derivative preparation	12
3) Viva-Voce	6
4) Note Book	2

Books suggested

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

SEMESTER–III

CHEMISTRY

PHYSICAL CHEMISTRY – I: States of matter and electrochemistry

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(15 Hrs.)**

Gaseous States: Postulates of kinetic theory of gases, deviation from ideal behaviour, van der Waals equation of State. Critical Phenomena: PV isotherms of real gases, continuity of states, the isotherms of van der Waal's equation, relationship between critical constants and van der Waals constants, the law of Corresponding states, reduced equation of state. Molecular Velocities: Root mean square, average and most probable velocities. Qualitative Discussion of the Maxwell's distribution of molecular velocities. Collision number, mean free path and collision diameter. Liquefaction of gases.

Liquid State: Intermolecular forces, surface tension and viscosity of liquids and its determination. Structure of liquids (a qualitative description). Structural differences between solids, liquids and gases.

SECTION-B **(15 Hrs.)**

Colloidal State: Definition of colloids, classification of colloids. Solids in liquids (Sol): kinetic, optical and electrical properties, stability of colloids, protective action, Hardy Schulze law, gold number. Liquids in liquids (emulsions): Types of emulsions, preparation. Emulsifiers. General applications of colloids.

Solid State: Definition of space lattice and unit cell, Law of crystallography- (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices, (iii) Symmetry elements in crystals. X-ray diffraction by crystals. Derivation of Bragg's Law in Reciprocal space. Determination of crystal structure of NaCl, KCl by use of Powder method; Laue's method. Liquid crystals, Classification, structure of nematic and cholestric phases.

SECTION-C **(15 Hrs.)**

Solutions, Dilute Solutions and Colligative Properties: Ideal and non–ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, non-ideal system, azeotropes-HCl-H_2O and ethanol-water system. Relative lowering of vapour pressure, molecular weight determination. Osmosis, Law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, degree of dissociation and association of solutes.

Electrochemistry–I: Specific conductance and equivalent conductance, measurement of equivalent conductance, Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations.

SECTION-D **(15 Hrs.)**

Electrochemistry–I: Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only). Migration of ions, Transport number, Applications of conductivity measurements, Electrolytic and Galvanic cells-reversible and irreversible cells, conventional representation of electrochemical cells. Standard electrode potential, standard hydrogen electrode, reference electrodes, sign conventions, electrochemical series and its significance. Nernst equation, derivation of cell E.M.F. and single electrode potential. EMF of a cell and its measurements. Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K). Types of reversible electrodes: gas- metal ion, metal ion, metal insoluble salt-anion and redox electrodes. Electrode reactions. EMF of reversible electrodes.

Electrochemistry–II: Polarization, over potential, hydrogen overvoltage and its application. Concept of activities and activity coefficient. Concentration cells with and without transference, liquid junction potential, application of concentration cells, valency of ions, solubility product and pH determination, potentiometric titrations.

Course Outcome:

To teach the applications of basic concepts related to three states of matter. The contents of the paper cover the areas of physical chemistry such as electrochemistry which will provide the basic knowledge and theoretical foundation about these topics.

Books Suggested

1. Atkins, P., Paula, J.de, Atkins Physical Chemistry; 8th edition, Pubs: Oxford University Press, 2008.
2. Puri, B.R., Sharma, L.R., Pathania, M.S., Principles of Physical Chemistry; 43rd edition, Pubs: Vishal Publishing Co., 2008.
3. Barrow, G.M., Physical Chemistry; 6th edition, Pubs: McGraw Hill Inc, 1996.
4. Rao, C.N.R., University General Chemistry; Pubs: Macmillan India, 1985.
5. Berry, R.S., Rice, S.A., Ross, J., Physical Chemistry; 2nd edition, Pubs: Oxford University Press, 2000.
6. Albert, R.A., Silbey, R.J., Physical Chemistry; 1st edition, Pubs: John Wiley & Sons Inc., 1992.
7. Dogra, S.K., Dogra, S., Physical Chemistry Through Problems; Pubs: Wiley Eastern Limited, 1991.
8. Levine, I.N., Physical Chemistry; 5th edition, Pubs: Tata McGraw Hill Publishing Co. Ltd., 2002.
9. Moore, W. J., Basic Physical Chemistry; Pubs: Prentice Hall of India Pvt. Ltd, 1983.
10. University General Chemistry, C.N.R. Rao, Macmillan.
11. Metz, C.R., Theory and problems of Physical Chemistry; Schaum's outline series, 2nd edition, Pubs: McGraw-Hall Book Company, 1989.

SEMESTER–III

CHEMISTRY

PHYSICAL CHEMISTRY – I: Lab

(PRACTICAL)

Time: 2 Hrs **Marks: 25**

Credits: 0-0-1 **15 Hrs.**

1. To determine the specific reaction rate of hydrolysis of ethyl acetate catalysed by acid at room temperature.
2. To study the effect of acid strength on hydrolysis of an ester.
3. To find the relative and absolute viscosity of given liquid at room temperature. (n-butyl alcohol, sucrose, and glycerine solution in water)
4. To study the surface tension of liquids by drop number and drop weight methods.
5. To determine the Refractive indices of given liquids (water, acetone, methanol, ethyl acetate, cyclohexane) by Abbe's refractometer & calculate their molecular refractivity.
6. To determine the composition of unknown mixture of two liquids by refractive index measurements.
7. Indexing of a given powder diffraction pattern of a cubic crystalline system.
8. Preparation of buffer solutions of different pH (a) Sodium acetate-acetic acid (b) Ammonium chloride-ammonium hydroxide
9. pH metric titration of (a) strong acid vs. strong base, (b) weak acid vs. strong base.
10. Determination of dissociation constant of a weak acid.

Course Outcome

The students will get hand on experience of the properties of matter and correlate with the theory learnt.

Practical Examination

1) Titration 1	08
2) Titration 2	08
3) Viva-Voce	07
4) Note Book	02

Books Suggested

1. Experimental Organic Chemistry, Vol. I & II, P.R. Singh, D.S. Gupta and K.S. Bajpai, Tata McGraw Hill.
2. Laboratory Manual in Organic Chemistry, R.K. Bansal, Wiley Eastern.
3. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, V. Rogers, P.W.G. Smith and A.R. Tatchell, ELBS.
4. Experiments in General Chemistry, C.N.R. Rao and U.C. Aggarwal, East-West Press.
5. Experiments in Physical Chemistry, R.C. Das and B. Behra, Tata McGraw Hill.
6. Advanced Practical Physical Chemistry, J.B. Yadav, Goel Publishing House.
7. Advanced Experimental Chemistry, Vol. I, Physical, J.N. Guru and R. Kapoor, S. Chand & Co.
8. Selected Experiments in Physical Chemistry, N.G. Mukherjee, J.N. Ghosh & Sons.
9. Experiments Physical Chemistry, J.C. Ghosh, Bharati Bhavan.
10. Findlay's Practical Physical Chemistry, Author: Alexander Findlay, Publisher: Wiley, 1972, ISBN-10:0470258853.
11. Advanced Practical Physical Chemistry, Author: J. B. Yadav, Publisher: Krishna Prakashan Media (P) Ltd (2015), ISBN-10:8182835925.

SEMESTER–IV

CHEMISTRY

INORGANIC CHEMISTRY–II: Periodic table and coordination chemistry

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(15 Hrs.)**

p–Block Elements: Group 16: General characteristics: atomic radii, Ionisation energies, Melting and boiling point, Electron affinity, Oxidation state, Catenation, Elemental state, Allotropy, Hydrides of group 16, Chemical properties of SO_2, structure of SO_2 & SO_3, Oxoacid of sulphur: structure and basicity. Preparation of sulphuric acid by contacts process and its chemical properties

Group 17: General characteristics: atomic radii, Ionisation energies, melting and boiling point, Electron affinity, Electronegativity, Non-metallic character, colour, Oxidation state and reactivity**,** Hydrides of group 17, Relative acidic strength of hydro acids and Oxoacids of group 17, structure of interhalogen compounds and polyhalides.

Important compounds of p-block: Carbides, fluorocarbons, Silicones and phosphazenes, triphosphazenes.

SECTION-B **(15 Hrs.)**

Chemistry of Transition Elements: General characteristics of Transition Elements. Properties of the elements of the first transition series, Relative stability of their oxidation state. Coordination number and geometry. General characteristics of elements of Second and Third Transition Series. Difference in the properties of first transition elements with second and third transition series elements in respect of ionic radii, oxidation states, magnetic behaviour.

***f*-block elements**: Lanthanoids: Electronic configurations, oxidation states, ionic radii, lanthanide contraction, colour, spectral and magnetic properties, lanthanum compounds. Actinoids: electronic configurations, oxidation states, ionic radii, actinide contraction, colour,

spectral and magnetic properties. Comparison of lanthanoids and actinoids and their analytical applications.

SECTION-C **(15 Hrs.)**

Coordination Compounds: Nomenclature of coordination compounds, Werner's coordination theory, effective atomic number, polydentate, chelating ligands and chelation, factors affecting stability of chelates, structural and stereoisomerism in coordination compounds with co-ordination number 4 and 6, resolution of racemic mixture, Valence bond theory of transition metal complexes, hybridization and geometry of complexes of Cr, Fe, Co, Cu and its ions, Magnetic properties and colour of coordination compounds.

Transition Metal complexes: an elementary idea of crystal field theory, Jahn-Teller effects. methods of determining magnetic susceptibility by Gouy's and Faraday method. L-S coupling, correlation of μ_s and μ_{eff} values, Nucleophilic Substitution reactions in square planar complexes

SECTION-D **(15 Hrs.)**

Electronic Spectra of Transition Metal Complexes: Types of electronic transitions, selection rules and relaxations, splitting of Russel-Saunder states in octahedral and tetrahedral, spectrochemical series, Orgel diagram of one electron-one hole system and two electron-two hole system in octahedral and tetrahedral complexes. Limitation of Orgel diagram.

Organometallic Compounds: Definition, nomenclature and classification of organometallic compounds. σ and π complexes, types of organoligands, EAN rule, bonding in organometals, Preparation, properties, bonding and applications of alkyl lithium and organoaluminium compounds (AlR_3). Metal olefin complexes, bonding in metal-ethylenic complexes, Mechanism of homogeneous hydrogenation reactions of alkene. Metal carbonyls: examples and bonding.

Course Outcome

This course will provide the knowledge of the p, d, f block elements and will also cover basics of coordination and organometallic chemistry.

Books Suggested

1. Cotton, F.A., Wilkinson, G., Gaus, P.L., Basic Inorganic Chemistry; 3rd edition, Pubs: John Wiley Sons. 1995.
2. Lee, J.D., Concise Inorganic Chemistry; 4th edition, Pubs: Chapman Hall Ltd., 1991.
3. Shriver, D.E., Alkins, P.W., Langford, C.H., Inorganic Chemistry; 4th edition, Oxford Publisher: Oxford University Press, 2006.
4. Douglas, B. McDamiel, D., Alexander, J., Concepts and Models of Inorganic Chemistry; 3rd edition, Pubs: John Wiley and Sons Inc., 1994.
5. Porterfield, W.W., Wesley, A., Inorganic Chemistry; Pubs: Addison-Wesley Publishing Company, 1984.
6. Miessler, G.L., Larr, D.A., Inorganic Chemistry; 3rd edition, Pubs: Pearson Education Inc., 2004.
7. Jolly, W.L., Modern Inorganic Chemistry; 2nd edition, Pubs: McGraw-Hill Publishing Company Limited, 1991.
8. Purcell, K.F., Kotz, J.C., Inorganic Chemistry; Pubs: W.B. Saunders Company, 1977.
9. Puri, B.R., Sharma, L.R., Kalia, K.C., Principles of Inorganic Chemistry; 30th edition, Pubs: Milestones Publisher, 2006-07.
10. Inorganic Chemistry, W.W. Porterfield Addison-Wesley.
11. Inorganic Chemistry, A.G. Sharpe, ELBS.

SEMESTER–IV

CHEMISTRY

INORGANIC CHEMISTRY – II: Lab Volumetric, gravimetric analysis and preparations

(PRACTICAL)

Time: 2 Hrs **Marks: 25**

Credits: 0-0-1 **15 Hrs.**

Quantitative Analysis

Volumetric Analysis

1. Determination of acetic acid in commercial vinegar using NaOH.
2. Determination of alkali content-antacid tablet using HCI.
3. Estimation of calcium content in chalk as calcium oxalate by permanganometry.
4. Standardisation of EDTA with $Pb(NO_3)_2$ / $ZnSO_4$. $7H_2O$ and Estimation of hardness of water by EDTA.
5. Estimation of ferrous and ferric by dichromate method.
6. Estimation of copper using sodium thiosulphate.

Gravimetric Analysis

Analysis of Cu as CuSCN; Ni as Ni (dimethylgloxime) and Determination of silver(I) as its chloride

Inorganic Preparations:

Synthesis of Iron(III) Hexacyanoferrate(II) $Fe_4[Fe(CN)_6]_3$ (Prussian Blue).

Preparation of Potassium Aluminum Sulfate $KAl(SO_4)\cdot 12H_2O$ (Potash Alum)

Preparation of bis Acetylacetonate Copper(II) $Cu(O_2C_5H_7)_2$.

Course Outcome:

To develop good laboratory technical skills relevant to quantitative analysis and synthesis of inorganic compounds.

Practical Examination

1) Volumetry/Gravimetry	08
2) Inorganic Preparations	07
3) Viva-Voce	07
4) Note Book	03

Books Suggested

1. Vogel's Textbook of Quantitative Inorganic Analysis (revised), J. Bassett, R.C. Denney, G.H. Jeffery and J. Mandham, ELBS.
2. Standard Methods of Chemical. Analysis, W.W. Scott: The Technical Press.
3. Experimental Inorganic Chemistry, W.G. Palmer, Cambridge.
4. Laboratory Manual in Organic Chemistry, R.K. Bansal, Wiley Eastern.
5. Vogel's Textbook of Practical Organic Chemistry, B.S. Furniss, A.J. Hannaford, V. Rogers, P.W.G. Smith and A.R. Tatchell, ELBS.
6. Experiments in General Chemistry, C.N.R. Rao and U.C. Aggarwal, East-West Press.
7. Experimental Organic Chemistry, Vol. I & II, P.R. Singh, D.S. Gupta and K.S. Bajpai, Tata McGraw Hill.
8. Marr, G. and Rockett, B.W. Practical Inorganic Chemistry, 1972

SEMESTER–V

CHEMISTRY

ORGANIC CHEMISTRY–II: Chemistry of O/N containing compounds

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(15 Hrs.)**

Alcohols: Classification and nomenclature. Monohydric and Dihydric alcohols alcohols—nomenclature. Acidic nature, methods of formation, chemical reactions, oxidative cleavage [$Pb(OAC)_4$] and [HIO_4] and pinacol-pinacolone rearrangement.

Phenols: Nomenclature, structure and bonding, Preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols—electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Reimer Tiemann reaction.

Ethers and epoxides: Preparation and chemical reactions ethers and epoxides.

Sulphur containing compounds: Preparation and reactions of thiols, thioethers and sulphonic acids.

SECTION-B **(15 Hrs.)**

Aldehydes and Ketones: Nomenclature and structure of the carbonyl group. Synthesis of aldehydes and ketones, Physical properties. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations. Condensation with ammonia and its derivatives. Witting reaction. Mannich reaction. Use of acetals as protecting group. Cannizzaro reaction. Halogenation of enolizable ketones. Addition reactions of unsaturated carbonyl compounds, Active methylene compounds.

Carboxylic Acids: Nomenclature, structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength. Synthesis of acid chlorides, esters and amides.

SECTION-C **(15 Hrs.)**

Reactions of carboxylic acids, Hell Volhard-Zelinsky reaction, Reduction of carboxylic acids, Mechanism of decarboxylation.

Carboxylic Acids Derivatives: Structure and nomenclature of acid chlorides, esters, amides and acid anhydrides, Relative stability & reactivity of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution. Preparation of carboxylic acid derivatives, chemical reactions.

Organic Compounds of Nitrogen: Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes, Mechanisms of nucleophilc substitution in nitroarenes and their reduction in acidic, neutral and alkaline media. Reactivity, Structure and nomenclature of amines,

SECTION-D **(15 Hrs.)**

Organic Compounds of Nitrogen: Methods of preparation of amines by Reductive amination of aldehydic and ketonic compounds, Gabriel-phthalimide reaction and Hofmann bromamide reaction. Physical properties. Stereochemistry of amines. separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts.

Heterocyclic Compounds: Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole.

Course Outcome:

The objective of this course is to teach the chemistry of organic functional groups to the students.

Book Suggested

1. Morrison, R.T., Boyd, R.N., Organic Chemistry; 6th edition, Pubs: Prentice-Hall, 1992.
2. Wade Jr., L.G., Singh, M.S., Organic Chemistry; 6th edition, Pubs: Pearson Education, 2008.

3. Mukherji, S.M., Singh, S.P., Kapoor, R.P., Organic Chemistry; Pubs: Wiley Eastern Limited, 1985, Vol. I, II, III.
4. Solomons, T.W., Fryhle, C.B., Organic Chemistry; 9th edition, Pubs: Wiley India, 2007.
5. Carey, F.A., Organic Chemistry; 4th edition, Pubs: McGraw-Hill, 2000.
6. Streitwieser, A., Clayton, Jr., Heathcock, H., Introduction to Organic Chemistry; 3rd edition, Pubs: Macmillan Publishing Company, 1989.
7. Introduction to Organic Chemistry, Sireitwieser, Heathcock and Kosover, Macmilan.

SEMESTER–V

CHEMISTRY

ORGANIC CHEMISTRY – II: Lab Preparations

(PRACTICAL)

Time: 2 Hrs **Marks: 25**

Credits: 0-0-1 **15 Hrs.**

Thin Layer Chromatography: Determination of Rf values and identification of organic compounds.
Column Chromatography: Separation of o & p nitrophenol

Synthesis of Organic Compounds

1. Preparation of p-nitroacetanilide
2. Preparation of Methyl Orange
3. Preparation of quinoline (Skraup Synthesis)
4. Preparation of 1,2-dihydro-1,5-dimethyl-2-phenyl-3H-pyrazole-3-one) (antipyrine)
5. Synthesis of flavone (2-Phenyl-4H-1-benzopyran-4-one, 2-Phenylchromone)
6. Acetylation of amines and phenols
7. Bromination of Acetanilide.
8. Reduction of meta dinitrobenzene and p-nitrobenzaldehyde.
9. Semicarbazone of ethyl methyl ketone and benzaldehyde

Course Outcome

To provide the synthetic skills to the students and to make them aware of various techniques involved in synthesis.

Suggested Books

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Vogel's text book of practical organic chemistry, 5th Ed., Pearson (2012)
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).

4. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).
5. Experimental organic chemistry by Laurence M. Harwood, C. J. Moody, Black well Scientific Publications, Oxford, 1989.
6. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
7. Arthur, I. V. Quantitative Organic Analysis, Pearson.

SEMESTER–V

SUMMER INTERNSHIP

(02 WEEKS)

Time: 3 Hrs **Marks: 50**

Credits: 0-0-2 **02 Weeks**

Students will be required to undertake Community Engagement and service/ Field based learning/ Minor Projects and will have to submit a Report along with original certificate at the completion of the Internship. Every student will be required to submit an internship report in typed standard prescribed format containing a copy of original certificate. The objective of the Summer Internship is to test the ability of the student to grasp the practical knowledge. Every student will make PowerPoint presentation of internship and will be orally examined in the context of the training report. The Summer Internship Report shall be evaluated by a committee constituted by the college Principal. i) Head of the department ii) one senior faculty member from the department

Course Outcomes: Students should work in the industry/laboratories as trainees so that they can acquire knowledge about the different processes.

SEMESTER–VI

CHEMISTRY

PHYSICAL CHEMISTRY–II: Thermodynamics and equilibrium

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(15 Hrs.)**

Thermodynamics-I: Definition of thermodynamic terms, Types of systems, intensive and extensive properties. State and path functions. Thermodynamic process. Concept of heat and work.

First Law of Thermodynamics: Statement and definitions, Heat capacity at constant volume and pressure and their relationship. Joule's law, Joule-Thomson coefficient and inversion temperature, Calculation of w, q, ΔU & ΔH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry: Standard state, types of enthalpies of reactions, Hess's Law of heat summation. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, temperature dependence of enthalpy. Kirchhoff's equation.

SECTION-B **(15 Hrs.)**

Thermodynamics-II: *Second Law of Thermodynamics:* Statements, Carnot cycle and its efficiency, Carnot theorem. Thermodynamic scale of temperature, Entropy as a state function, entropy as a function of V & T; P & T, entropy change in physical change, Clausius inequality, entropy as a criterion of spontaneity and equilibrium. Entropy changes in ideal gases and mixing of gases.

Thermodynamics-III: *Third Law of Thermodynamics:* Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data. Gibbs and Helmholtz functions; Gibbs function (G) and Helmholtz function (A) as thermodynamic

quantities, A & G as a criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, Variation of G and A with P, V and T.

SECTION-C (15 Hrs.)

Chemical Equilibrium: Determination of Kp, Kc, Ka and their relationship, Clausius-Clapeyron equation

Introduction to Phase Equilibrium: Phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system, two component systems-solid-liquid equilibria, Solid solutions-compound formation with congruent and incongruent melting point, Lower and upper consulate temperature, Nernst distribution law.

Introduction to Ionic equilibria: Strong, moderate and weak electrolytes, 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-, di-and triprotic acids, calculation of hydrolysis constant, derivation of Henderson equation, applications of buffers in analytical chemistry, applications of solubility product principle Qualitative treatment of acid – base titration curves, Theory of acid–base indicators

SECTION-D (15 Hrs.)

Quantum Mechanics: Black-body radiation, Planck's radiation law, Photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. Sinusoidal wave equation, Hamiltonian operator, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one-dimensional box, quantization of energy levels, extension to two and three-dimensional boxes, degeneracy. Simple harmonic oscillator model of vibrational motion, setting up Schrodinger equation and discussion of solution and wave functions. Rigid rotator model of rotation of diatomic molecules transformation to spherical polar coordinates spherical harmonics and their discussion. Qualitative investigation H-atom, setting up Schrodinger equation, radial and angular part, radial distribution functions of 1s, 2s, 2p, 3s, 3p and 3d.

Course Outcome

The student will get the information about basic phenomenon/concepts related to the thermodynamics and how the knowledge of these thermodynamic parameters will be useful for various applications.

Books Suggested

1. Atkins, P., Paula, J.de, Atkins, Physical Chemistry; 8th edition, Pubs: Oxford University Press, 2008.
2. Puri, B.R., Sharma, L.R., Pathania, M.S., Principles of Physical Chemistry; 43rd edition, Pubs: Vishal Publishing Co., 2008.
3. Barrow, G.M., Physical Chemistry; 6th edition, Pubs: McGraw Hill Company Inc., 1996.
4. Berry, R.S., Rice, S.A., Ross, J., Physical Chemistry; 2nd edition, Pubs: Oxford University Press, 2000.
5. Albert, R.A., Silbey, R.J., Physical Chemistry; I edition, Pubs: John Wiley & Sons Inc., 1992.
6. Dogra, S.K., Dogra, S., Physical Chemistry Through Problems, Pubs: Wiley Eastern Ltd., 1991.
7. Moore, W.J., Basic Physical Chemistry; Pubs: Prentice Hall of India Pvt. Ltd., 1983.
8. Metz, C.R., Theory and Problems of Physical Chemistry; Schaum's outline series, 2nd edition, Pubs: McGraw-Hall Book Company, 1989.
9. Banwell, C.N., McCash, E.M., Fundamentals of Molecular Spectroscopy; 4th edition, Pubs: Tata McGraw Hill Publishing Co. Ltd., 1999.
10. Atkins, P. Friedman, R., Molecular Quantum Mechanics; 4th edition Pubs: Oxford University Press, 2007.
11. Levine, I.N., Quantum Chemistry; 5th edition, Pubs: Prentice Hall International Inc., 2000.
12. Glasstone, B. (2003) Thermodynamics for Chemists, East West Press, New Delhi. ISBN-10: 8176710148.
13. Rock, P.A. (1983) Chemical Thermodynamics, University Science Books, Sausalito, CA. ISBN 10: 1891389327
14. Maron S.H., Prutton C.F. (1965) Principles of Physical Chemistry, 4th Edition, Mac Millan Publishing Company, New York.
15. Kapoor, K.L (2006) A Text Book of Physical Chemistry, 6th Volume, Macmillan Publishers India Ltd., New Delhi. ISBN10: 0230332765
16. Laidler, K.J. (1995) The world of Physical Chemistry, 3rd Volume, Oxford University Press, London. ISBN-10: 0198559194

17. Jou D., Llebot J.E. (1990) Introduction to the Thermodynamics of Biological Processes, Prentice Hall. ISBN: 9780135028810
18. Rajaram J., Kuriacose J. C. (1986) Thermodynamics for Students of Chemistry, Shoban Lal Nagin Chand & Co. Delhi ISBN-13: 1234567145987.

SEMESTER–VI

CHEMISTRY

PHYSICAL CHEMISTRY–II: Lab

(PRACTICAL)

Time: 2 Hrs **Marks: 25**

Credits: 0-0-1 **15 Hrs.**

1. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
2. Determination of heat of solution of Na_2SO_4.
3. Determination of Lattice energy of NaCl (using Born-Haber cycle).
4. Study of the solubility of benzoic acid in water and determination of ΔH.
5. To determine the dissociation constant of picric acid by studying its distribution between benzene and water.
6. To determine the molecular weight of naphthalene by Rast method.
7. To prepare and draw phase diagram of microemulsions comprising sodium dodecyl sulfate, water and hexanol.
8. Potentiometry: (a) Titration of HCl solution with NaOH solution using quinhydrone solution; (b) Titration of CH_3COOH solution with NaOH; (c) Titration of oxalic acid solution with NaOH.
9. Conductometry: (a) To find strength of given strong acid; (b) To find dissociation constant of weak electrolyte.
10. Colorimetry: To verify the Lambert – Beer's Law.

Course Outcome

The practical's mentioned in the syllabus will reinforce the theoretical concepts of the students taught in the class rooms.

Practical Examination

1) Titration 1	08
2) Titration 2	08
3) Viva-Voce	07
4) Note Book	02

Suggested Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, New Age International: New Delhi (2001).
3. Findlay's Practical Physical Chemistry, Author: Alexander Findlay Publisher: Wiley, 1972, ISBN-10:0470258853.
4. Advanced Practical Physical Chemistry, Author: J. B. Yadav, Publisher: Krishna Prakashan Media (Pvt) Ltd (2015), ISBN-10: 8182835925.
5. Quantitative Organic Analysis by Vogel, Author: A. I. Vogel, Publisher: Wiley, John & Sons, Incorporated, ISBN-13: 780582442504

SEMESTER–VII

CHEMISTRY

PHYSICAL CHEMISTRY–III: CHEMICAL KINETICS

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 3-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(12 Hrs.)**

Recapitulation of Basic Concepts of Kinetics: Scope of chemical kinetics. Rate laws. Molecularity and order of a reaction. Activation energy. Experimental Methods of Chemical Kinetics: Potentiometric, conductometric, optical methods; polarimetry, and spectrophotometry. Kinetics of Reactions: Reversible or/ opposing reactions. Consecutive or/ series reactions. Parallel reactions. Theories of Reaction Rates: The Collision theory of bimolecular reactions based on hard sphere model. Steric factor. Lindemann's mechanism. The transition state theory. Thermodynamic treatment and statistical mechanical approach. Eyring treatment. Transmission coefficient. Tunneling effect. Kinetic theory of termolecular reactions. Elementary Gas-phase Reactions: Lindemann-Christiansen hypothesis. Hinshelwood's treatment. Rice-Ramsperger-Kassel (RRK) treatment. Slater's treatment. Rice-Ramsperger-Kassel Marcus (RRKM) treatments of unimolecular gas phase reactions.

SECTION-B **(11 Hrs.)**

Reactions in Solutions: Factors affecting reactions in solutions. Ionic reactions in solutions. Effect of solvent. Effect of ionic strength. Primary and Secondary salt effects. Composite/Complex Reactions: Types of composite mechanisms. Rate equations for composite mechanisms. Simultaneous and Consecutive reactions. Steady-state treatment. Rate-determining (Rate- controlling) steps. Microscopic reversibility and detailed balance.

SECTION-C **(11 Hrs.)**

Homogeneous Catalysis: Catalysis. Character of catalyst. Simple Catalysed reactions. Kinetics of acid-base catalysis; General acid base catalysis. Mechanisms of acid-base catalysis. Catalysis by enzymes; Influence of substrate concentration, Influence of pH,

Influence of temperature. Transient - phase kinetics. Reaction in Flow Systems: Techniques for very fast reactions. General features of fast reactions. Stopped-flow method. Relaxation method. Shock tube method. Pulse radiolysis. Flash photolysis. Nuclear- magnetic resonance and electron spin resonance methods.

SECTION-D (11 Hrs.)

Kinetics of Dynamic Chain Reactions: Hydrogen-bromine reaction. Hydrogen-chlorine reaction. Pyrolysis of acetaldehyde. Organic decomposition. Decompositon of ethane. Photochemical Reactions: Hydrogen-bromine reaction. Hydrogen-chlorine reaction. Oscillatory Chemical Reactions: Belousov-Zhabotinsky reactions. Classification of Oscillatory Reactions, Lotka-Voltera model.

Course Outcome:

The study will get the information about how rate of reaction provides important kinetic data in establishing the mechanism by which the reaction takes place.

Books Suggested

1. Chemical Kinetics, 3rd edn, Author: Laidler, K. J., Publisher: Pearson Education India (2003), ISBN-10: 8131709728.
2. Kinetics and Mechanism, 2ndedn, Author: Frost, A. A. & Pearson, R. G., Publisher: John Wiley & Sons. Inc. New York (1961), ISBN-10: B0037F1GMQ.
3. Comprehensive Chemical Kinetics, Author: Bam Ford, C. H. & Tipper, C. F. H., Publisher: Elsevier Science Ltd (1978), ISBN-10: 044441651X.
4. Principles of Physical Chemistry, Author: Maron, S. H. & Prutton, C.F. Publisher: Collier Macmillan Ltd; 4th Revised edn (1965) ISBN-10: 0023762306
5. Kinetics and Mechanism of Chemical Transformations, Author: Rajaraman, J. & Kuriacose, J. Publisher: Macmillan/Laxmi Publications (P) Ltd., New Delhi (2000) ISBN-10: 0333926587.

SEMESTER–VII

CHEMISTRY

ORGANIC CHEMISTRY–IV: Structure-reactivity relationship

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 3-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(11 Hrs.)**

Mechanistic significance of entropy, enthalpy and Gibb's free energy. Arrhenius equation. Transition state theory. Hammond's postulate. Potential energy surface model. Marcus theory of electron transfer. Reactivity and selectivity principles. Kinetic isotope effects: Theory of isotope effects. Primary and secondary kinetic isotope effects. Heavy atom isotope effects. Tunneling effect. Solvent effects.

SECTION-B **(12 Hrs.)**

Linear free energy relationships (LFER). The Hammett equation, substituent constants, theories of substituent effects. Reaction constant ρ. Deviations from Hammett equation. Dual-parameter correlations, inductive substituent constant. The Taft model, Qualitative understanding of solvent-solute effects on reactivity, Effects of solvation on reaction rates and equilibria. Use of solvation scales in mechanistic studies. Solvent effects from the curve-crossing model. Acids, Bases, Electrophiles, Nucleophiles and Cataylsis: Acid-base dissociation. Electronic and structural effects, acidity and basicity. Acidity function and their applications. Hard and soft acids and bases. Nucleophilicity scales. Nucleofugacity. The α - effect. Ambivalent nucleophiles. Acid- base catalysis, specific and general catalysis. Bronsted catalysis. Nucleophilic and electrophilic catalysis. Catalysis by non-covalent binding-micellar catalysis, phase transfer catalysis.

SECTION-C **(11 Hrs.)**

Various type of steric strain and their influence on reactivity. Steric LFER. Conformational barrier to bond rotation-spectroscopic detection of individual conformers. Acyclic and monocyclic systems. Rotation around partial double bonds. Winstein-Holness and Curtin-

Hammett principle. Aliphatic Nucleophilic Substitution: The mixed SN_1 and SN_2 and SET mechanisms. The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations.

SECTION-D (11 Hrs.)

Aliphatic Electrophilic Substitution: Bimolecular mechanisms- SE_2 and SEi. The SE_1 mechanism, electrophilic substitution accompanied by double bond shifts. Free Radical Reactions: Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactvity in the attacking radicals. The effect of solvents on reactivity, Allylic halogenation (NBS), Free radical rearrangement. Hunsdiecker reaction.

Course Outcome

The course content will provide knowledge of nucleophilic, electrophilic and free radical substitution and addition reactions and their reactivity.

Books Suggested

1. Mechanism and Theory in Organic Chemistry, T.H. Lowry and K.C. Richardson, Harper and Row.
2. Introduction to Theoretical Organic Chemistry and Molecular Modeling, W.B. Smith, VCH, Weinheim.
3. Physical Organic Chemistry, N.S. Issacs, ELBS/Longman
4. The Physical Basis of Organic Chemistry, H. Maskill, Oxford University Press.
5. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
6. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
7. Modern Physical organic Chemistry, Eric V. Anslyn and Deniis A. Doughutes. P 637-655 (2004) University, Science Books.
8. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
9. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
10. Modern Organic Reactions, H.O. House, Benjamin.
11. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
12. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.

SEMESTER–VII

CHEMISTRY

INORGANIC CHEMISTRY–III: ORGANOMETALLICS

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 3-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(10 Hrs.)**

Introduction: Brief history of organometallic chemistry, Importance of organometallic compounds as reagents, additives and catalysts. The 18 Valence Electron Rule: counting of electrons and finding metal-metal bonds and related problems. Alkyl and Aryl Ligands: Sigma bonded alkyl groups as ligands: Synthesis of metal-alkyl compounds, β-hydride elimination, σ-bonded η1 -aryl ligands.

SECTION-B **(12 Hrs.)**

Ligands with Higher Hapticity: Cyclic and acyclic polyenyl π-bonded ligands: Cyclopentdienyl (Cp-), Synthesis of Cp based sandwich compounds, Structure and properties of MCp2 complexes, The first metal-sandwich compound Ferrocene, Reactions of metal-sandwich compounds, Bent sandwich compounds, Schwartz reagent and hydrozirconation, Chemistry of Cp^*, Chemistry of arene sandwich compounds, Allyl groups as ligands, 1,3-Butadiene complexes, Cyclobutadiene complexes, Cycloheptatriene and Cyclooctatetraene as ligands. Davies-Green-Mingos (DGM) rules.

SECTION-C **(10 Hrs.)**

Ferrocene: Structure and bonding of ferrocenes, Basic chemical reactions of Ferrocene, Reactions of Acetyl Ferrocene and formyl Ferrocene, lithiated ferrocenes and their reactions, (Dimethylaminomethyl)Ferrocene and its methiodide salt, Ferrocene boronic acid and haloferrocenes, Chirality in Ferrocene derivatives, Synthesis of chiral Ferrocene based compounds, Ferrocene based condensation polymers.

SECTION-D **(13 Hrs.)**

Applications of Organometallic Complexes to Catalysis: Catalysis, Terminology in catalysis, sequences involved in a catalysed reaction, asymmetric synthesis using a catalyst. Hydrogenation catalysts: classification of hydrogenation catalysts, catalytic cycle of Wilkinson's catalyst, catalytic cycles of iridium and ruthenium-based catalysts, hydrogenation by lanthanide organometallic compounds, catalytic asymmetric synthesis. Hydroformylation: Cobalt catalysts and phosphine modified cobalt catalysts, Rhodium-phosphine catalysts, factors affecting the n/iso ratio of hydroformylation products. Methanol Carbonylation and Olefin Oxidation: Monsanto, Cativa and Wacker Processes. Polymerisation and oligomerisation of olefins and dienes. Synthetic gas. Bioorganometallic Chemistry: Role of organometallics in heavy metal poisoning: Mercury and Arsenic poisoning. Organometallic compounds as drugs: ruthenium and ferrocene-based drugs. Organometallics as radiopharmaceutical, tracers, ionophores and sensors.

Course Outcome

This course will provide a systematic examination of the formation, structure and reactivity of transition metal-carbon (M-C) bonds and their utility in catalysis.

Books suggested

1. B. D. Gupta and A.J. Elias, Basic organomettallic chemistry-concepts, synthesis and applications, 2nd edition, Universities Press (2013).
2. C. E. Elschenbroich and A. Salzer and Organometallics- A Concise Introduction, 2nd edition, VCH publisher (1992).
3. Robert H. Crabtree, The organometallic chemistry of the transition metals, 4th edition, John Wiley & Sons, Inc., Publication (2005)
4. J. E. Huheey, E. A. Keiter and R.L. Keiter, Inorganic Chemistry- Principles of Structure and Reactivity, 4th edition, Harper Collins publisher (1993).
5. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 3rd edition, Wiley Inter-Science

SEMESTER–VII

CHEMISTRY

PHYSICAL CHEMISTRY–IV: Thermodynamics of biopolymer solutions

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 3-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(11 Hrs.)**

Thermodynamics of Biopolymer Solutions: Introduction, Dissolution of Low Molecular Weight Solutes and Macromolecules: Effect of Molecular Weight and Thermodynamics, Thermodynamics of Dissolution of Crystalline and Amorphous Polymers: Heat of Dissolution, Solubility parameters, The Flory-Huggins Theory of Polymer Solutions.

SECTION-B **(12 Hrs.)**

Thermodynamics in Biological Systems: Laws of Thermodynamics and Biological Systems, Standard free energy change in biochemical reactions, effect of pH and concentration, Additivity Rule of Standard Free Energy Change (Exergonic, Endergonic and Coupled reaction); Free Energy-Hydrolysis of ATP-Complex Equilibria (dependence of pH, metal ions and Concentration), Group Transfer Potential, Energetics of Hydrolysis of Phospho-Creatine, Acetyl Phosphate and 1,3-bisphosphoglycerate.

SECTION-C **(11 Hrs.)**

Characterization of Biological Systems: Isothermal Titration calorimetry, Differential Scanning Calorimetry, Circular Dichroism (Theoretical background, Instrumentation, Application to Study Protein-Protein, Protein-Ligand, Protein-Drug and Protein Surfactant Interactions, and Stability of Biomolecules).

SECTION-D **(11 Hrs.)**

Optical Properties of Biomacromolecules: Light Scattering, fundamental concepts, Rayleigh Scattering, Scattering by Larger particles, Information about size and molecular weight. Ultracentrifugation: Svedberg equation, sedimentation equilibrium, density gradient sedimentation. Electrophoresis: General principles, Double layer techniques, moving

boundary electrophoresis, zonal electrophoresis, isoelectric focusing. Osmotic Pressure: Second virial coefficient, Donnan effect, molecular mass and geometry from osmotic pressure measurements.

Course Outcome

This course will provide information about the applications of physical chemistry in fundamental biological processes.

Books Suggested

1. Principles of Biochemistry, A. L. Lehninger, Worth Publishers.
2. Biochemistry, L. Stryer, W. H. Freeman.
3. Biochemistry, Voet and Voet, John Wiley.
4. Biophysical Chemistry, J. P. Allen, John Wiley.
5. Macromolecules: Structure and Function, F. Wold., Prentice Hall.
6. Text Book of Polymer Science, F. W. Billmeyer.
7. Physical Chemistry of Polymers, A. Tager.

SEMESTER–VII

CHEMISTRY

ORGANIC CHEMISTRY-IV: Lab Preparations-II

(PRACTICAL)

Time: 3 Hrs **Marks: 50**

Credits: 0-0-2 **30 Hrs.**

1. An NMR study of Keto-Enol Tautomerism in β-dicarbonyl compounds (J. Chem Edu., 1976, 53, p392).
2. Preparation of bromohydrin of methyl oleate (Eur. J. Lipid Sci. Technol. 2004, 106, p27)
3. Epoxidation of methyl oleate (JACS, 1944, 66, p1925; J. Agric Food Chem, 2010, 58, p6234)
4. Solvent free Cannizaro reaction using 2-chlorobenzaldehyde (J. Chem Edu., 2009, 86, p85)
5. Reduction of 3- nitroacetophenone using i) NaBH4 ii) using Sn and HCl. Identification of the products with NMR, UV, IR spectra (Modern projects and experiments in organic chemistry, p193)
6. Synthesis of N,N-diethyl-m-toluamide (mosquito repellent) from m-toluic acid (Modern projects and experiments in organic chemistry, p227)
7. Dihydroxylation of cyclohexene with: (a) $KMnO_4$ (J. Chem. Edu. 2008, 85, p959) and (ii) p-toluene sulphonic acid/H_2O_2 (J. Chem. Edu. 2011,88, 1002-1003) and HCO_2H/H_2O_2 (Book 1, p 549) Compare product distribution by TLC.
8. Preparation of fluorescein from resorcinol and phthalic anhydride (Book 1, p935).
9. Synthesis of benzpinacol and its pinacol rearrangement.
10. Synthesis of 2,4-dinitrophenyl hydrazine from chlorobenzene.

Course Outcome

The use of multi-step approach in organic synthesis and applications of spectroscopic techniques to determine the structures of the compounds prepared.

Books Suggested

1. Vogel's text book of practical organic chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, 5th Ed., 1989, Longman Group.
2. Introduction to Organic Laboratory Techniques – A Contemporary Approach. D. L. Pavia, G. M. Lampmana and G. S. Kriz, W. B. Saunders Company, 1976.

SEMESTER–VII

CHEMISTRY

PHYSICAL CHEMISTRY–III: Lab

(PRACTICAL)

Time: 3 Hrs **Marks: 50**

Credits: 0-0-2 **30 Hrs.**

(I) Adsorption:

1. To investigate the adsorption of oxalic acid from aqueous solution by activated charcoal and examine the validity of Freundlich and Langmuir's adsorption isotherms.

2. To determine the adsorption isotherms of CH_3COOH from aqueous solutions by charcoal.

(II) Colloidal State:

3. To prepare colloidal solutions of arsenius sulphide, cadmium sulphide and ferric hydroxide. 4. To determine the precipitating values of KCl, K_2SO_4 and $K_3Fe(CN)_6$ for ferric hydroxide solution.

5. To study the protective action of hydrophilic colloid on the precipitation of a hydrophobic colloid.

6. To prepare and characterize (melting and gelling temperature by ball bearing method) the hydrogel of agarose.

7. To investigate the effect of concentration of agarose on melting and gelling temperature of hydrogel.

8. To prepare and draw phase diagram of microemulsions comprising sodium dodecyl sulfate, water and hexanol (or propanol) (III) Molecular weight determination:

9. Determination of molecular weight of a volatile substance by Victor Mayer's method.

10. Determination of molecular weight of a liquid by steam distillation.

11. Determination of molecular weight of high polymer (polystyrene) by viscosity measurements.

12. To determine the critical micelle concentration of a soap (potassium laurate) by surface tension measurements.

13. To extract oil from given seeds with the help of soxhlet apparatus.

Course Outcome

The practical's mentioned in the syllabus will reinforce the theoretical concepts taught in the class rooms.

Books Suggested

1. Findlay's Practical Physical Chemistry, Author: Alexander Findlay Publisher: Wiley, 1972, ISBN-10:0470258853.

2. Advanced Practical Physical Chemistry, Author: J. B. Yadav, Publisher: Krishna Prakashan Media (Pvt) Ltd (2015), ISBN-10: 8182835925.

3. Quantitative Organic Analysis by Vogel, Author: A. I. Vogel, Publisher: Wiley, John & Sons, Incorporated, ISBN-13: 780582442504

SEMESTER–VII

Minor Stream Course

SYNTHESIS AND CHARACTERIZATION OF MATERIALS

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(15 Hrs.)**

Single crystal growth: Czochlralski, Bridgmann and float zone methods, Preparation of bulk polycrystalline materials by solid state reaction, sintering, calcination and annealing. Glass synthesis by melt-quenching, Preparation of nanomaterials by Inert gas condensation, Ball Milling, Thin film deposition by evaporation, sputtering, Molecular beam epitaxy, Chemical vapour deposition method, Electrodeposition.

SECTION-B **(15 Hrs.)**

Metal nanocrystals by reduction, Solvothermal synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, post-synthetic size-selective processing. Sol- gel, Micelles and microemulsions, Cluster compounds.

SECTION-C **(15 Hrs.)**

X-ray and neutron diffraction, Atomic Force Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Tunnelling Microscope, Optical transmission and metallurgical microscope; their description, operational principle and application for analysis of materials, UV-VIS-IR Spectrophotometers, Principle of operation and application for band gap measurements, Raman spectroscopy, Magnetic measurements, electrical conductivity measurement by two probe, four probe and Van-der-Pauw methods

SECTION-D **(15 Hrs.)**

AFM based nanolithography and nanomanipulation, electron beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography.

Course Outcome

The students will get the knowledge about the synthesis of nanomaterials and their characterization using state of the art techniques.

Books Suggested

1. Nanostructures and Nanomaterials G. Cao World Scientific Principles of Nanotechnology G. Ali. Mansoori World Scientific
2. Structure and properties of Atomic Nanoclusters J. A. Alonso World Scientific Nanoscience Dupas Claire Springer, June, 2006

SEMESTER–VII

SUMMER INTERNSHIP

(02 WEEKS)

Time: 3 Hrs **Marks: 50**

Credits: 0-0-2 **02 Weeks**

Students will be required to undertake Community Engagement and service/ Field based learning/ Minor Projects and will have to submit a Report along with original certificate at the completion of the Internship. Every student will be required to submit an internship report in typed standard prescribed format containing a copy of original certificate. The objective of the Summer Internship is to test the ability of the student to grasp the practical knowledge. Every student will make PowerPoint presentation of internship and will be orally examined in the context of the training report. The Summer Internship Report shall be evaluated by a committee constituted by the College principal

Course Outcomes: Students should work in the industry/laboratories as trainees so that they can acquire knowledge about the different processes.

SEMESTER–VIII

CHEMISTRY

INORGANIC CHEMISTRY–IV: Cluster and cage compounds

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 4-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(10 Hrs.)**

Chains: Catenation, heterocatenation, zeolites, intercalation chemistry, one-dimensional conductors; Rings: Borazines, Phosphazenes (synthesis, bonding & reactions), Phosphazene polymers, other heterocyclic inorganic systems, homocyclic inorganic systems.

SECTION-B **(12 Hrs.)**

Cages: Introduction, boranes, styxnumbers, bonding problems in Boranes, Chemistry of boranes- reaction with Lewis bases, Borane cages, $[B_{12}H_{12}]^{2-}$ and other boranes derived from $[B_{12}H_{12}]^{2-}$, structure relationship of closo, nido, archano and hypo boranes, heteroboranes, carboranes, metallocarboranes, structure prediction of heterocarboranes. Cage compounds having phosphorus and oxygen, Cage compounds of phosphorus and sulphur.

SECTION-C **(13 Hrs.)**

Cluster Compounds: Cluster compounds, molecular structures of clusters, metal carbonyl clusters, Low nuclearity carbonyl clusters (LNCCs), high nuclearity carbonyl clusters (HNCCs) (Structure patterns, synthesis methods), Electronic structures of clusters with π-acid ligands, Polyhedral skeletal electron pair theory (PSEPT), electron counting schemes for HNCCs, the capping rule, structures not rationalized by PSEPT model, isoelectronic and isolobal relationships, stereochemical nonrigidity in metal clusters, heteroatoms in metal clusters: carbide and nitride containing clusters, HNCCs of Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt.

SECTION-D **(10 Hrs.)**

Lower Halide and Chalcogenide Clusters: Octahedral metal halide and chalcogenide clusters (M_6X_8 and M_6X_{12} types), Chevrel phases, triangular clusters and solid-state extended arrays.

Compounds with M-M multiple bonds: Major structural types, quadrupole bonds, other bond orders in tetragonal context, relation of clusters to multiple bonds.

Course Outcome

This course will enrich the knowledge of students about the concepts of inorganic chains, rings and cages.

Books suggested

1. B. E. Douglas, D. H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, John Wiley & Sons, Inc., New York., 1994.

2. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry, 4th Edn., Pearson Education, Singapore, 1999.

3. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 5th or 6th Edition Interscience Publishers.

SEMESTER–VIII

CHEMISTRY

ORGANIC CHEMISTRY-V: Organic Synthesis-I

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 4-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(11 Hrs.)**

Addition to Carbon-Carbon Multiple Bonds: Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydroboration, Sharpless asymmetric epoxidation. Elimination Reactions: The E2, E1 and E1cB mechanisms and their spectrum. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

SECTION-B **(12 Hrs.)**

Reagents for protection and deprotection of hydroxyl, amino, carbonyl and carboxylic acid in organic synthesis, preparation and reactions of Sulfonium and Sulfoxonium ylides, Umpolung reactions (Sulphur compounds, nitro compounds, lithiated ethers and related compounds). Chemistry of organometallic Reagents: Synthesis and chemical reactions based on organomagnesium, organozinc, organolithium, organocopper, organoboron, organosilicon and organotin.

SECTION-C **(11 Hrs.)**

Selected named reactions and rearrangements: Baker-Venkataraman, Barbier, Baylis-Hillman, Corey-Bakshi-Shibata, Corey-Seebach, Darzen, Dakin, Fischer, Friedlander, Fukuyama, Mukaiyama, Pictet-Spengler, Prins, Stork, Strecker, Vilsmeier. Mitsonobu reaction. 1,3-dipolar cycloaddition in the construction of rings. Prevost and Woodward procedures, Benzidine, Cope, Fries, Lossen, Wolf and Demjanov, Von-richter, Discussion on Steven’s reaction, Sommelet rearrangement and related reactions and Smiles Rearrangement.

SECTION-D **(11 Hrs.)**

Palladium in Organic Synthesis: Palladium-catalyzed cross-coupling and related reactions of Unactivated/activated alkyl electrophiles with organometallic compounds: Wacker reaction, Heck reaction, Suzuki, Negishi, Stille, Sonogashira, Hiyama, Kumada-Murahashi, Buchwald-Hartwig coupling, and Tsuji-Trost reaction, Palladium-catalyzed Annulation of alkynes, Palladium catalyzed cycloaddition reaction of Arynes.

Course Outcome

The objective of this course is to provide information about the organic reactions involving C-C bond formation using different reagents.

Books Suggested

1. Advanced Organic Chemistry, 5th Edition, Part B: Reactions and Synthesis by Francis A. Carey and Richard J. Sundberg, Plenum Press, N. York, 2007.
2. Palladium in Organic Synthesis (Editor: Jiro Tsuji) Volume 14, 2005, Springer.
3. Advanced Organic Chemistry: Reaction mechanism by Reinhard Bruckner (2001) “Reactionof Ylides with Saturated or α,β -Unsaturated Carbonyl Compounds”, Chapter 9, pp 347-372.
4. Organic Reaction Mechanism by Jerry March, John Wiley Ed. 5, 2002; 5. Advanced Organic Chemistry by Francis Carey, Vol. A and Vol. B
5. T. W. Greens, P. G. M. Wuts. Protective groups in Organic synthesis, 3rd / 4th Ed. John Wiley &Sons, INC.
6. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.

SEMESTER–VIII

CHEMISTRY

INORGANIC CHEMISTRY-V: Nuclear chemistry

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 3-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(11 Hrs.)**

Nuclear chemistry: Introduction, nuclear and chemical reactions. Nuclear particles: properties of alpha, beta, gamma, positrons, mesons, hyperons, neutrino and antineutrino, antiprotons, antineutrons and quarks. Nuclear structure, forces and stability: Nucleus shape, isotopes, isobars, isotones, isomers and nuclear forces, nuclear mass & binding Energy, packing Fraction, Mass defect, binding energies and stability.

SECTION-B **(12 Hrs.)**

Radioactivity: Rate of radioactive disintegration and units of radioactivity. Artificial radioactivity: artificial transmutation of elements and induced radioactivity. Cyclotron. Preparations of tranuranic elements. Q-values of nuclear reactions: endoergic and exoergic. Nuclear coulombic barrier. Group displacement law - statement and explanation - with examples; radioactive series - U, Th, Ac and Np series (mention of the first and last stable elements, number of α- and β- particles. Type of series: viz., 4n, (4n+1), (4n+2) and (4n+3).

SECTION-C **(11 Hrs.)**

Nuclear Models: Detail information about the nuclear shell and nuclear liquid drop model. Nuclear reactions: Nuclear reactions induced by charged particles: Protons, deuterons, neutrons and alpha particles.Nuclear fission - explanation with an example, chain reaction, principle of atomic bomb, calculation of energy liberated, fissionable isotopes. Nuclear fusion - explanation with an example, thermonuclear reaction, advantages and disadvantages of fusion over fission, the principle of a hydrogen bomb.

SECTION-D **(11 Hrs.)**

Nuclear reactor and detectors: Nuclear reactors: principle, working of a thermal reactor, diagram, and explanation of the terms like nuclear fuel, control rods, moderators and coolant. Breeder reactors- a brief explanation of their functioning. Nuclear detection of radioactivity: The Geiger-Muller Counter and Wilson cloud chamber. Nuclear hazards, waste disposal and applications nuclear isotopes: Hazards of nuclear materials. Disposal methods of nuclear waste. Applications of radioisotopes in tracer technique - agriculture (phosphorous in agriculture research), medicine (phosphorous to check crack in bones, sodium/iodine to detect clots in blood vessels), food preservation. Carbon dating - formation of radioactive carbon in the atmosphere. Explanation of the determination of age of wood/peat or fossil. Numerical problems on carbon dating.

Course Outcome

The students will get the knowledge about Radiation and Nuclear chemistry along with knowledge of types of radioactive decay, natural decay series, nuclear models, nuclear properties,

Books suggested

1. B.C. Harvey, Introduction to Nuclear Chemistry, Prentice-Hall (1969)
2. G. Friedlander, J.W. Kennedy, E.S. Marcus & J.M. Miller Nuclear & Radiochemistry. John- Wiley & Sons (1981)
3. H.V. Keer, Principles of the Solid State, Wiley Eastern Ltd. (1993)
4. A.R. West Solid State Chemistry and Its Applications" John Wiley & Sons (1987)
5. A.K. Cheetham and P. Day Eds. Solid State Chemistry Techniques, Clarendon Press, Oxford (1987)
6. G. Timp Ed. Nanotechnology Springer-verlag (1999)

SEMESTER–VIII

CHEMISTRY

PHYSICAL CHEMISTRY-V: Electroanalytical techniques

(THEORY)

Time: 3 Hrs **Marks: 75**

Credits: 3-0-0 **45 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A **(12 Hrs.)**

Introduction: Electrolytic and galvanic cell, Cell components, Faradaic and Non-Faradaic currents, electrical double layer, mass transfer in cells, schematic representation of cells. Potentials in electroanalytical cells: thermodynamics of cell potential, liquid junction potential. Electrode potentials: nature of electrode potential, sign conventions of electrode potential, standard electrode potential, measurement of electrode potentials, effect of activity on electrode potential, limitation to the use of standard electrode potentials. Calculation of cell potentials from electrode potentials. Currents in electrochemical cells: Ohmic potential, polarization, charge transfer polarization, mechanism of mass transport. Types of electroanalytical methods: interfacial and bulk methods.

SECTION-B **(11 Hrs.)**

Voltammetry and Polarography: General introduction, Polarographic cells, Polarograms, polarographic waves, equation of the polarographic waves, Effect of complex formation on polarographic waves. The dropping mercury electrode (DME): advantages and disadvantages of DME. Polarographic diffusion current, Ilkovic equation, capillary characteristics, residual current, anodic Waves, mixed anodic-cathodic waves, oxygen waves, supporting electrolyte. Applications of polarography. Modified voltametric methods: differential pulsed polarography, rapid-scan polarography, cyclic voltammetry, alternating current polarography, stripping methods. Amperometric titrations and its applications.

SECTION-C **(11 Hrs.)**

Potentiometric Methods: Reference electrodes (Calomel, Ag/AgCl), Metallic indicator electrodes (Electrodes of the First, second and third types), Metallic redox indicator

electrode. Membrance indicator electrodes: classification of membranes, properties of membranes, glass electrode for pH measurements and cations, crystalline membrane electrode, liquid membrane electrodes. Ion-selective field transistors (ISFET): Mechanism and application of ISFET. Molecular selective electrode systems: gas sensing probes, biosensors. Instruments for measuring cell potential, direct potentiometric measurements and potentiometric titrations.

SECTION-D (11 Hrs.)

Conductometric Methods: Electrolytic conductance, variation of equivalent conductance with concentration, measurement of conductance, conductometric titrations, Applications to various types of titrations for detection of end points. Kohlrausch's law and Ostwald's dilution law, conductometric titrations. Coulometry: Current voltage relationships, electrolysis at constant applied voltage, constant current electrolysis. Coulometric methods of Analysis: types of coulometric methods. Controlled-potential coulometry: instrumentation and applications. Coulometric titrations and its applications. Turbidimetry and Nephelometry: Theory of Nephelometry and Turbidimetry, Brief Instruments, applications.

Course Outcome

To provide basic principles, theoretical background, and key applications/examples of various analytical techniques being used in laboratory experiments.

Books suggested

1. D. A. Skoog, F. J. Holler, and S. R. Crouch: Principles of Instrumental Analysis-Sixth addition. Thomson Brooks/Cole, 2007.
2. D. A. Skoog and D. M. West: Principles of Instrumental Analysis-Second addition. Saunders College, 1980.
3. G. W. Ewing: Instrumental Methods of Analysis.
4. H. H. Willard, L.L. Marritt & J.A. Dean: Instrumental Methods of Analysis.

SEMESTER–VIII

CHEMISTRY

INORGANIC CHEMISTRY–III: Lab

(PRACTICAL)

Time: 3 Hrs **Marks: 50**

Credits: 0-0-2 **30 Hrs.**

1. Preparation tris(ethylenediamine)cobalt(III) chloride. Record and interpret IR and UV visible spectrum of the complex. [Ref. J. Chem. Educ.1976, 53, 10, 667]
2. Preparation of tris(thiourea)mercury(II), record and interpret its IR and how it helps to establish metal-ligand bonding. [Ref. Inorg. Synth. Vol. VI, p.26].
3. Preparation of [chloro(pyridine)cobaloxime(III)], record and interpret its IR, and UV-vis. spectral data. [Inorg. Synth. Vol. XI, p. 61].
4. Preparation of $[Zn(acac)_2]$.HO, record and interpret its IR spectrum TGA/DTA/DSC. [Ref. Inorg. Synth. Vol. X, p.74].
5. Synthesis of Prussian Blue: $Fe_4[Fe(CN)_6]_3.nH_2O$ (n=14-16). Record and interpret its IR and TGA. [Inorg. Chem. 1977, 16, 2704-2710]
6. Preparation of Preparation of sodium tetrathionate, potassium dithionate, and interpretation of their IR spectra. [Ref. Marr and Rockett, 1972, p. 270].
7. Preparation of potassium trioxalatoaluminate(III) trihydrate. Its TGA and DTA studies and its interpretation of its IR spectrum.
8. Preparation of cis-and trans-potassium dioxalatodiaquochromate(III). Interpretation of their IR and electronic absorption spectral data. Calculation of β and 10 Dq values.
9. Preparation of chloropentaamminecobalt(III) chloride from cobalt carbonate. Interpretation of their IR and UV-visible spectra.
10. Preparation of $HgCo(NCS)_4$, its IR and measure its magnetic moment. Explain how the magnetic moment is calculated using the Gouy's balance and the roll of this compoun (ref. Marr and Rockett, 1972, page 365).

Course Outcome:

To familiarize the students with some synthetic methods for the preparation of coordination complexes and their characterization using NMR, IR, UV-Vis, techniques.

Books suggested

1. G. Marr and B.W. Rockett: Practical Inorganic Chemistry, Van Nostrand Reinhold Company.
2. W. L. Jolly, The Synthesis and Characterization of Inorganic Compounds. Prentice Hall.

SEMESTER–VIII

Minor Stream Course

ATOMIC AND MOLECULAR SPECTROSCOPY

(THEORY)

Time: 3 Hrs **Marks: 100**

Credits: 4-0-0 **60 Hrs.**

Instructions for the Paper Setters: Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A (15 Hrs.)

Spectra of one and two valance electron systems: Magnetic dipole moments; Larmor's theorem; Space quantization of orbital, spin and total angular momenta; Vector model for one and two valance electron atoms; Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectroscopic terminology; Spectroscopic notations for L-S and J-J couplings in two electron systems, Spectra of alkali and alkaline earth metals, Lande's Internal rule, Interaction energy in L-S and J-J coupling for two electron systems; Selection and Intensity rules for doublets and triplets.

SECTION-B (15 Hrs.)

Breadth of spectral line and effects of external fields: The Doppler effect; Natural breadth from classical theory; natural breadth and quantum mechanics; External effects like collision damping, asymmetry and pressure shift and stark broadening; The Zeeman Effect for two electron systems; Intensity rules for the zeeman effect; The calculations of Zeeman patterns; Paschen-Back effect; LS coupling and Paschen –Back effect; Lande's factor in LS coupling; Stark effect.

SECTION-C (15 Hrs.)

Microwave and Infra-Red Spectroscopy: Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator, Intensity of rotational lines, Effect of isotopic substitution, Microwave spectrum of polyatomic molecules, Microwave oven, The vibrating diatomic molecule as a simple harmonic and an harmonic oscillator, Diatomic vibrating rotator, The vibration-rotation spectrum of carbon monoxide, The interaction of rotation and vibrations, Outline of technique and instrumentation, Fourier transform spectroscopy.

SECTION-D **(15 Hrs.)**

Raman and Electronic Spectroscopy: Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrational Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, Born Oppenheimer approximation- The Franck Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, Example of spectrum of molecular hydrogen. (15 Lectures)

Course Outcome

The students will get the information about the theory and applications of different spectroscopic techniques.

Books Suggested

1. Introduction to Atomic Spectra: H.E. White, McGraw Hill, 1934.
2. Fundamentals of Molecular Spectroscopy: C.B. Banwell-Tata McGraw Hill, 1986.
3. Spectroscopy Vol. I, II & III: Walker & Straughen
4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1962.
5. Spectra of diatomic molecules: Herzberg-New York, 1944.
6. Molecular spectroscopy: Jeanne L McHale.
7. Atomic and Molecular Physics by Raj Kumar