

2017 REGULATIONS

SCY 1111	GENERAL CHEMISTRY-I	L	T	P	Credits	Total Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To understand the theoretical aspects of volumetric analyses.
- To understand the nature of bond in a given compounds.
- To understand the nomenclature of organic molecules.
- To develop the habit of handling analytical data.
- To study the gas laws and its applications

UNIT 1 ANALYTICAL METHODS-I

12 Hrs.

Safety and hygiene in the Chemistry Lab Storage and handling of chemicals, first aid procedure. Error in chemical analysis Accuracy and precision. Absolute and relative errors. Methods of eliminating or minimizing errors. Precision: mean, median, average deviation and coefficient of variation. Volumetric Analysis: Preparation of standard solutions-normality and molarity - Types of titrations. Requirements for titrimetric analysis. Primary and secondary standards. Limitations of volumetric analysis. Acid-base titrations-types of acid-base titrations-titration curves selection of suitable indicators. Problems.

UNIT 2 IONIC BOND

12 Hrs.

General characteristic of ionic bond, size effect and radius ratio rule, limitation of radius ratio rule, Lattice energy - Factors affecting lattice energy. Born equation and its application. Born - Haber cycle application of lattice energy, Role of lattice energy and hydration energy, Covalent character of ionic compounds-Fajan's rules, effects of polarization and polarizability, Crystal structure of AX₂ type.

UNIT 3 COVALENT BOND

12 Hrs.

General characteristic of covalent bond, Valence Bond theory-arrangement of electrons in molecules, Hybridization and geometry. VSEPR model-Effect of bonding and nonbonding electrons on the structure of molecules, effect of electronegativity, Illustration of structures by VSEPR. MO theory: LCAO method- criteria of orbital overlap, types of molecular orbitals, qualitative MO energy level diagram of homo diatomic molecules, and their magnetic properties, bond length, bond energy, bond order and stability of molecules.

UNIT 4 CLASSIFICATION AND PROPERTIES OF ORGANIC COMPOUNDS

12 Hrs.

IUPAC Nomenclature (Monofunctional and polyfunctional) - Shapes of simple molecules - Bond energy, bond length and bond angle - Bond polarity - dipole moment - Bond dissociation energy - Isomerism - Structural and Stereoisomerism - types of isomerism with suitable examples - Concept of hybridization - Structure of organic molecules based on sp³, sp² and sp hybridization - Energy requirements of a reaction - Activation Energy - Transition state - Intermediate - Effect of catalyst on energy of activation.

UNIT 5 GASEOUS STATE

12 Hrs.

Gas Laws from the kinetic theory of gases. Transport properties - viscosity - thermal conductivity - diffusion - Maxwell's distribution of molecular velocities (no derivation) - mean - rms, most probable, velocity equi-partition of energy - heat capacity - molecular basis - virial equation of state - Boyle temperature - coefficient of compressibility and thermal expansion.

Max. 60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

- CO1: Aware of Lab safety and to learn sources and eradication of errors; and to handle, prepare the various laboratory reagents.
- CO2: Learn the periodicity of elements, ionic and covalent character of compounds.
- CO3: Understand the concept of MO energy level diagram.
- CO4: Deal with the concepts of kinetic theory of gases.
- CO5: Understand the IUPAC nomenclature, isomerism and stereochemistry of organic molecules.
- CO6: Gain the knowledge of hybridization.

TEXT / REFERENCE BOOKS

1. R. Gopalan, P. S. Subramanian and K. Rengarajan, Elements of Analytical Chemistry, Sultan Chand, New Delhi, 2007.
2. Selected topics in inorganic chemistry, R.D Madan, G D Tuli & Wahid U Malik, S.Chand publication, 1976.
3. R. T. Morrison and R. N. Boyd, Organic Chemistry, 6th ed., Prentice-Hall of India Limited, New Delhi, 1992.
4. Bahl B.S. and ArunBahl, Advanced Organic Chemistry, (12th edition), New Delhi, Sultan Chand & Co., (1997).
5. S. H. Pine, Organic Chemistry, 5th ed., McGraw Hill International Edition, Chemistry Series, New York, 1987.
6. B. R. Puri and L.R. Sharma, Principles of Physical Chemistry, Shoban Lal Nagin Chandand Co. 23rd edition, 1993.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

PART A: 10 Questions of 2 marks each-No choice

PART B: 2 Questions from each unit with internal choice, each carrying 16 marks

Exam Duration: 3 Hrs.

20 Marks

80 Marks

SCY 1611	Analytical Chemistry	L	T	P	Credits	Total marks
		3	1	0	4	100

COURSE OBJECTIVES

- To enable the students learn the principles of separation and purification techniques.
- To understand the principles of various chromatographic techniques.
- To construct the techniques for separation of metal ions using various chromatographic methods.
- To develop the skill of learning various thermal methods.
- To discuss the basic principle of polarimetry and amperometry methods.

UNIT 1 SEPARATION AND PURIFICATION TECHNIQUES

12 Hrs.

Principles involved in the separation of precipitates, solvent extraction and electrophoresis. Purification of solid organic compounds, extraction - use of immiscible solvents, soxhlet extraction, crystallization, use of miscible solvents, fractional crystallization, sublimation. Purification of liquids, experimental techniques of distillation, fractional distillation, vacuum distillation, steam distillation, tests for purity.

UNIT 2 CHROMATOGRAPHY I

12 Hrs.

Principles adsorption, thin layer, partition and paper. Chromatography column chromatography, adsorbents, preparation of column, adsorption, elution, recovery of substance and applications. TLC - choice of adsorbent and solvent, preparation of chromatogram and applications, Rf value. Paper chromatography, Solvents used and principles, factors affecting Rf value, separation of amino acid mixtures. Radial paper chromatography.

UNIT 3 CHROMATOGRAPHY II

12 Hrs.

Ion exchange chromatography – principle, resins, action of resins, experimental techniques, applications, separation of Zn-Mg, Co-Ni, Cd-Zn, Chloride, bromide. Gas chromatography and high pressure liquid chromatography – principles, Detectors, experimental techniques, instrumentation and applications.

UNIT 4 THERMAL ANALYSIS

12 Hrs.

Thermal analytical methods - Principle involved in thermogravimetric analysis and differential gravimetric analysis, discussion of various components with block diagram, characteristics of TGA and DTA, factors affecting TGA and DTA curves, thermometric titrations.

UNIT 5 POLAROGRAPHY

12 Hrs.

Principle, concentration polarization, dropping mercury electrode, advantages and disadvantages, convection, migration and diffusion currents, Ilkovic equation (derivation not required) and significance, experimental assembly, electrodes, capillary solutions, current voltage curve, oxygen wave, influence of temperature and agitation on diffusion layer, polarography as an analytical tool in quantitative and qualitative analysis. Amperometry - basic principles and uses. Polarimetry principle – instrumentation, comparison of strengths of acids, estimation of glucose.

Max.60 Hours

COURSE OUTCOMES

On successful completion of the course, student will be able to

- CO1: Explain the principles involved in various separation techniques and its purification.
- CO2: Discuss the basic principles and applications of different chromatographic techniques.
- CO3: Determine the various chromatographic techniques for efficient separation of metal ions and its applications.
- CO4: Discuss the principle and instrumentation of various thermal methods and thermometric titrations.
- CO5: Explain the principles in polarography and amperometry techniques.
- CO6: Construct the Ilkovic equation for dropping mercury electrode.

TEXT / REFERENCE BOOKS

1. Concise Inorganic Chemistry – J.D. Lee – 3rd Edition, Von Nostrand
2. Inorganic Chemistry – P. L. Soni – Sultan Chand
3. Inorganic Chemistry – Pun and Sharma Nagin
4. Inorganic Chemistry – Modan S. Chand
5. Advanced Inorganic Chemistry – Cotton and Wilkinson
6. A Textbook of Inorganic Chemistry – A.K. De – New Age
7. Industrial Chemistry- B.K. Sharma – Goel Publications
8. General and Inorganic Chemistry Part I Sarkar, Books and Allied (P) Ltd
9. General and Inorganic Chemistry Part II Sarkar, Books and Allied (P) Ltd
10. Chemical Methods for Environmental Analysis Ramesh and Anbu, Macmillan

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 10 Questions of 2 Marks each-No choice

20 Marks

PART B: 2 Questions from each unit of internal choice, each carrying 16 Marks.

80 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

SCY 1311	INORGANIC CHEMISTRY I	L	T	P	Credits	Total Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To elaborate on the general characteristics, oxidation reduction processes and catalytic applications of coordination compounds.
- To explain the chelate effect, types of isomerism and the theories related to coordination complexes.
- To understand the importance of crystal field splitting based on the theories and correlating them with the properties of the complexes.
- To understand the formation and stability of various organometallic compounds based on EAN rule.
- To learn the properties and uses of important inorganic oxidizing and reducing compounds.

UNIT 1 d-BLOCK ELEMENTS

12 Hrs.

First, second and third transition series, general characteristics, metallic character, atomic and ionic radii, standard reduction potentials, variable oxidation states and stabilization, colour, complex formation, catalytic and magnetic properties. Origin of magnetism, measurements by Gouy's balance method, Electroneutrality principle, coordination numbers, coordination numbers from 1 – 10 with examples, Kepert model.

UNIT 2 COORDINATION CHEMISTRY I

12 Hrs.

Introduction- Types of ligands, coordination number, IUPAC nomenclature, chelate effect - Isomerism- linkage, ionization, hydrate, coordination, coordination position isomerism. Stereoisomerism- geometrical (cis-/trans- and fac-/mer-), optical isomerism in 4 and 6 coordinated complexes. Theories of coordination compounds-Werner's and Sidgwick's EAN concept.

UNIT 3 COORDINATION CHEMISTRY II

12 Hrs.

Valence bond theory-applications and limitations, hybridization, geometry and magnetic properties of tetrahedral and octahedral complexes. Crystal field theory- splitting of 'd' metal orbitals in octahedral, tetrahedral and square planar complexes-factors influencing the magnitude of crystal field splitting, low-spin and high-spin complexes, Jahn Teller distortion, explanation of colour and magnetic properties, comparison of VBT and CFT, spectrochemical series.

UNIT 4 ORGANOMETALLIC COMPOUNDS

12 Hrs.

Definition, Types of organometallic compounds, Classification of ligands, EAN and Nomenclature of organometallic compounds. Preparation, reaction and structure of ferrocene, metal-olefins and metal -alkynes complexes. Carbonyl compounds of transition metals, structure of mono and polynuclear carbonyls.

UNIT 5 INORGANIC COMPOUNDS

12 Hrs.

Preparation, properties, uses and structures of $\text{Ti}(\text{NO}_3)_4$, TiO_2 , VOCl_2 , K_2CrO_4 , $\text{K}_2\text{Cr}_2\text{O}_7$, Chromyl chloride, Manganese dioxide, Potassium permanganate, potassium ferrocyanide, potassium ferricyanide, Prussian blue, sodium nitroprusside, Lithium aluminium hydride, aluminium chloride, hexamine cobalt(III) chloride, Cuprous chloride.

Max.60 Hours

COURSE OUTCOMES

On successful completion of the course, student will be able to

- CO1: Explain the characteristics and mechanism involved in oxidation and reduction processes taking place in coordination compounds.
 CO2: Discuss the chelate effect and theories related to transition metal complexes.
 CO3: Understand the properties exhibited by the coordination complexes based on CFSE.
 CO4: Analyze the structure and isomerism in coordination complexes and explain the color and magnetic properties of coordination complexes.
 CO5: Understand the stability of complexes based on EAN rule and design the structure.
 CO6: Identify important inorganic oxidizing and reducing agents for organic conversion and catalytic applications.

TEXT / REFERENCE BOOKS

1. Advanced Inorganic Chemistry, F.A. Cotton and G. Wilkinson, Wiley Eastern Private Limited 1992.
2. Inorganic Chemistry: Principles of Structure and Reactivity, J.E. Huheey, E.A. Keiter and R.L. Keiter, Addison-Wiley Publication Company, 1993.
3. Inorganic Chemistry, D.F. Shriver, P.W. Atkins, C.H. Longford, Oxford University Press, 1996
4. Concise Coordination Chemistry, R. Gopalan and V. Ramalingam, Vikas Publishing House Private Limited, 2001.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 10 Questions of 2 Marks each-No choice

20 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 16 Marks.

80 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

SCY 1312	ORGANIC CHEMISTRY-I	L	T	P	Credits	Total Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To understand the mechanism for substitution, elimination and addition reactions.
- To learn the importance of alcohols and phenols in organic reactions.
- To emphasize on chemical reactions involving ethers and epoxides.
- To recognize the importance of carbonyl compounds in organic reactions.
- To impart an insight into chemistry of carbohydrates.

UNIT 1 ALKYL AND ARYL HALIDES

12 Hrs

Structure and Nomenclature– General methods of Preparation– Sandmeyer and Gattermann reactions -Physical and Chemical properties – Nucleophilic substitution reactions (S_N1 , S_N2 , S_Ni and S_NAr), Reduction, Eliminations: E1 and E2 mechanisms – Mechanism – Formation of Grignard reagents, addition - Williamson's ether synthesis.

UNIT 2 ALCOHOLS AND PHENOLS

12 Hrs.

Alcohols –Structure, nomenclature and classification – Methods of preparation - hydration, hydrolysis, reduction of carbonyl compounds, from Grignard reagents – Physical and chemical properties – Reactions involving OH bond –Glycol, glycerols and thiols.
Phenols – Structure and nomenclature - Preparation from diazonium salts and sulphonic acid, hydrolysis - Physical and chemical properties –reactions involving OH group, acidity, ether formation, esterification – reactions involving the benzene ring, electrophilic substitution, nitration, sulphonation, halogenation, Friedel-Craft's reaction, coupling reactions, Kolbe's reaction and Reimer-Tiemann reaction.

UNIT 3 ETHERS AND EPOXIDES

12 Hrs.

Structure and nomenclature - Preparation by Williamson's synthesis and by dehydration of alcohols - Physical and Chemical properties – Halogenation, formation of peroxides, hydrolysis, cleavage of C-O bond. Thioethers – Structure – Preparation and Properties - Crown ethers - Preparation and reactions of epoxides.

UNIT 4 CARBONYL COMPOUNDS

12 Hrs.

Structure and nomenclature– General methods of preparation of aldehydes and ketones – oxidation, dehydrogenation, from Grignard reagents, Rosenmund reduction, Gattermann-Koch reaction - Physical and Chemical properties –Reactivity of carbonyl group and acidity of alpha hydrogen - Nucleophilic addition reactions – Mechanism of Aldol, Perkin, Knoevenagel, Claisen, Wittig, Cannizzaro, Reformatsky and Benzoin reactions – Oxidation and Reduction reactions –Clemmensen and Wolf-Kishner reduction – Electrophilic substitution reactions of aromatic aldehydes and ketones.

UNIT 5 CARBOHYDRATES

12 Hrs.

Classification and nomenclature– Monosaccharides: Stereochemistry – Conversion to next higher aldose -Kiliani-Fischer synthesis –Conversion to next lower aldose – Ruff's method - Building up of the sugar series – Reducing and non-reducing sugars - Glucose and Fructose (open chain and cyclic structure – Fisher and Haworth structure) – Structural elucidation of glucose – Epimerization and mutarotation – Physical and Chemical properties – Reactions of the open chain and cyclic form - Disaccharides: Sucrose, Lactose and Maltose – Ring structures (Haworth formula) – Polysaccharides: Starch and cellulose (structure only).

Max.60 Hrs

COURSE OUTCOMES

On successful completion of the course, student will be able to

- CO1: Interpret and analyze the products in organic chemical reactions involving Substitution, Elimination and addition reactions of alkyl and aryl halides
CO2: Explain the chemical reactions in alcohols and phenols.
CO3: Examine the chemical reactions involving ethers and epoxides.
CO4: Analyze the reactivity of carbonyl group their preparations and properties.
CO5: Predict the oxidation, reduction and name chemical reactions based on carbonyl compounds.
CO6: Understand the stereochemistry and structure of monosaccharides, disaccharides and polysaccharides

TEXT / REFERENCE BOOKS

1. R. T. Morrison and R. N. Boyd, Organic Chemistry, 6th ed., Prentice-Hall of India Limited, New Delhi, 1992.
2. Bahl B.S. and ArunBahl, Advanced Organic Chemistry, (12th edition), New Delhi, Sultan Chand & Co., (1997).
3. S. H. Pine, Organic Chemistry, 5th ed., McGraw Hill International Edition, Chemistry Series, New York, 1987.
4. I. L. Finar, Organic Chemistry, Vol-1, 6th ed., Pearson Education Asia. 2004.
5. I. L. Finar, Organic Chemistry, Vol-2, 6th ed., Pearson Education Asia. 2004.
6. J. March and M Smith, Advanced Organic Chemistry, 5th ed., John-Wiley and sons, 2001.
7. Agarwal O. P., Chemistry of Organic Natural Products, Vol. 1, Goel Publishing House, 1997.
8. Jain J. L., Jain S., and Jain N., Fundamentals of Biochemistry, S. Chand, 2007

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 10 Questions of 2 Marks each-No choice

20 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 16 Marks.

80 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

SCY 1313	PHYSICAL CHEMISTRY-I	L	T	P	Credits	Total Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To understand the concepts of thermodynamics.
- To understand the concepts and applications of electrolytic conductance.
- To study the rate the order of reactions.
- To study the phase rule and its application to different system.

UNIT 1 THERMODYNAMICS-I

12 Hrs

State functions E and H – Concept of ideal gas: Gas laws, Kinetic theory of gases – postulates and derivation – Deviation from ideal behaviour – Vander-Waals equation of state – derivation – First law of thermodynamics - Applications of the laws of thermodynamics to ideal gases: Heat capacity, relation between C_p and C_v – Isothermal process: Change in internal energy, work done, W (rev) and W (irrev) – Adiabatic process: work done, and entropy changes – Application of the laws of thermodynamics to real (vander Waals) gases: Isothermal process – Work done, change in internal energy, heat absorbed – Adiabatic process: Work done – Joule-Thomson effect – Joule-Thomson coefficient and its significance, inversion temperatures – Variation of enthalpy change of reaction with temperature (Kirchoff's equation) – Zeroth law of thermodynamics.

UNIT 2 ELECTROCHEMISTRY-I

12 Hrs

Metallic and electrolytic conductors – Faraday's laws of electrolysis – Specific, equivalent and molar conductance – Determination of conductance – Variation of equivalent conductance with dilution – Kohlrausch's law and its applications – Transport number – Absolute velocity of ions and ionic mobility – Determination of transport number – Hittorf's method and moving boundary method – Applications of conductance measurements – Determination of i) Ionic product of water, ii) Solubility of sparingly soluble salt and iii) Degree of dissociation – Conductometric titrations.

UNIT 3 THEORIES OF IONISATION

12 Hrs

Arrhenius theory of electrolytic dissociation – Ostwald's dilution law – Limitations of Arrhenius theory – Theory of strong electrolytes – Debye-Huckel-Onsager theory – Inter-ionic effect – Asymmetry effect – Electrophoretic effect – Debye-Falkenhagen effect – Wien effect – Mean activity coefficient – Ionic strength – Limiting law equation,

UNIT 4 CHEMICAL KINETICS-I

12 Hrs

Rate of reaction – Factors influencing rates of reactions – Order and molecularity of reaction – Derivation of rate constant of Zero, First, Second, Third, Pseudo-order reactions – Half-life of reaction – Determination of order of reaction – Integration method, Graphical method, Half-life method.

UNIT 5 PHASE EQUILIBRIA

12 Hrs

Gibb's phase rule: Terms-phase, component and degree of freedom – Phase diagram of one component system - Water and Sulphur systems – Reduced phase rule – Phase diagram of two component system – Simple eutectic – Pb-Ag systems, desilverisation of lead – Phase diagram of system with compound formation with congruent melting point – Mg-Zn and FeCl₃-Water system – Incongruent melting point – Na-K system.

Max. 60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

- CO1: Learn the basics of law of thermodynamics.
- CO2: Analyze and interpret the laws of thermodynamics and its applications.
- CO3: Discuss the importance of conductance of electrolytic solutions.
- CO4: Learn and understand the advanced electrochemistry.
- CO5: Understand the derivation of rate laws.
- CO6: Construct and interpret the phase diagram for one component and two component systems.

TEXT/REFERENCE BOOKS

1. B. R. Puri and L.R. Sharma, *Principles of Physical Chemistry*, Shoban Lal Nagin Chand and Co. 23rd edition, 1993.
2. ArunBahl, B. S. Bahl and G. D. Tuli, *Essentials of Physical Chemistry*, S. Chand publishing, 2012
3. P.W. Atkins, *Physical Chemistry*, 7th ed., Oxford university press, 2001.
4. Glasston & Lewis, *Physical Chemistry*, 2nd Edition, McMillan publishers, 1973
5. A.S. Negi and S. C. Anand, *A Textbook of Physical Chemistry*, New Age International, 2004

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

PART A: 10 Questions of 2 Marks each-No choice

PART B: 2 Questions from each unit of internal choice, each carrying 16 Marks.

(Out of 100 Marks, maximum of 10% problems may be asked.)

Exam Duration: 3 Hrs.

20 Marks

80 Marks

SCY 1212	GENERAL CHEMISTRY-IV	L	T	P	Credits	Total Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To understand the chemistry of aromatic hydrocarbons
- To study the compounds of Boron and Carbon group elements
- To learn the preparation of Nitrogen and Oxygen group elements
- To appreciate the concept of stereochemistry and optical isomerism
- To understand the basic concepts of quantum chemistry

UNIT 1 BORON AND CARBON GROUP ELEMENTS

12 Hrs.

Group 13 (boron group): extraction of B and Si; types of compounds; reactions of B. Compounds of boron with oxygen: boron sesquioxide, borates, and borax. Boronhydrides-reaction with ammonia, hydroboration, structure of boranes; borohydrides and their uses. Aluminium-amphoteric behaviour, aluminates.

Group 14 (carbon group): catenation and heterocatenation, allotropy of carbon-graphite, diamond, fullerenes and carbon nanotubes (structural features and uses); carbides-salt-like carbides, interstitial carbides, covalent carbides. Silicates-ortho-, pyro-, cyclic-, chain-, sheet-, three dimensional silicates and their properties and structures; silicates in technology-alkali silicates.

UNIT 2 NITROGEN AND OXYGEN GROUP ELEMENTS

12 Hrs.

Group-15 (nitrogen group): metallic and nonmetallic character of group 15 elements. Compounds of Nitrogen and Phosphorous like N_2H_4 , NH_2OH , HN_3 etc. Phosphorous halides and oxohalides of phosphorous

Group-16 (oxygen group): Types of oxides - basic oxides, amphoteric oxides, acidic oxides, neutral oxides. Oxides of sulphur- S_2O , SO_3 ; oxyacids of sulphur-thionic acid series, peroxyacid series, oxohalides-thionyl compounds (methods of preparation and properties).

UNIT 3 BENZENE AND POLYAROMATIC COMPOUNDS

12 Hrs.

Structure of Benzene –Stability of the benzene ring – Resonance hybrid - Molecular Orbital picture – Aromaticity – Huckel's rule for benzenoid and non-benzenoid compounds –General methods of preparation– Physical and Chemical Properties – Electrophilic substitution – nitration, sulphonation, halogenation, FriedelCrafts alkylation and acylation with mechanism – Orientation in aromatic disubstitution– orientation and reactivity. Polynuclear aromatic hydrocarbons – Preparation and properties of naphthalene – Structure of anthracene and phenanthrene.

UNIT 4 STEREOCHEMISTRY – II

12 Hrs.

Optical isomerism – Chirality – Measurement of optical activity – Specific rotation – Enantiomerism and Diastereomerism - Wedge, Fischer, Newmann and Sawhorse projection formulae — Difference between Configuration and Conformation - Absolute and Relative configuration - D and L notation - Cahn-Ingold-Prelog's rules – R and S notation – Optical isomerism in compounds containing more than one carbon atom – Isomerism in tartaric acid - Racemic modification – Racemization - Resolution of racemic mixtures –Asymmetric synthesis (definition only) - Walden inversion.

UNIT 5 BASIC QUANTUM CHEMISTRY

12 Hrs.

Planck's law - photo electric effect – Compton effect - de Broglie's relationship - Heisenberg's uncertainty principle – Bohr's theory – Derivation for energy of an electron in hydrogen atom – Emission spectrum of hydrogen atom – Zeemann effect - Schrodinger wave equation (no derivation) - significance of wave functions - probability distribution of electrons - radial probability distribution functions.

Max.60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1:Explain the different types of compounds of boron with oxygen, carbon compounds and silicates

CO2:Explain the preparation and chemical properties and structure of benzene and naphthalene

CO3:Discuss the methods of preparation, properties of nitrogen, phosphorous and oxides of sulphur

CO4:Differentiate the conformation and configuration and explain the concept of absolute and relative configuration, D and L notation, Cahn-Ingold-Prelog's rules and R and S notation

CO5:Apply the concept of Huckel's rule in determining the aromaticity of Benzenoid and Non-Benzenoid compounds

CO6:Derive the energy of electron in hydrogen atom by Bohr's theory

TEXT / REFERENCE BOOKS

1. R. T. Morrison and R. N. Boyd, Organic Chemistry, 6th ed., Prentice-Hall of India Limited, New Delhi, 1992.
2. Selected topics in inorganic chemistry, R D Madan, G D Tuli & Wahid U Malik, S.Chand publication, 1976.
3. Bahl B.S. and ArunBahl, Advanced Organic Chemistry, (12th edition), New Delhi, Sultan Chand & Co., (1997).
4. S. H. Pine, Organic Chemistry, 5th ed., McGraw Hill International Edition, Chemistry Series, New York, 1987.
5. I. L. Finar, Organic Chemistry, Vol-1, 6th ed., Pearson Education Asia. 2004.
6. Kalsi P. S., Stereochemistry, 3rd Edition, New Age International Publishers, 1995.
7. Eliel E. L., Stereochemistry of Carbon Compounds, Tata-McGraw Hill, 2000.
8. B. R. Puri and L.R. Sharma, Principles of Physical Chemistry, Shoban Lal Nagin Chandand Co. 23rd edition, 1993.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 10 Questions of 2 Marks each-No choice

20 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 16 Marks.

80 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

SCY 1612	FUNDAMENTALS OF SPECTROSCOPY	L	T	P	Credits	Total Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To study the interaction of radiation with matter and selection rules
- To learn the fundamentals of spectroscopic techniques
- To understand the principle and instrumentation of various spectroscopic techniques
- To interpret the spectra of various spectroscopic techniques
- To apply the concept of spectral data to assign the structure of organic compounds

UNIT 1 INTRODUCTION TO SPECTROSCOPY

12 Hrs.

Interaction of radiation with matter – Electromagnetic spectrum – quantization of energy – Boltzman distribution (formula only) - Electronic, vibrational and rotational energy levels: Relative population – Absorption and emission spectra – Selection rules – line widths – resolution and signal to noise ratio.

UNIT 2 UV-VISIBLE SPECTROSCOPY

12 Hrs.

Electromagnetic spectrum – Energy-Wavelength relationship – Introduction to UV-VIS spectroscopy – Beer-Lamberts Law – Instrumentation – Bands in UV-VIS spectrum – Possible electronic transitions – Types of electronic transitions based on selection rules – Characteristic absorption (λ_{max} and ϵ_{max}) – Factors influencing absorption – Chromophore, Auxochrome, Bathochromic shift, Hypsochromic shift, Hypochromic shift, Hyperchromic shift.

UNIT 3 IR AND RAMAN SPECTROSCOPY

12 Hrs.

Introduction to IR spectroscopy – Principle, types of stretching and bending vibrations, vibrational frequencies – Instrumentation – Bands in IR spectrum – Selection rules – Identification of organic molecules from characteristic absorption bands.

Raman spectroscopy – Principle – Raleigh and Raman scattering – Stoke's and antistoke's line – Differences between IR and Raman spectroscopy - Mutual exclusion principle – applications.

UNIT 4 NMR SPECTROSCOPY

12 Hrs.

Principle of nuclear magnetic resonance – Instrumentation – Shielding mechanism - Chemical shift – Multiplicity – Spin-spin coupling and coupling constants – Splitting of signals - Deuterium labeling – Interpreting the NMR spectra of some organic molecules.

UNIT 5 MASS SPECTROMETRY

12 Hrs.

Basic principles of mass spectrometry – Molecular ion peak – Base peak – Isotopic peak – Metastable peak and their uses – Fragmentation – m/z values of various fragments – Nitrogen rule - McLafferty rearrangement - Interpreting the mass spectra of some organic molecules – Instrumentation – Combined application in identifying organic compounds.

Max.60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

- CO1: Understand the interaction of radiation with matter, electronic, vibrational and rotational energy levels and selection rules
 CO2: Explain the principle and instrumentation of UV-VIS, IR and Raman, NMR spectroscopy and Mass spectrometry
 CO3: Discuss the types of electronic transitions and factors influencing absorption.
 CO4: Differentiate the IR and Raman spectroscopy and explain the concept of Mutual exclusion principle
 CO5: Explain the concept of spin-spin coupling and coupling constant, Nitrogen rule, McLafferty rearrangement
 CO6: Interpret the spectral data and assign the structure of organic molecules

TEXT / REFERENCE BOOKS

1. Banwell C. N., Fundamentals of Molecular Spectroscopy, Tata McGraw Hill, 1983.
2. Kalsi P. S., Stereochemistry, 3rd Edition, New Age International Publishers, 1995.
3. Barrow G. M., Introduction to Molecular Spectroscopy, McGraw-Hill, 1962.
4. Willard H. H., Merritt Jr. L. L., Dean J. A., and Settle Jr. A. F., Instrumental methods of analysis, 6th Edition, Van Nostrand, 1981.
5. Kemp W., Applications of Spectroscopy, English Language Book Society, 1987.
6. Skoog D. A., West D. M., Holler f. J., and Crouch S. R., Fundamentals of Analytical Chemistry, 9th Edition, Wadsworth Publishing Co. Inc., 2012

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 10 Questions of 2 Marks each-No choice

20 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 16 Marks.

80 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

SCY 1620	SYNTHETIC ORGANIC CHEMISTRY	L	T	P	C	Max. Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To learn the importance of oxidizing agents in organic reaction.
- To understand the significance of reducing agents in organic chemical reactions.
- To recognize the importance of organometallic compounds in organic reactions.
- To impart an insight into modern methodologies used in synthesis of organic compounds.
- To emphasize on chemical reactions involving the formation of cyclic transition structures.

UNIT 1 ORGANIC REAGENTS- I

12 Hrs.

Introduction to Organic Reagents - Types of Reagents - Oxidation Reagents – DDQ - SeO₂ - KMnO₄ - OsO₄ - Epoxidation of Olefins - Jones Reagent - Oppenauer Oxidation - HIO₄.

UNIT 2 ORGANIC REAGENTS-II

12 Hrs.

Reducing Agents - Hydride ion transfer mechanism - Electron Transfer mechanism – LAH - NaBH₄ - Electrophilic Reducing Agents - Allanes and Boranes. Hydroboration - Dissolving metal reduction - Birch Reduction - Clemmensen Reduction - Wolf-Kishner Reduction - Lindlars Reagent.

UNIT 3 ORGANIC REAGENTS-III

12 Hrs.

Introduction to organo-metallic reagents - Grignard reagent, Gilman's reagent – LDA - 1, 3 dithianes - Wittig Reagent - Peterson olefination.

UNIT 4 GREEN CHEMISTRY

12 Hrs.

Need - principles - planning of green synthesis - examples of green reactions - Importance and experimental conditions required – Green reactions in condensation, oxidation, reduction, rearrangement and addition reactions - Microwave assisted reactions, solid state synthesis and ionic liquid reaction.

UNIT 5 INTRODUCTION TO PERICYCLIC REACTIONS

12 Hrs.

Pericyclic reactions – Introduction, Definition and classification – Electrocyclic, cycloaddition, sigmatropic and cheletropic reactions – Thermal and Photochemical approach – Diels Alder reaction – Frontier Molecular Orbital approach – Woodward-Hoffmann's rules

Max. 60 Hrs.

COURSE OUTCOMES

On successful completion of the course, student will be able to

CO1: Interpret the products in organic chemical reactions involving oxidizing reagents.

CO2: Solve the chemical reactions involving reducing agents.

CO3: Predict the products formed in organic chemical reactions catalyzed by organometallic reagents.

CO4: Analyze the methodologies involved in Green chemistry.

CO5: Propose a strategic plan for basic chemical reactions based on Green chemistry principles.

CO6: Design and predict the reaction mechanism in electrocyclic, cycloaddition, sigmatropic and cheletropic reactions.

TEXT / REFERENCE BOOKS

1. Clayden, Greeves, Warren and Wothers., Organic chemistry, Oxford University, 2001.
2. J. March's Advanced Organic Chemistry Reaction, Mechanisms and Structure, Wiley 2007.
3. Ian Fleming, Pericyclic Reactions, Oxford Science Publications, Cambridge, 1999.
4. Finar I. L., Organic Chemistry, 6th Edition, Pearson Education Asia, 2004.
5. Rashmi Sanghi, M.M. Srivastava, Green chemistry, Environment Friendly Alternatives, Narosa Publishing House, 2007.
6. Carey F. A., and Sundberg R. J., Advanced Organic Chemistry Part-A and B, 4th edn, Kluwer Academic/Plenum Publishers 2000.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 10 Questions of 2 Marks each-No choice

20 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 16 Marks.

80 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

SEMESTER 5										
Sl. No.	Course Type	Course Code	Course Title	L	T	P	C	Marks		Page No.
								CAE	ESE	
1	Theory	SCY1311	Inorganic Chemistry-I	3	1	0	4	50	50	55
2	Theory	SCY1312	Organic Chemistry-I	3	1	0	4	50	50	56
3	Theory	SCY1313	Physical Chemistry-I	3	1	0	4	50	50	57
4	Theory	SCH 1314	Processes and Separation In Chemical Industry	3	0	0	3	50	50	58
5	Theory		Elective – 4	3	1	0	4	50	50	-
6	Practical	SCY 4315	Industrial Chemistry Lab	0	0	3	2	50	50	59
7	Practical	SCH 4061	Chemical Process and Separation Lab	0	0	3	2	50	50	60
8	I	S03PT	Professional Training	0	0	0	3	I	100	-
Total Credits for Semester: 26										
Total Marks for Semester: 800										

S03 PROJECT	PROJECT WORK	L	T	P	C	Max. Marks
		0	0	0	4	100

COURSE OBJECTIVES

1. To learn the theoretical and experimental basis of synthetic and analytical methods.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1:Able to synthesis and interpretation of the results independently

CO2:To improve the technical presentation skills.

SCH1314	PROCESSES AND SEPARATION IN CHEMICAL INDUSTRY	L	T	P	C	Max. Marks
		3	0	0	3	100

COURSE OBJECTIVES:

- To equip the learners with chemical processes and separation processes followed in chemical process industries.

UNIT 1 INTRODUCTION

9 Hrs.

Basic principles of unit operations and unit process to common devices used in process industries - Standard symbols used for such devices, Process flow sheet.

UNIT 2 CHEMICAL PROCESSES

9 Hrs.

Stoichiometric principles, Limiting, excess reactant, conversion, selectivity and yield. Application of material balance in unit process - batch operation, continuous operation, semi-batch operation. – Reactors - ideal batch reactor, plug flow reactor and mixed flow reactor.

UNIT 3 SEPARATION PROCESSES

9 Hrs.

Basic principles, types of separation processes like distillation, crystallization, extraction, absorption. Application of material balance in various unit operations.

UNIT 4 HEAT TRANSFER

9 Hrs.

Heat capacity of solids, liquids and gases, sensible heat and latent heat, Standard heat of reaction, heat of formation, combustion, mixing. - Calculation of standard heat of reaction. Introduction - types of heat exchangers, types of evaporators.

UNIT 5 MEMBRANE SEPARATION

9 Hrs.

Solid and liquid membranes, Membrane fouling, Osmosis, reverse osmosis, Electrodialysis, Ultrafiltration, Microfiltration, Nanofiltration, Pervaporation, IonExchange, Industrial application of membrane process.

Max. 45 Hrs.

COURSE OUTCOME:

On completion of the course, student will be able to:

CO1: Ability to explore and apply techniques, skills necessary to solve problems in chemical industry

CO2: Understanding the flow sheets of any process.

CO3: Ability to develop material balance and energy calculation

CO4: Students gain knowledge in chemical kinetics

CO5: Acquire knowledge in Heat transfer and Mass transfer operations

REFERENCE BOOKS:

1. Treybal, R.E, Mass Transfer Operations, 3rd Edition, McGraw Hill, 2004.
2. McCabe and Smith, Unit Operations of Chemical Engineering, 7th Edition, McGraw Hill, 2009
3. Bhatt, B.L., Vora, S.M., Stoichiometry, 4th Edition, Tata McGraw-Hill, 2004.
4. Levenspiel, O., Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, New York, 1995.
5. Smith J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw-Hill, 2003.
6. Shreve. N., Chemical Process Industries, 8th Edition, McGraw Hill, 2004.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

PART A: 10 Questions of 2 Marks each-No choice

PART B: 2 Questions from each unit of internal choice, each carrying 16 Marks.

(Out of 100 Marks, maximum of 10% problems may be asked.)

Exam Duration: 3 Hrs.

20 Marks

80 Marks

SBT 1002	BASIC BIOCHEMISTRY	L	T	P	Credits	Total Marks
		3	1	0	4	100

COURSE OBJECTIVE

- To give an insight into the chemical aspects of biological macromolecules and their importance..

UNIT 1

12 Hrs.

Carbohydrates: Classification of carbohydrates, Monosaccharides:- linear and ring forms (Haworth's formula), Structures, Stereoisomers and structural isomers, mutarotation, and chemical properties. Oligosaccharides:- Dissaccharides-structure and importance of sucrose, Lactose, maltose, Polysaccharides:- Structure and significance of homopolysaccharides and heteropolysaccharides.

UNIT 2

12 Hrs.

Amino acids: Structures and Classifications of aminoacids, Essential and Non essential amino acids, properties of aminoacids. Amphoteric nature, isoelectric point.

Protein: Classification - shape, solubility and composition; biological functions of proteins, bonds involved in protein structure, structural levels of organization:- primary, secondary, tertiary and quaternary structures with examples.

UNIT 3

12 Hrs.

Lipids: Classifications of lipids, physical and chemical properties of fats, structure and functions of saturated and unsaturated fatty acids.

Nucleic acids: Nitrogenous bases, structures of Ribonucleotides and deoxyribonucleotides, structure and functions of DNA and RNA.

UNIT 4

12 Hrs.

Enzymes: Holoenzyme, Apoenzyme, coenzymes, cofactors/prosthetic groups, IUB classification of enzymes with example. Active site:- characteristic features and theories of ES complex, enzyme units, Enzyme kinetics:- MM equation and LB plot, factors affecting enzyme activity.

UNIT 5

12 Hrs.

Vitamins: fat soluble and water soluble vitamins. Minerals: Micro and Macro minerals. Biological importance of vitamin and minerals.

Max.60 Hrs.

COURSE OUTCOMES

1. To understand about the basic classification and biological significance of carbohydrates.
2. To have insight on structure, classification and properties of aminoacids and to study their impact on organizing the structure of proteins.
3. To recite the categorization, structure and various functions of lipids and nucleic acids.
4. To understand the functional mechanism of interaction between enzyme and substrate.
5. To know the mechanism of enzyme kinetics.
6. To know the vital role of vitamins and minerals

TEXT / REFERENCE BOOKS

1. Lehninger, Nelson and Cox, Principles of Biochemistry, W.H.Freeman, 4th Edition, 2005
2. Donald Voet, Judith Voet and Charlotte Pratt, Principles of Biochemistry, John Wiley and Sons, 2008.
3. Reginald H. Garrett and Charles M. Grisham, Biochemistry, 6th Edition, Brooks Cole publisher, 2017.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 10 Questions of 2 Marks each-No choice

20 Marks

PART B: 2 Questions from each unit of internal choice, each carrying 16 Marks.

80 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

SBT 4101	BIOCHEMISTRY LAB	L	T	P	Credits	Total Marks
		0	0	3	2	100

S. No.	EXPERIMENT
1.	QUALITATIVE ANALYSIS OF CARBOHYDRATES
2.	QUALITATIVE ANALYSIS OF AMINO ACIDS
3.	WORKING PRINCIPLE AND STANDARDIZATION OF COLORIMETER
4.	QUANTITATIVE ESTIMATION OF PROTEIN BY LOWRY'S METHOD.
5.	QUANTITATIVE ESTIMATION OF UREA BY DAM METHOD.
6.	QUANTITATIVE ESTIMATION OF TOTAL PHENOL
7.	DETERMINATION OF CARBOHYDRATE BY ANTHRONE METHOD

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs

CAE	Evaluation of Regular Lab class	25 Marks	50 Marks
	Model practical exam	25 Marks	
ESE	University Practical exam		50 Marks

2019 REGULATIONS

SCYA 5103	THERMODYNAMICS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES:

- To construct second law of thermodynamics, concept of entropy and Carnot cycle.
- To determine the methods for fugacity, activity and activity coefficients.
- To understand the partition function for distinguishable and indistinguishable molecules.
- To derive the various statistical approach and free energy functions of mono and diatomic gases.
- To learn the Onsager theory and applications of irreversible thermodynamics to biological and non-linear systems.

UNIT 1 CLASSICAL THERMODYNAMICS - I

12 Hrs.

Need for the second law – Concept of entropy – Carnot cycle – Gibbs function – Gibbs – Helmholtz equation – Clausius – Clapeyron equation – Thermodynamics of systems of variable compositions – Partial molar quantities, partial molar volume – Chemical potential, Gibbs – Duhem equation – Third law of thermodynamics. Ellingham diagram and its significance.

UNIT 2 CLASSICAL THERMODYNAMICS – II

12Hrs.

Thermodynamics of real gases and real solutions: Fugacity: Methods of determination. Dependence on temperature, pressure and composition. Activity and activity coefficient – Determination of activity and activity coefficient of non-electrolytes and electrolytes. Solubility of ionic solids in water – Solubility curves – Ternary system involving water and two soluble ionic solids – Formation of double salts.

UNIT 3 STATISTICAL THERMODYNAMICS – I

12Hrs.

Phase space – Ensembles: Different types of ensembles – Micro canonical, canonical and grand canonical – Distinguishable and indistinguishable molecules – Maxwell-Boltzmann statistic – Partition function and thermodynamic functions – Separation of partition function – Translational, rotational, vibrational and electronic partition functions. Statistical approach to thermodynamic properties - Internal energy, entropy, enthalpy, Helmholtz function, pressure, Gibbs function, residual entropy, equilibrium constant.

UNIT 4 STATISTICAL THERMODYNAMICS - II

12 Hrs.

Quantum Statistics Bose-Einstein statistics – Fermi-Dirac statistics – Free energy function Heat capacity of mono and diatomic gases. Ortho- and para hydrogen and mixture of the two viz., ortho H₂ and para H₂ – Heat capacity of solids – Einstein and Debye models – Sackur-Tetrode equation.

UNIT 5 NON EQUILIBRIUM THERMODYNAMICS

12 Hrs.

Near equilibrium process: General theory – Conservation of mass and energy – Entropy production in open system by (i) heat (ii) matter and (iii) current flow – Onsager theory: Validity and verification – Application of irreversible thermodynamics to biological and non-linear systems.

Max. 60 Hours

COURSE OUTCOME:

On successful completion of the course, student will be able to

- CO1: Construct the Second law of thermodynamics for explaining the concept of entropy and to derive Carnot cycle and various Gibbs functions.
- CO2 : Determine the methods for fugacity, activity and activity coefficient of electrolytes and non-electrolytes.
- CO3 : Derive the various partition functions in statistical approach.
- CO4 : Discuss the Bose-Einstein and Fermi-Dirac statistics and heat capacity of solids.
- CO5 : Explain the conservation of mass and energy and entropy production in open systems.
- CO6 : Discuss the Onsager theory validity and verification.

TEXT / REFERENCE BOOKS

1. P. R. Rastogi and R. R Misra, An Introduction to Chemical Thermodynamics, 6th Revised Edition, Vikas Publishing House Ltd., 2009.
2. P. W. Atkins, Physical Chemistry, Oxford University Press, 1978.
3. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, 1974.
4. I. M. Klotz and R. M. Rosenberg, Chemical Thermodynamics: Basic Theory and Methods, 18th Edition, Benjamin/Cummings Pub. Co., 1986.
5. R. P. Rastogi and R. R. Misra, Classical Thermodynamics, Vikas Publishing House Ltd., 1990.
6. J. Rajaram and J. C. Kuriakose, Thermodynamics, 3rd Edition, S. Chand & Co., 1999.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 6 Questions each carrying 5 marks without choice

30 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 14 marks

70 marks

(Out of 100 marks, maximum of 10% problems may be asked)

SCYA 5105	QUANTUM CHEMISTRY AND GROUP THEORY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES:

- To have a good foundation in understanding the physical and mathematical aspects of quantum mechanics
- To understand the basic concepts of postulates of quantum mechanics
- To study the fundamental principles of quantum chemistry, Schrodinger wave equation and its applications
- To learn the approximation methods to Helium and Hydrogen molecule ion
- To study the elements of group theory and the applications of group theory

UNIT 1 BASICS OF QUANTUM MECHANICS

12 Hrs.

Black-body radiation – Planck's law of radiation – Photoelectric effect – Compton effect – wave particle duality – de-Broglie's hypothesis – Heisenberg's uncertainty principle – Bohr's theory and its limitations – Classical waves and wave equation for electrons. Operators – Linear operators, Commutator algebra – Evaluation of commutators, Hermitian operators and its properties – Eigen value and Eigen function – Momentum – Hamiltonian operator – Postulates of quantum mechanics.

UNIT 2 APPLICATION OF QUANTUM MECHANICS

12 Hrs.

Derivation of Schrodinger wave equation – Orthogonality and normalization of wave functions – Characteristics of wave function. Application of SWE to free particle, particle in one dimensional box and three dimensional box – Simple harmonic oscillator – Rigid rotor – ladder operator – Angular momentum operator. Schrodinger equation for hydrogen – Significance of quantum numbers – shapes of atomic orbitals – spin angular momentum.

UNIT 3 APPROXIMATION METHODS

12 Hrs.

Need for approximation methods – Approximation methods - perturbation and variation methods and their application to Helium atom – Born - Oppenheimer approximation – Hydrogen molecule ion – Huckel- π -electron theory and its applications to ethylene and butadiene.

UNIT 4 GROUP THEORY

12 Hrs.

Group and Subgroup –Symmetry elements and operations – Determination of point groups of representative molecules/complexes - Symmetry point groups – Vector and matrix algebra – Matrix representation of Symmetry operations – Reducible and irreducible representations – Great orthogonality theorem – Characters – Construction of a character tables– C_{2v} , C_{3v} , C_{2h} , D_{2h} .

UNIT 5 APPLICATION OF GROUP THEORY

12 Hrs.

Determination of representation of vibrational modes in non- linear molecules such as H_2O , CH_4 and NH_3 – symmetry of Hybrid orbitals in non- linear molecule (BF_3 , CH_4 , NH_3) – Symmetry selection rules of infra-red and Raman spectra – application of group theory for the electronic spectra of ethylene and formaldehyde.

Max. 60 Hours

COURSE OUTCOME:

On successful completion of the course, student will be able to

CO1: Understand the various laws of radiation and principle that explain the basics of quantum mechanics

CO2: Apply the quantum mechanical treatment to derive the various quantum mechanical operators

CO3: Derive the wave function and energy of particle in 1D and three-dimensional box, Simple harmonic oscillator, Rigid rotor and hydrogen atom

CO4: Explain the Born - Oppenheimer approximation and apply the Perturbation and variation methods to Helium atom

CO5: Construct the character table of C_{2v} , C_{3v} , C_{2h} point groups and explain the Great Orthogonality theorem

CO6: Determine the representation of vibrational modes and symmetry of hybrid orbitals in non- linear molecules

TEXT / REFERENCE BOOKS

1. A. K. Chandra, Introductory Quantum Chemistry, Tata Mc Graw Hill Publishing Co., 4th Edition 1994.
2. R. K. Prasad, Quantum Chemistry, New Age International Publishers, Revised 3rd Edition, 2006.
3. H. L. Strauss, Quantum Mechanics, Prentice Hall, 1972.
4. P. W. Atkins and R. S. Friedman, Molecular Quantum Mechanics, Oxford University Press, 5th Edition, 2010.
5. H. Eyring, J. Walter and G. E. Kimball, Quantum Chemistry, John Wiley & Sons, 1944
6. F. A. Cotton, Chemical Applications of Group Theory, John Wiley & Sons, 3rd Edition, 1999.
7. K. V. Raman, Group Theory and its Applications to Chemistry, Tata McGraw-Hill, 3rd Edition, 1990.
8. V. Ramakrishnan and Gopinath, Group Theory in Chemistry, Vishal Publications, 2nd Edition 2013.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

PART A : 6 Questions each carrying 5 marks without choice

PART B : 2 Questions from each unit of internal choice, each carrying 14 marks

(Out of 100 marks, maximum of 10% problems may be asked)

Exam Duration : 3 Hrs.

30 Marks

70 marks

SCYA 6202	INORGANIC CHEMISTRY LAB-II	L	T	P	Credits	Total Marks
		0	0	4	2	100

COURSE OBJECTIVES:

- To learn the theoretical basis of qualitative inorganic analysis
- To understand the method of identification of group and cations using semi-microanalysis
- To gain knowledge about systematic semi-microanalysis

Course Contents

Semi-micro qualitative analysis of mixtures containing two common and two rare cations

COURSE OUTCOME:

On successful completion of the course, student will be able to

C01- Develop practical skills in inorganic qualitative analysis

C02- Understand the concept of systematic identification of metal cation as their compounds

C03- Recognize the classification of various cations under different groups

C04- To analyze the mixture using semi-microanalysis

C05- To identify the common and rare cations in the mixture

C06- To acquire the group separation skills

TEXT / REFERENCE BOOKS

1. V. V. Ramanujam, Inorganic semimicro qualitative analysis, The national publishing company, Chennai, India, 3rd edition, reprinted 2008.
2. G. H. Jeffery, J. Bassett, J. Mendham and R. Denney, Vogel's Textbook of Quantitative chemical analysis, Pearsons Education, 6th Edition, 2004.
3. I. M. Kolthoff and E. B. Sandell, Text Book of Qualitative Inorganic Analysis, The Macmillan Company, 3rd edition, 1956.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 50

Exam Duration: 6 Hrs

CAE	Evaluation of Regular Lab class	25 Marks	50 Marks
	Model practical exam	25 Marks	
ESE	University Practical exam		50 Marks

SCYA 5202	CHEMICAL KINETICS AND CATALYSIS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES:

- To elucidate the use of chemical kinetics in understanding reaction mechanisms.
- To understand the kinetics of fast reactions.
- To understand adsorption phenomena.
- To enable the learners to understand the importance and significance of heterogeneous catalysis.
- To learn the kinetics of polymerization and experimental methods of determination of molar masses of polymers.

UNIT 1 ADVANCED CHEMICAL KINETICS

12 Hrs.

Thermodynamic formulation of activated complex theory – Theories of unimolecular reactions: Lindemann mechanism – Hinshelwood mechanism – Temperature dependence of pre-exponential factor. Kinetics of reactions in solution: Effect of solvent on reaction rates (reaction between two ions) – Effect of ionic strength on reaction rates: Primary salt effect and secondary salt effect.

UNIT 2 KINETICS OF FAST REACTIONS

12 Hrs.

Chemical relaxation methods: Temperature and pressure jump methods – Reactions in flow systems: Continuous and Stopped flow methods – Shock tube methods – Laser Flash photolysis – Ultrasonic absorption technique.

UNIT 3 KINETICS OF POLYMERIZATION

12 Hrs.

Kinetics of Free radical mechanism, Cationic mechanism and Anionic mechanism – Molar masses of polymers: Number average molecular mass – Weight average molecular mass. Determination of molecular weight of polymers: Light scattering method – Ultracentrifuge method (Sedimentation velocity method).

UNIT 4 ADSORPTION

12 Hrs.

Adsorption isotherms: Types of adsorption isotherm – Langmuir theory of unimolecular layer adsorption isotherm – The BET theory of multimolecular layer isotherm – Determination of surface area of adsorbents – The Gibbs adsorption isotherm equation – Surfactants: Classification of surfactants – Formation of micelles – Critical micelle concentration (CMC) – Thermodynamics of micellization. Emulsions: Hydrophilic-Lipophilic Balance (HLB).

UNIT 5 CATALYSIS

12 Hrs.

Definition of Catalysis – Types of catalysis: homogeneous and heterogeneous. Catalytic kinetics: Concept of Langmuir-Hinshelwood – Photocatalysis using semiconducting oxides: Definition, basic principles and mechanism of photocatalysis – Application of photocatalysis in water remediation, air cleaning – Heterogeneous catalysis by intercalation compounds: Structural aspects of graphite intercalation compounds, catalytic reaction – Kinetics of enzyme catalysis – Lineweaver-Burk plot for the determination of Michaelis constant

Max. 60 Hours

COURSE OUTCOME:

On successful completion of the course, student will be able,

- C01-** To study thermodynamic and theoretical aspects of chemical kinetics.
- C02-** To learn the experimental and theoretical aspects of kinetics of fast reaction techniques.
- C03-** To understand the kinetics of polymerization and learn the methods of determination of molecular mass of polymers.
- C04-** To learn about surface chemistry and their kinetics.
- C05-** To understand the importance of surfactants, micelle, and emulsions.
- C06-** To study the importance of heterogeneous catalysis.

TEXT / REFERENCE BOOKS:

- Keith J. Laidler, Chemical Kinetics, Pearson Education India, 3rd Edition, 2003.
- John W. Moore and Ralph G. Pearson, Kinetics and Mechanism, Wiley, 3rd Edition, 1981.
- Julian R.H. Ross, Heterogeneous Catalysis: Fundamentals and Applications, Elsevier, 1st Edition, 2011.
- G.C. Bond, Heterogeneous Catalysis: Principles and Application. Oxford University Press, USA, 1987.
- B. Vishwanathan, S. Sivasankar and A.V. Ramaswamy, Catalysis: Principles and Applications, Narosa Publishing House, New Delhi, 2004
- C. Kalidas C, Chemical Kinetic Methods, New Age International, 1996.
- F. Wilkinson, Chemical Kinetics and Reaction Mechanism, Van Nostrand Reinhold Co., 2000.
- R. Aveyard and D.A Haydon, An Introduction to the Principles of Surface Chemistry, Cambridge University Press, 1973.
- V.R. Gowarikar, N.V. Vishwanathan and Jayadev Sreedhar, Polymer Science, 2nd Edition, New Age International Publishers, 2006.
- F.W. Billmeyer, Textbook of Polymer Science, John Wiley & Sons, 3rd Edition, 1990.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

PART A : 6 Questions each carrying 5 marks without choice

PART B : 2 Questions from each unit of internal choice, each carrying 14 marks

(Out of 100 marks, maximum of 10% problems may be asked)

Exam Duration : 3 Hrs.

30 Marks

70 marks

SCYA 5301	ORGANIC REACTION MECHANISM	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES:

- To learn the various types of bonding and conjugation in organic compounds
- To apply the concept of Huckel rule to determine the aromaticity of compounds
- To know the concept of stability and reactivity of reactive intermediates
- To understand the mechanism of nucleophilic and electrophilic substitution reactions
- To appreciate the concept of substitution, addition and elimination reactions and their reaction mechanism

UNIT 1 NATURE OF BONDING IN ORGANIC MOLECULES

12 Hrs.

Nature of Bonding in Organic Molecules, Delocalized chemical bonding – Conjugation, cross-conjugation, hyperconjugation and hydrogen bonding. Aromaticity. Benzenoid and nonbenzenoid compounds. **Huckel and Craig rules**. Application of Huckel's rule for annulenes, heteroannulenes, fullerenes, cyclopropenium cation, cyclopentadienyl anion, cycloheptadienyl cation, Homo- and antiaromaticity, Ψ -aromaticity Energy levels of π molecular orbitals, FMO approach.

UNIT 2 REACTION MECHANISM – REACTIVE INTERMEDIATES

12 Hrs.

Field effects (inductive, electromeric effects), mesomerism, resonance, steric effects. Types of reactions and mechanism. **Generation, structure, stability and reactivity of carbocations, carbanions and free radicals. Structure of carbenes, nitrenes and benzyne.**

UNIT 3 ELECTROPHILIC AND NUCLEOPHILIC ALIPHATIC SUBSTITUTION REACTIONS

12 Hrs.

Aliphatic Nucleophilic substitution: Types of nucleophiles – attacking nucleophile, ambident nucleophiles, hard and soft Nucleophiles. **SN^1 , SN^2 and SN^i mechanisms. Neighbouring group participation, anchimeric assistance.** Nucleophilic substitution at allylic, aliphatic trigonal and vinylic carbon. Nucleophilicity and solvent effects, Competition between nucleophilicity and basicity, leaving group effects, steric substituent effects on substitution. Aliphatic Electrophilic substitution: Mechanisms - **SE^2 and SE_i , SE^1 , Substitution by double bond shifts.** Effect of substrates, leaving group and solvent polarity on the reactivity.

UNIT 4 ELECTROPHILIC AND NUCLEOPHILIC AROMATIC SUBSTITUTION REACTIONS

12 Hrs.

Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, Ortho/para ratio, ipso attack, orientation in naphthalene ring systems. Diazonium coupling, Gattermann-Koch reaction.

Aromatic Nucleophilic Substitution: Mechanisms: **$SNAr$, SN^1 and Benzyne mechanisms.** - Reactivity, Effect of structure, leaving group and attacking nucleophile. Typical reactions: O and S-nucleophiles, Bucherer reaction and Rosenmund reduction and Smiles rearrangements.

UNIT 5 ADDITION AND ELIMINATION REACTIONS

12 Hrs.

Addition to C-C Multiple Bond: Mechanism of addition of HX (X=Halo, OH) to alkenes and alkynes – **Micheal addition Addition** to Carbon-Hetero Atoms Multiple Bonds –Nucleophilic addition of carbonyl compounds. Addition - Elimination Reactions of Ketones and Aldehydes, Reactivity of carbonyl compounds towards Addition. Elimination Reactions: The E1, E1cB and E2 mechanism, **Syn elimination**, Orientation Effects in Elimination. Reactions - **Pyrolytic eliminations, Chugaev reaction.**

Max. 60 Hours

COURSE OUTCOME:

On successful completion of the course, student will be able to

C01- Understand the various types of bonding and conjugation in organic molecules and concept of aromaticity, anti-aromaticity and non-aromaticity

C02- Apply the Huckel rule for benzenoid and non-benzenoid compounds

C03- Learn the stability and reactivity of carbocations, carbanions and free radicals and concept of NGP, Field effects.

C04- Explain the mechanism of aliphatic nucleophilic and electrophilic substitutions such as SN^1 , SN^2 and SN^i mechanism and SE^2 and SE_i , SE^1 , Substitution by double bond shifts

C05- Discuss the mechanism of aromatic nucleophilic and electrophilic substitutions such as arenium ion mechanism, orientation, reactivity and $SNAr$, SN^1 and Benzyne mechanisms

C06- Illustrate the addition to C-C multiple bond, Carbon-Hetero atoms multiple bonds with suitable examples and explain the mechanism of Elimination reactions such as E1, E1cB and E2 mechanism

TEXT / REFERENCE BOOKS

1. J. March and M. Smith, Advanced Organic Chemistry, John-Wiley and Sons, 7th Edition, 2013.
2. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part-A and B, Kluwer Academic/Plenum Publishers, 5th Edition, 2007.
3. R. Morrison and R. Boyd, Organic Chemistry, Allyn & Bacon, 2nd Edition, 1967.
4. R. K. Bansal, Organic Reaction Mechanism, New Age International Pvt. Ltd. Publishers, 4th Edition, 2014.
5. S. H. Pine, Organic Chemistry, McGraw Hill International Edition, 5th Edition, 1987.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 6 Questions each carrying 5 marks without choice

30 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 14 marks

70 marks

(Out of 100 marks, maximum of 10% problems may be asked)

SCYA 7301	APPLICATIONS OF SPECTROSCOPY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the principles of Molecular Spectroscopy.
- To apply the principles of UV-Visible, IR, NMR and Mass spectroscopy
- To know the application of spectroscopy to study the structure of molecules
- To elucidate the structures of simple organic molecules using the given spectral data.
- To interpret spectra of various spectroscopic techniques.

UNIT 1 ELECTRONIC SPECTROSCOPY

12 Hrs.

Electronic transitions (185-800 nm) – Beer-Lambert law – Effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Electronic spectra of inorganic and coordination compounds: Charge transfer and d-d transitions, electronic spectra of transition metal halides and oxo compounds.

UNIT 2 IR SPECTROSCOPY

12 Hrs.

Principle, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies. Study of isomerism: linkage isomerism in coordination compounds-cyano and isocyanato-thiocyanato- and isothiocyanato complexes.

UNIT 3 ¹H NMR AND ¹³C SPECTROSCOPY

12 Hrs.

General introduction and definition – Chemical shift, spin-spin interaction, shielding and deshielding mechanism and measurement, chemical shift values and correlation for protons bonded to carbon complex spin-spin interaction between two, three, four and five nuclei (first order spectra), spin system-Pople notation, virtual coupling. Hindered rotation, Karplus curve – variation of coupling constant with dihedral angle. Fourier transform technique. Further tools for simplification (chemical and instrumental) and elucidation of structures by NMR. Carbon-13 NMR Spectroscopy – General considerations, chemical shift – coupling constants. nuclear overhauser effect (NOE).

UNIT 4 MASS SPECTROMETRY

12 Hrs.

Principle of Mass spectra - Representation of Mass spectrum, Molecular ion – types of ions in mass spectra. Effect of isotopes on mass spectra – Determination of molecular formula – McLafferty rearrangement- ortho effect- Meta stable ions – Doubly charged ion – Nitrogen rule – General fragmentation modes – Mass spectra of hydrocarbons – Alkanes, cycloalkanes, alkene, alkynes, aromatic hydrocarbons, alcohols and thiophenols.

UNIT 5 ESR AND MÖSSBAUER SPECTROSCOPY

12 Hrs.

ESR Hyperfine splitting: hyperfine splitting in isotropic systems involving one nucleus and more than one nucleus, hyperfine splitting caused by quadrupole nuclei. Anisotropic systems: anisotropy in g-value, factors causing anisotropy. EPR spectra of systems with more than one unpaired electrons: zero-field splitting, causes of ZFS, ZFS and EPR transitions, EPR spectrum of triplet naphthalene and highspin Mn(II) complexes.

Principles of Mössbauer spectroscopy: Doppler shift, recoil energy, experimental technique- sources, absorber, calibration. Applications of Mossbauer spectroscopy: isomer shift, quadrupole splitting, magnetic interactions; magnetic and quadrupole splitting in ferromagnetic ⁵⁷Fe compounds, Mossbauer spectra of high and low-spin Fe(II) and Fe(III) compounds, site symmetry of metal centers in iron complexes, differentiation of nonequivalent metal centers in polynuclear complexes, discovering oxidation states-Sn, Sn(II), Sn(IV) compounds. Problems pertaining to known and unknown simple organic and inorganic compounds by using UV, IR, Mass and NMR spectroscopy.

Max. 60 Hours

Course Outcomes

On successful completion of the course, student will be able to

- CO1: Identification Of λ_{max} Value Of Inorganic and Organic Compounds.
- CO2: Explains – how to identify the functional group of molecules using IR Spectral data.
- CO3: Demonstrate the processes responsible for NMR chemical shifts and splitting patterns
- CO4: Identification and Ionization of Mass spectra of a given organic molecule using Mc-Lafferty rearrangement.
- CO5: To demonstrate application of ESR hyperfine splitting and Mossbauer spectroscopy.
- CO6: Evaluating experimental tools to obtain information to confirm or reject a reaction mechanism

TEXT / REFERENCE BOOKS

1. Banwell C. N and McCash E. M., Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw Hill, New Delhi, 2000.
2. Silverstein R. M and Webster F. X., Spectroscopic Identification of Organic Compounds, 6th Edition, John Wiley & Sons, New York, 2003.
3. Levine I. N., Molecular Spectroscopy, John Wiley & Sons, New York, 1974.
4. Williams D. H and Fleming I., Spectroscopic Methods in Organic Chemistry, 4th Edition, Tata McGraw-Hill Publishing Company, New Delhi, 1988.
5. Kemp W., Applications of Spectroscopy, English Language Book Society, 1987.
6. J. A. Weil, J. R. Bolton and J. E. Wertz, Electron Paramagnetic Resonance; Wiley Interscience: 1994.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

PART A : 6 Questions each carrying 5 marks without choice

PART B : 2 Questions from each unit of internal choice, each carrying 14 marks

(Out of 100 marks, maximum of 10% problems may be asked)

Exam Duration : 3 Hrs.

30 Marks

70 marks

SCYA 5302	ADVANCED INORGANIC CHEMISTRY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES:

1. To learn about organometallic compounds in terms of structure and bonding including dinitrogen and dioxygen as ligands.
2. To understand various synthesis methods of different types of organometallic compounds and to learn their reactivity with mechanism.
3. To learn about different reactions involving organometallic compounds as catalysts in chemical synthesis.
4. To understand the role of metals and their complexation in the formation of biological compounds like enzymes and their application in medicinal chemistry.
5. To learn different types of nuclear reactions with radioactive techniques and to know the applications of radio isotopes in different fields.

UNIT 1 ORGANOMETALLIC COMPOUNDS

12 Hrs.

EAN Rule - Valence electron count (16/18 electron rules) – concept of hapticity - Structure and bonding of mono and heteroleptic metal carbonyls – dinitrogen and dioxygen as ligands in organometallic compounds - Infrared spectra of metal carbonyls – Metal clusters – Low and high nuclearity clusters – clusters having interstitial atoms - Isolobal analogies - Metallocenes and bent metallocenes.

UNIT 2 SYNTHESIS OF ORGANOMETALLIC COMPOUNDS

12 Hrs.

Types of M-C bonds – structure and bonding of metal alkyls, alkenes, allyl, alkynes and arenes - Ligand dissociation and substitution - Oxidative addition - Reductive elimination - Nucleophilic displacement – Insertion - Alkyl migration – 1, 2 insertion - Hydride elimination.

UNIT 3 ORGANOMETALLIC CATALYSTS

12 Hrs.

Terminology in catalysis: Turnover, Turnover number (TON), Turnover frequency (TOF). Homogeneous catalysis – Hydroformylation - Monsanto acetic acid process - Hydrogenation by Wilkinson's catalyst - Wacker (Smidt) process - Olefin metathesis - Heterogeneous catalysts – Ziegler Natta polymerization - Water gas reaction.

UNIT 4 BIOINORGANIC CHEMISTRY

12 Hrs.

Transition metal ions in biology. Active site structure and functions of dioxygen binding heme (hemoglobin and myoglobin) and non-heme (hemocyanin and hemerythrin) proteins. Characterization of coordinated O₂ species in oxy forms of heme and non-heme proteins by resonance Raman spectroscopy. Bohr effect. Electron transfer proteins: Active site structure and functions of cytochromes, and iron-sulphur proteins. Significance of electron transfer proteins in photosynthesis (Z scheme). Coenzyme F430, carboxypeptidase, carbonic anhydrase, vitamin B₁₂, ferritin and transferrin. Mechanism of action of cytochrome P450 and urease. Therapeutic uses of cisplatin, and radioisotopes (Tc, Co and Cu). Basic principles of MRI and application of metal (Mn and Fe) complexes as contrast agents. Toxicity of Cd, Hg and Pb in biology with specific examples.

UNIT 5 NUCLEAR CHEMISTRY

12 Hrs.

Terminology, Concept and formulae of Nuclear chemistry; Radioactivity, Types of particles, Radioactive decay, Radioactive decay constants, equilibrium, Nuclear reactions; Q – Value, Chemical effects of Nuclear Transformations, Fission and Fusion, stability of Nucleus, Radioactive techniques – Tracer technique, Neutron activation analysis, counting technique – G.M. ionization, Proportional counter. Application of Radioisotopes.

Max. 60 Hours

COURSE OUTCOME:

On successful completion of the course, student will be able to

- CO1- Identify organometallic compounds based on EAN rule and to elaborate on the different types of substituted carbonyl compounds.
- CO2- Interpret the structure, reactivity and significance of organometallic compounds with dinitrogen and dioxygen as ligands.
- CO3- Analyze the mechanism involved in various ligand dissociation and substitution reactions of organometallic compounds.
- CO4- Analyze the role of organometallic compounds in various catalysis processes which are of commercial use.
- CO5- Understand the role and importance of metals in forming biomolecules based on complexation and their application in biotransformation.
- CO6- Identify different particles in nuclear fission and fusion reactions and to evaluate the application of different radioactive isotopes.

TEXT / REFERENCE BOOKS

1. C.E. Housecroft and A.G. Sharpe, Inorganic Chemistry, 4th Edition, Pearson, 2012.
2. B. D. Gupta and A. J. Elias, Basic Organometallic Chemistry: Concepts, Synthesis, and Applications, 2nd Edition, Universities Press (India), 2013.
3. J. E. Huheey, E. A. Keiter, R.L. Keiter and O.K. Mehdi, Inorganic Chemistry, Principles of Structure and Reactivity, Pearson, 2006.
4. F. A. Carey, G. Wilkinson G., C.A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, Wiley Interscience, 2003.
5. J. Lippard and J.M. Berg, Principles of Bioinorganic Chemistry, University Science Books, 1994.
6. W. Kaim, B. Schwederski and Axel Klein, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life (An introduction and Guide), 2nd Edition, John Wiley & Sons, 2013.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 6 Questions each carrying 5 marks without choice

30 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 14 marks

70 marks

(Out of 100 marks, maximum of 10% problems may be asked)

SBIA 5205	COMPUTATIONAL CHEMISTRY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the role of computers in chemistry.
- To appreciate thermodynamics and spectroscopic aspects in relevance to transition states.
- To understand the basic aspects of molecular mechanics.
- To understand the docking principles.
- To understand the basics of algorithms in computational chemistry.

UNIT 1 INTRODUCTION TO COMPUTATIONAL CHEMISTRY

12 Hrs.

Introduction, Scope of computational chemistry, Subject of computational chemistry and its tools, Potential energy surface (PES); geometry optimization, Empirical force fields, molecular mechanics (MM), Thermodynamics.

UNIT 2 SOLVENT EFFECTS

12 Hrs.

Vibrational spectroscopy and gas phase thermodynamics, Description of electronically excited states, Description of solvent effects, Density Functional Theory (DFT): principles, applications in materials, Transition states in gas the phase reactions.

UNIT 3 MOLECULAR MECHANICS

12 Hrs.

Molecular mechanics of bond vibrations. Minimization methods, Molecular mechanics: Forces in polyatomic molecules, Intermolecular forces. Parameterization and testing of force fields, inter and intermolecular interactions

UNIT 4 MOLECULAR DOCKING

12 Hrs.

Geometry convergence, energy convergence, dipole moment convergence, vibrational frequencies convergence, bond dissociation curve, angle bending curve, transition state modeling using Chemoffice and Gaussian software - demo on docking software.

UNIT 5 BASIC ALGORITHMS

12 Hrs.

Monte Carlo method: Principles, Chemical and biochemical applications, Foundations of the MO theory Semi-empirical MO theory Abinitio MO Theory Principles and Applications, Importance sampling and Metropolis sampling, Basic algorithms and technical details.

Max. 60 Hours

COURSE OUTCOMES

On completion of the course the student will be able to

CO1: Appreciate the significance of computational chemistry.

CO2: Analyze the effect of solvents on the molecules.

CO3: Analyze and distinguish the forces involved in molecular mechanics.

CO4: Study the interaction between molecules by docking.

CO5: Apply the algorithms to study an interaction process.

CO6: Apply and evaluate the potential of small molecules by molecular mechanics and docking process using computational tools.

TEXT / REFERENCE BOOKS

1. F. Jensen, Introduction to Computational Chemistry, John Wiley & Sons, 2003
2. C. J. Cramer "Essentials of Computational Chemistry", 2nd ed., Wiley 2004.
3. Foresman, J. B.; Frisch, A.E. Exploring Chemistry with Electronic Structure Methods, 3rd ed.; Gaussian, Inc.: Wallingford, CT, 2015. (See also: <http://expchem3.com/>)
4. User manuals of Gaussian09, Chemoffice Ultra and Gauss View John M. Zelle, "Python Programming: An Introduction to Computer Science", Library of Congress.
5. Andrews Leach, Molecular Modeling: Principles and Applications, 2nd ed., 2001.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

PART A : 6 Questions each carrying 5 marks without choice

PART B : 2 Questions from each unit of internal choice, each carrying 14 marks

(Out of 100 marks, maximum of 10% problems may be asked)

Exam Duration : 3 Hrs.

30 Marks

70 marks

SBIA 6203	COMPUTATIONAL CHEMISTRY LAB	L	T	P	Credits	Total Marks
		0	0	3	2	100

Course Objectives:

- Assessment of Computational approaches used for structure and function relationships of biomolecules.
- Explore various computational tools used in drug designing
- Demonstration of virtual screening strategies
- Small molecules therapeutic efficacy assessment through computational approaches
- Explore the concepts of molecular docking and intermolecular assessment
- Explore the concepts in pharmacophore mapping and 3D-QSAR

List of suggested exercises

1. Protein sequence retrieval and structure modelling
2. Protein physical and chemical parameters evaluation
3. Pharmacophore features of target protein
4. Ligand design
5. Binding site analysis of macromolecule
6. Protein and protein docking
7. Protein and peptide docking
8. Protein and ligand docking
9. Binding free energy estimation
10. ADME Toxicity assessment of small molecules

Course outcomes:

On successful completion of the course, student will be able to

CO1: Perform all the computational methods used in Proteomics

CO2: Explain the concepts of molecular modeling, pharmacophore, virtual screening, molecular docking, 3D QSAR etc.,

CO3: Knowledge of limitations and advantages of different algorithm used in molecular Modeling and drug design.

CO4: Analyze the problem which could arise in drug designing Methods.

CO5: Knowledge of Pharmacogenomics will enable students to explore the Polymorphism concept for better treatment choices.

CO6: Demonstrate basic intermolecular interaction between protein ligand, protein-protein, protein-peptide in three dimensional structural environment

TEXT/REFERENCE BOOKS

1. Warren J Hehre, Laboratory book of computational organic chemistry, wave function, 1998.
2. Tim Clark, A Handbook of Computational Chemistry: A Practical Guide to Chemical Structure and Energy Calculations, Wiley Black Well, 1985.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 50

Exam Duration: 6 Hrs

CAE	Evaluation of Regular Lab class	25 Marks	50 Marks
	Model practical exam	25 Marks	
ESE	University Practical exam		50 Marks

SEMESTER 4										
Sl. No.	Course Type	Course Code	Course Title	L	T	P	C	Marks		Page No.
								CAE	ESE	
1	INTERNSHIP	S91 APT	Professional Training	0	0	0	5	50	50	-
2	PROJECT	S91APROJ	Project Work (Phase – 1 & 2)	0	0	0	12	50	50	36
Total Credits for Semester: 17										
Total Marks for Semester: 200										

S91APROJ	PROJECT	L	T	P	Credits	Total Marks
		0	0	0	12	100

Objectives

To make the student to understand and present a research finding on a topic in the subject related to Chemistry under the guidance of a department staff.

Project report: 60 Marks

Literature review

Problem Identification

Experimental / Results and Discussion

Originality, Technical and logical development

Summary and references

Viva-voce: 40 Marks

Communication

Presentation using Teaching aids

Language and diction

Interpretation of Technical data

2015 REGULATIONS

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
SCY5204: Advanced Inorganic Chemistry

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 50 Marks End-Sem (Paper): 50 Marks

Course Objectives

6. To learn about organometallic compounds in terms of structure and bonding including dinitrogen and dioxygen as ligands.
7. To understand various synthesis methods of different types of organometallic compounds and to learn their reactivity with mechanism.
8. To learn about different reactions involving organometallic compounds as catalysts in chemical synthesis.
9. To understand the role of metals and their complexation in the formation of biological compounds like enzymes and their application in medicinal chemistry.
10. To learn different types of nuclear reactions with radioactive techniques and to know the applications of radio isotopes in different fields.

Course Outcomes

On successful completion of the course, student will be able to

- C01: Explain about organometallic compounds based on EAN rule and to elaborate on the different types of substituted carbonyl compounds.
- C02: Discuss the structure, reactivity and significance of organometallic compounds with dinitrogen and dioxygen as ligands.
- C03: Discuss the mechanism involved in various ligand dissociation and substitution reactions of organometallic compounds.
- C04: Analyze the role of organometallic compounds in various catalysis processes which are of commercial utility.
- C05: Understand the role and importance of metals in forming biomolecules based on complexation and their application in biotransformation.
- C06: Identify different particles in nuclear fission and fusion reactions and to evaluate the application of different radioactive isotopes.

Course Contents		
Unit-I	ORGANOMETALLIC COMPOUNDS	9 Hrs

EAN Rule - Valence electron count (16/18 electron rules) - Structure and bonding in mono and polynuclear metal carbonyls - Substituted metal carbonyls and related compounds - Synthesis and reactivity of metal carbonyls; dinitrogen and dioxygen as ligands in organometallic compounds.

Unit-II **SYNTHESIS OF ORGANOMETALLIC COMPOUNDS** 9 Hrs

Types of M-C bonds - synthesis and reactivity of metal alkyls, carbenes, alkenes complexes - Metallocenes and bent metallocenes - Isolobal analogy. Ligand dissociation and substitution - Oxidative addition - Reductive elimination - Nucleophilic displacement - Insertion - Alkyl migration - 1, 2 insertion - Hydride elimination.

Unit-III **ORGANOMETALLIC CATALYSTS** 9 Hrs

Homogeneous catalysis - Hydroformylation - Monsanto acetic acid process - Hydrogenation by Wilkinson's catalyst - Wacker (Smidt) process - Olefin metathesis - Heterogeneous catalysts - Ziegler Natta polymerization - Water gas reaction.

Unit-IV **BIOINORGANIC CHEMISTRY** 9 Hrs

Metals in biology, structure and activity of Rubredoxin, Ferredoxin, Nitrogenase, Hemoglobin, Myoglobin, Deoxyhemoglobin, Zinc enzymes - Carboxy peptidase and carbonic anhydrase - Catalase - Peroxidase. Copper enzymes oxide dismutase - Molybdenum oxatransferase enzymes - Xanthine oxidase Porphyrins, Metalloenzymes. Ionophores - Ion transport mechanism, Applications of metals in medicine.

Unit-V **NUCLEAR CHEMISTRY** 9 Hrs

Terminology, Concept and formulae of Nuclear chemistry, Types of particles, Radio activity, Radioactive decay, Radioactive decay constants, equilibrium, Nuclear reactions; Q - Value, Chemical effects of Nuclear Transformations, Fission and Fusion, stability of Nucleus, Radioactive techniques - Tracer technique, Neutron activation analysis, counting technique - G.M. ionization, Proportional counter. Application of Radio isotopes.

Max. 45 Hours

TEXT / REFERENCE BOOKS

- Housecroft C. E., and Sharpe A. G., Inorganic Chemistry, Prentice Hall, 2005.
- Shriver D. F., Atkins P. W., and Langford C. H., Inorganic Chemistry, Oxford Univ. Press, 1990.
- Huheey J. E., Keiter E. A., and Keiter R. L., Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education, 2004.

10. Carey F. A., Wilkinson G., Murillo C. A., and Bochmann M. Advanced Inorganic Chemistry, Wiley Interscience, 2003.
11. Lippard S. J. and Berg J. M. Principles of Bioinorganic Chemistry, Univ. Science Books, 1994.
12. Kaim W., and Schwederski B., Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life (An introduction and Guide), John Wiley & Sons, 1994.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 6 Questions each carrying 5 marks without choice

PART B: 2 Questions from each unit of internal choice, each carrying 14 marks.

(Out of 100 marks, maximum of 10% problems may be asked)

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
SCY 5205 ELECTROCHEMISTRY AND SOLID STATE CHEMISTRY

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	In-Sem (Paper): 50 Marks End-Sem (Paper): 50 Marks

Course Objectives

1. To understand theories of inter-ionic interactions and to learn the concept of activity coefficient.
2. To study the structure of electrical double layer, and to learn electrochemical kinetics
3. To learn electroanalytical techniques.
4. To introduce and give an insight into the fascinating area of solid state chemistry and material science.
5. To know the preparative methods of solids

Course Outcomes

On the successful completion of the course, students will be able to:

- C01: Understand the theories and applications of electrochemistry
 C02: Derive Butler-Volmer equation and learn the structure of electrified interfaces
 C03: Know the techniques like polarography, cyclic voltammetry, ion selective electrodes, amperometry.
 C04: Study the concept of solid state chemistry of inorganic compounds.
 C05: Learn the various preparative methods crystalline solids.
 C06: Interpret Tafel plot and electrochemical impedance spectroscopy

Course Contents

Unit-I	IONICS Debye-Hückel theory of interionic attraction. Debye-Huckel limiting law. Debye-Huckel-Onsager theory of electrolytes: Asymmetry effect and Electrophoretic effect. Variation of conductance with applied potential: Wein effect and Debye-Falkenhagen effect. Concept of activity coefficient: Mean activity coefficient-Ionic strength.	12 hrs
Unit-II	ELECTRODICS The structure of electrical double layer: Helmholtz, Gouy-Chapman and Stern models. Polarisable and non-polarisable interfaces. Kinetics of electrode reactions: Derivation of Butler Volmer equation-Tafel equation. Over potential: Activation over potential-Concentration over potential-Ohmic over potential. Decomposition potential.	12 hrs

Unit-III	ELECTROANALYTICAL TECHNIQUES Polarography: The Ilkovic equation-Half wave potential. Amperometric titrations. Cyclic voltammetry for redox system. Polarization methods: Tafel extrapolation technique-Electrochemical impedance spectroscopy. Ion selective electrodes: Glass membrane electrode-Solid membrane electrode-Liquid membrane electrode.	12 hrs
Unit-IV	CRYSTAL STRUCTURE Crystalline and amorphous solids – Crystal systems – Bravais lattices Space groups – Point groups – Types of close packing: hcp and ccp – Limiting radius ratio for trigonal, tetrahedral, octahedral and cubic configurations – Methods of characterizing solids: Principle of Powder x-ray diffraction, electron and neutron diffraction – Structure of solids: AB type crystal; AB ₂ type crystal; A ₂ B type crystal; AB ₃ type crystal.	12 hrs
Unit-V	PREPARATIVE METHODS OF SOLIDS Wagner reaction mechanism for solid state synthesis – Chemical precursor method – Co-Precipitation – Sol-gel method for silica aerogel synthesis – Solid state Metathesis – Self-propagating high temperature synthesis – Ion exchange reactions – Intercalation / deintercalation reactions – Methods of Single Crystal Growth: Hydrothermal method of synthesis – Czochralski method.	12 hrs

Text Books / Reference Books

1. Bockris J. O. M., and Reddy A. K. N., Modern Electrochemistry 1: Ionics, 2nd Edition, Springer, 1998.
2. Bockris J. O. M., and Reddy A. K. N., Modern Electrochemistry 2A: Electrodics, 2nd Edition, Springer, 1998.
3. Glasstone S., Electro chemistry, Affiliated East-West Press, Pvt., Ltd., New Delhi, 1974.
4. Allen J. Bard, Larry R. Faulkner, Electrochemical methods : Fundamentals and Applications, 2nd Edition, John Wiley & Sons, 2001.
5. Smart L., and Moore E., Solid State Chemistry - An Introduction, Chapman & Hall, 1992.
6. Keer H. V., Principles of the Solid State, Wiley Eastern Limited, 1993.
7. Chakrabarty D. K., Solid State Chemistry, New Age Publishers, 1996.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 6 Questions of 5 Marks each-No choice

30 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 14 Marks.

70 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

Sathyabama Institute of Science and Technology

SCY5615: Synthetic Organic Chemistry

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	In-Sem (Paper): 50 Marks End-Sem (Paper): 50 Marks

Course Objectives

1. To learn the methods involved in determining the mechanism of an organic reaction.
2. To understand the significance of stereo, enantio, regio and chemo selectivity in chemical reactions.
3. To recognize the strategies involved in asymmetric synthesis.
4. To impart an insight into specific asymmetric reactions like aldol, hydrogenation, hydroformylation and Reformatsky reaction.
5. To emphasize on the importance of organometallic reagents in organic synthesis.

Course Outcomes

On successful completion of the course, student will be able to

- C01: Categorize and analyze the mechanism involved in basic organic reactions.
- C02: Solve the organic reactions with respect to stereo, enantio, regio and chemoselectivity.
- C03: Propose a strategic reaction pathway in synthesizing a chiral product.
- C04: Predict the products in asymmetric aldol, hydrogenation reactions
- C05: Solve the asymmetric hydroformylation and Reformatsky reactions.
- C06: Choose and predict the organometallic reagents in organic reaction.

Course Contents

Unit-I	MECHANISMS AND DETERMINATION METHODS	12 Hrs
Types of Mechanisms and Reactions - Thermodynamic and Kinetic requirements of a reaction - Representation of Potential Energy Changes in Reactions - General relationship between Thermodynamic stability and Reaction Rates - Kinetic vs thermodynamic control - Methods of Determining Mechanisms: Identification of Products, Determination of the presence of Intermediates, the study of catalysis, Isotopic labeling, Stereochemical Evidence, Kinetic Evidence - Isotope effects.		

Unit-II	STEREO, ENANTIO, REGIO, CHEMO SELECTIVE REACTIONS	12 Hrs
	Introduction: Enantiomeric excess, Diastereomeric excess, Enantioselective Reactions: Hydrogenation, Reduction of ketones, Epoxidation of Allylic alcohols, Dihydroxylation of alkenes – Stereo selective and Stereo specific reactions with suitable examples – Hydroboration - Regioselectivity with examples - The Use of acetylenes – Diastereoselectivity - Cram's Rule - Chemoselectivity in Oxidizing and Reducing agents, dissolving metal reductions, and Catalytic hydrogenation.	
Unit-III	ASYMMETRIC SYNTHESIS – I	12 Hrs
	Introduction to Asymmetric Synthesis – General strategies for asymmetric synthesis - "Chiron" approaches – Acyclic Diastereoselective approaches – Double asymmetric synthesis – Asymmetric Oxidations: Asymmetric Epoxidation of Allylic Alcohols: Sharpless Epoxidation - Selective opening of 2, 3 epoxy alcohols by metallic hydride and organometallic reagents - Asymmetric Diels Alder Reaction: Intramolecular and Retro Diels Alder Reaction.	
Unit-IV	ASYMMETRIC SYNTHESIS –II	12 Hrs
	Asymmetric Reformatsky Reactions - Double Asymmetric Cycloaddition – Asymmetric aldol reactions –Aldol reactions – Substrate controlled aldol reactions – Reagent controlled aldol reactions – Chiral catalyst controlled aldol reactions – Double Asymmetric aldol reactions – Asymmetric Transfer Hydrogenation - Asymmetric Hydroformylation.	
Unit-V	REAGENTS IN ORGANIC SYNTHESIS	12 Hrs
	Reagents: Organo-Zinc compounds , Organo-Copper compounds, Organo-lead compounds, Organo- silicon compounds and Organo-cadmium compounds.	

Max. 60 Hours

TEXT / REFERENCE BOOKS

- 1) Clayden, Greeves, Warren and Wothers., Organic chemistry, Oxford University, 2001.
- 2) J. March's Advanced Organic Chemistry Reaction, Mechanisms and Structure, Wiley 2007.
- 3) Guo-Qiang Lin, Yue-Ming Li, Albert S.C. Chan., Principles and applications of Asymmetric synthesis, John Wiley 2001.
- 4) Finar I. L., Organic Chemistry, 6th Edition, Pearson Education Asia, 2004.
- 5) Carey F. A., and Sundberg R. J., Advanced Organic Chemistry Part-A and B, 4th edn, Kluwer Academic/Plenum Publishers 2000.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 6 Questions, each carrying 5 marks -No choice

PART B: 2 Questions from each unit of internal choice, each carrying 14 marks.

(Out of 100 marks, maximum of 5% problems may be asked)

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
SCY5203 ORGANIC REACTION MECHANISM

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	In-Sem (Paper): 50 Marks
		End-Sem (Paper): 50 Marks

Course Objectives

1. To learn the various types of bonding and conjugation in organic compounds
2. To apply the concept of Huckel rule to determine the aromaticity of compounds
3. To know the concept of stability and reactivity of reactive intermediates
4. To understand the mechanism of nucleophilic and electrophilic substitution reactions
5. To appreciate the concept of substitution, addition and elimination reactions and their reaction mechanism

Course Outcomes

On completion of the course, student will be able to

- C01: Understand the various types of bonding and conjugation in organic molecules and concept of aromaticity, anti-aromaticity and non-aromaticity
- C02: Apply the Huckel rule for benzenoid and non-benzenoid compounds
- C03: Learn the stability and reactivity of carbocations, carbanions and free radicals and concept of NGP, Field effects.
- C04: Explain the mechanism of aliphatic nucleophilic and electrophilic substitutions such as SN^1 , SN^2 and SN^i mechanism and SE^2 and SE^i , SE^1 , Substitution by double bond shifts
- C05: Discuss the mechanism of aromatic nucleophilic and electrophilic substitutions such as arenium ion mechanism, orientation and reactivity and SN_{Ar} , SN^1 and Benzyne mechanisms
- C06: Illustrate the addition to C-C multiple bond, Carbon-Hetero atoms multiple bonds with suitable examples and explain the mechanism of Elimination reactions such as $E1$, $E1cB$ and $E2$ mechanism

Course Contents

Unit-I	NATURE OF BONDING IN ORGANIC MOLECULES	12 Hrs
	Nature of Bonding in Organic Molecules, Delocalized chemical bonding – Conjugation, cross-conjugation, hyper conjugation and hydrogen bonding. Aromaticity. Benzenoid and nonbenzenoid compounds. Huckel and Craig rules. Application of Huckel's rule for annulenes, heteroannulenes, fullerenes, Ferrocene, cyclopropenium cation, cyclopentadienyl anion, cycloheptadienyl cation, Homo-and antiaromaticity, Ψ -aromaticity Energy levels of pi molecular orbitals, PMO approach.	
Unit-II	REACTION MECHANISM – REACTIVE INTERMEDIATES	12 Hrs

Field effects (inductive, electromeric effects), mesomerism, resonance, steric effects. Types of reactions and mechanism. Generation, structure, stability and reactivity of carbocations, carbanions and free radicals. Structure of carbenes, nitrenes and benzynes.

Unit-III ELECTROPHILIC AND NUCLEOPHILIC ALIPHATIC SUBSTITUTION REACTIONS 12 Hrs

Aliphatic Nucleophilic substitution: Types of nucleophiles – attacking nucleophile, ambident nucleophiles, hard and soft Nucleophiles. SN^1 , SN^2 and SN^i mechanisms. Neighbouring group participation, anchimeric assistance. Nucleophilic substitution at allylic, aliphatic trigonal and vinylic carbon. Nucleophilicity and solvent effects, Competition between nucleophilicity and basicity, leaving group effects, steric substituent effects on substitution.

Aliphatic Electrophilic substitution: Mechanisms - SE^2 and SE^i , SE^1 , Substitution by double bond shifts. Effect of substrates, leaving group and solvent polarity on the reactivity.

Unit-IV ELECTROPHILIC AND NUCLEOPHILIC AROMATIC SUBSTITUTION REACTIONS 12 Hrs

Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, Ortho/para ratio, ipso attack, orientation in naphthalene ring systems. Diazonium coupling, Gattermann-Koch reaction.

Aromatic Nucleophilic Substitution: Mechanisms: $SNAr$, SN^1 and Benzyne mechanisms. - Reactivity, Effect of structure, leaving group and attacking nucleophile. Typical reactions: O and S-nucleophiles, Bucherer reaction and Rosenmund reduction and Smiles rearrangements.

Unit-V ADDITION AND ELIMINATION REACTIONS 12 Hrs

Addition to C-C Multiple Bond: Mechanism of addition of HX (X=Halo, OH) to alkenes and alkynes – Micheal addition.

Addition to Carbon-Hetero Atoms Multiple Bonds –Nucleophilic addition of carbonyl compounds. Addition - Elimination Reactions of Ketones and Aldehydes, Reactivity of carbonyl compounds towards Addition.

Elimination Reactions: The $E1$, $E1cB$ and $E2$ mechanism, Syn elimination, Orientation Effects in Elimination. Reactions - Pyrolytic eliminations, Chugaev reaction.

TEXT / REFERENCE BOOKS

1. March J., and Smith M., Advanced Organic Chemistry, 5th Edition, John-Wiley and Sons, 2001.
2. Carey F. A., and Sundberg R.J., Advanced Organic Chemistry Part-A and B, 4th Edition, Kluwer Academic/Plenum Publishers, 2007.
3. Morrison R., and Boyd R., Organic Chemistry, 2nd Edition, Allyn & Bacon, 1967.
4. Bansal R. K., Organic Reaction Mechanism, New Age International Pvt. Ltd. Publishers, 2010.

5. Pine S. H., Organic Chemistry, 5th Edition, McGraw Hill International Edition, 1987.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 100

Exam Duration : 3 Hrs.

PART A : 6 Questions of 5 Marks each-No choice

30 Marks

PART B : 2 Questions from each unit of internal choice, each carrying 14 Marks.

70 Marks

(Out of 100 Marks, maximum of 10% problems may be asked.)

Sathyabama Institute of Science and Technology

SCY5101: Organic synthesis and Retrosynthetic Method

Teaching Scheme:	Credit	Examination Scheme:
TH: 3 Hours/Week	03	In-Sem (Paper): 50 Marks End-Sem (Paper): 50 Marks

Course Objectives

1. To understand the strategies involved in designing a chemical reaction.
2. To recognize the importance of oxidizing and reducing agents in functional group conversion reactions.
3. To comprehend the name reactions of alkyl halide and carbonyl groups with their mechanism.
4. To learn the significant organic name reactions applied in industries with their mechanism.
5. To highlight on importance of molecular rearrangement in organic chemistry.

Course Outcomes

On successful completion of the course, student will be able to

- C01: Construct a single step retrosynthetic pathway for organic reaction.
- C02: Interpret the products in organic chemical reactions involving oxidizing and reducing reagents.
- C03: Construct and predict the reaction mechanism for name reactions outlined.
- C04: Formulate chemical reactions and mechanism for name reactions outlined.
- C05: Design chemical reaction based on molecular rearrangements outlined
- C06: Design and predict the products in organic reactions.

Course Contents

Unit-I	ORGANIC SYNTHESIS	12 Hrs
	Synthetic Analysis and Planning: Retrosynthetic analysis – Synthetic equivalent – Synthon, Rethon – Control of stereochemistry – Linear, convergent and divergent syntheses – Use of protecting groups in Hydroxyl	

and Carbonyl compounds: Different protection and deprotection methods.

Unit-II **REAGENTS IN ORGANIC CHEMISTRY** 12 Hrs

Oxidation Reagents: Potassium Permanganate, HIO_4 , OsO_4 , MnO_2 – Alcohol to carbonyls: Cr (VI) oxidants, PCC, 1,3-dithiane – Swern oxidation, Silver carbonate, Prevost and Woodward oxidation, Oxidation of allylic – C-H bonds: DDQ, SeO_2 . Reducing Reagents: LAH, NaBH_4 , DIBAL, Electrophilic metal hydrides: BH_3 , AlH_3 . Functional group transformations: Use of Organo-lithium compounds – Lithium diisopropyl amide (LDA), RMgX and Tri-N-butyltinhydride, Phase transfer catalysts – Crown ethers and Merrifield resin, Baker yeast.

Unit-III **NAMED REACTIONS-I** 12 Hrs

Wurtz Reaction – Wolf Kishner – Clemmenson reduction – Kolbe – Corey-House reaction – Reformatsky reaction – Claisen condensation – Dieckman reaction – Aldol condensation – Knoevenagel condensation – Perkin reaction – Stobbe – Friedel crafts alkylation and acylation – Cannizzaro reaction – Benzoin condensation – Vilsmeier-Hack reaction – Reimer-Tiemann reaction – Bischler-Napieralski reaction.

Unit-IV **NAMED REACTIONS-II** 12 Hrs

Wittig reaction – Robinson-Mannich reaction – Stork enamine reaction – Mannich Reaction – Sharpless asymmetric epoxidation – Ene reaction – Barton reaction – Hofmann-Löffler-Freytag reaction – Chichibabin reaction – Suzuki Coupling – Stille coupling – Umpolung reaction.

Unit-V **MOLECULAR REARRANGEMENT** 12 Hrs

General mechanistic considerations: Types of rearrangement by nature of migration – Intra and Inter molecular rearrangement – Cross over experiment. C-C Migration: Pinacol-Pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorski rearrangements. C-N Migration: Neber, Arndt-Eistert synthesis, Beckmann, Hofman, Curtius, Schmidt rearrangements. C-O Migration: Bayer-Villiger, Shapiro reaction. Miscellaneous: Fries, Cope, Somlet hauser, Stevens, Von-Richter rearrangement.

Max. 60 Hours

TEXT / REFERENCE BOOKS

1). March J., and Smith M., Advanced Organic Chemistry, 5th Edition, John-Wiley and Son, 2001.

- 2). Gould E. S., Mechanism and Structure in Organic Chemistry Holt, Rinehart and Winston Inc., 1959.
- 3). Gilchrist T. L., Heterocyclic Chemistry, Longman Scientific and Tech., 1985.
- 4). Finar I. L., Organic Chemistry, 6th Edition, Pearson Education Asia, 2004.
- 5). House H.O., Modern Synthetic Reactions, W.A. Benjamin Inc, 1972.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 6 Questions, each carrying 5 marks -No choice

PART B: 2 Questions from each unit of internal choice, each carrying 14 marks.

(Out of 100 marks, maximum of 5% problems may be asked)

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
SCY5102: COORDINATION CHEMISTRY

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	In-Sem (Paper): 50 Marks End-Sem (Paper): 50 Marks

COURSE OBJECTIVES

1. To know the nature of metal-ligand bonding in coordination compounds and quantification of the bonding parameters.
2. Learn the various bonding theories in coordination chemistry and their application in understanding spectra and magnetism.
3. Understand Reaction Mechanism in Coordination Chemistry
4. To be able to describe the stability of metal complexes by the use of formation constants and to calculate thermodynamic parameters from them.
5. To study the basic concepts of acids and bases

Course Outcomes

On successful completion of the course, student will be able to

- C01 : To Understand the structure, isomerism and bonding in coordination complexes
- C02 : Deduce the crystal field splitting diagram for octahedral, tetrahedral, and square planar complexes; decide the electronic configuration. Generate the ligand field diagram for octahedral complexes.
- C03 : To Understand the factors affecting the stability of metal complexes
- C04 : To characterize the electronic spectra of metal complexes based on Orgel and Tanabe-Sugano diagram
- C05 : To Understand the types of mechanisms in reactions of metal complexes
- C06 : Apply soft-hard acid-base theory to predict the stability of complexes; interpret chelate effect; determine the relative stability of complexes according to structural factors.

Course Contents

Unit-I	STRUCTURES AND ISOMERS Coordination compounds: Ligand – Coordination number –Nomenclature of coordination compounds. Types of isomerism; Hybridization and geometries of coordination compounds. Thermodynamic stability and structural effects – Successive and overall stability constants – Irving-William series – Chelate and macrocyclic effect.	12 hrs
Unit-II	THEORIES OF BONDING	12 hrs

Valence Band Theory – Crystal Field Theory and their limitations – d-orbital splitting in octahedral – Jahn Teller distortions: Distorted octahedral – Square planar – Square pyramidal – Trigonal bipyramidal and tetrahedral complexes. Crystal field stabilisation energy for d^1 to d^{10} systems – Pairing energy – Low-spin and high-spin complexes and magnetic properties – Ligand Field Theory and Molecular Orbital (MO) theory of octahedral and tetrahedral complexes.

Unit-III

12 hrs

ELECTRONIC SPECTRA

Absorption spectra: Charge transfer spectra – Colors, intensities and origin of spectra – Interpretation – Term Symbols and splitting of terms in free atoms – Selection rules for electronic transitions – Orgel and Tanabe-Sugano diagram – Calculation of Dq , Racah parameter (B), C , Spectrochemical and Nephelauxetic series.

Unit-IV

12 hrs

REACTIONS AND MECHANISMS

Substitution reactions in octahedral and square planar complexes, mechanism, trans effect and its influence, water exchange – Anation and base hydrolysis – Stereochemistry – Oxidation and reduction reactions. Inner and outer sphere electron transfer mechanisms – Conditions for high and low oxidation numbers – Template reactions.

Unit-V

12 hrs

ACIDS AND BASES

Arrhenius concept – Bronsted-Lowry concept – Lux-Flood concept – Lewis concept – Usanovich concept – Theory of hard and soft acids and bases (HSAB) – Classification of acids and bases as hard and soft – Lewis-acid base reactivity approximation – Donor and acceptor numbers, E and C equation – Applications of HSAB concept – Solvation and acid-base strength – Non-aqueous solvents and acid-base strength – Levelling effect – Symbiosis – Proton sponges.

Max. 60 Hours

TEXT / REFERENCE BOOKS

1. Huheey J. E., Keiter E. A., and Keiter R. L., Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006.
2. Atkins P. W., Overton T., Rourke J., Weller M., and Armstrong F., Shriver & Atkins: Inorganic Chemistry, 4th Edition, Oxford University Press, 2006.
3. Cotton F. A., Wilkinson G., Murillo C. A., and Bochmann M., Advanced Inorganic Chemistry, 6th Edition, Wiley, 1999.
4. Drago R. S., Physical Methods in Inorganic Chemistry, Affiliated East-West Press, 1971.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 6 Questions each carrying 5 marks without choice

PART B: 2 Questions from each unit of internal choice, each carrying 14 marks.

(Out of 100 marks, maximum of 10% problems may be asked)

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
SCY5110 STEREOCHEMISTRY AND ORGANIC PHOTOCHEMISTRY

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	In-Sem (Paper): 50 Marks
		End-Sem (Paper): 50 Marks

Course Objectives

1. To suggest synthetic route for simple organic compounds with stereochemistry
2. To make the students understand and appreciate the concept of stereochemistry and reaction mechanism
3. To know the nature of addition in pericyclic reactions
4. To learn the alpha cleavage and gamma hydrogen transfer reactions
5. To understand the photochemical organic reactions and rearrangement reactions

Course Outcomes

On completion of the course, student will be able to

- C01: Understand the various symmetry elements and representation of organic molecules and their interconversion
- C02: Apply the D and L notation, R and S notation, absolute and relative configurations to organic molecules
- C03: Apply the E and Z notation to C=C and cyclic systems and explain the conformational analysis of acyclic and cyclic systems
- C04: Explain the mechanism of various pericyclic reactions such as electrocyclic, cycloaddition, cheletropic and sigmatropic reactions and understand the concept of Woodward Hoffmann rules, The Mobius and Huckel concept and FMO method
- C05: Discuss the Frank-Condon principle and Jablonski diagram and apply the alpha cleavage or Gamma hydrogen transfer mechanism to organic molecules
- C06: Illustrate the mechanism of various photochemical reaction and rearrangement with suitable examples

Course Contents

Unit-I	STEREOCHEMISTRY-I	12 Hrs
	Elements of symmetry – Chirality – Representation of organic molecules (Fischer, Sawhorse, Newman and Zig-Zag) and their interconversion – Molecules with more than one chiral centre: Erythro and threo isomers – Optical activity in the absence of chiral carbon – biphenyls, allenes and spiranes – Criteria for optical purity – D and L Notation, Cahn-Ingold-Prelog rules – R and S-notations – Absolute and relative configuration	

Racemic modifications – Racemisation – Thermal, anion, cation, reversible formation – Resolution of racemic modifications – Epimerisation – Mutarotation – Stereospecific synthesis – Stereochemistry of compounds containing nitrogen, sulphur and phosphorus.

Unit-II **STEREOCHEMISTRY-II**

12 Hrs

Geometrical isomerism: E, Z notations, geometrical isomerism in C=C and cyclic systems – Configuration and Conformation – Conformational analysis: In acyclic systems – Simple 1,2 disubstituted ethane derivatives – In cyclic systems (cyclobutane, cyclopentane, cyclohexane and cycloheptane) – Conformation and reactivity in disubstituted cyclohexanes – Cis and trans decalins – Topicity of ligands and faces – Enantiotopic and diastereotopic atoms – Prochiral centre and pseudoasymmetry – Stereoselective reactions – Cram's rule and Felkin-Ahn's modification – Prelog's rule.

Unit-III **PERICYCLIC REACTIONS**

12 Hrs

Characteristics – Types of pericyclic reactions – electrocyclic, cycloaddition, cheletropic and sigmatropic reactions – Woodward Hoffmann rules; The Mobius and Huckel concept, FMO method and Correlation diagrams – Electrocyclic reactions of conjugated dienes and trienes – Cycloaddition and Cheletropic reactions [2+2] and [4 + 2] cycloadditions. Diels Alder and Retro Diels Alder reactions – 1, 3-dipolar cycloaddition – Sigmatropic rearrangements involving hydrogen and carbon migration – Cope and Claisen rearrangements.

Unit-IV **ORGANIC PHOTOCHEMISTRY-I**

12 Hrs

Organic photochemistry – General principles – Frank-Condon principle – Electronic transitions – Jablonskidiagram: Inter-system crossing and Energy transfer – Photochemistry of carbonyl compounds: $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ transitions – alpha cleavage or Norrish type I reaction – Gamma hydrogen transfer or Norrish type II reaction – Energy transfer reactions – Sensitizer and Quencher.

Unit-V **ORGANIC PHOTOCHEMISTRY-II**

12 Hrs

Photoreduction – Paterno-Buchi reactions – di-pi-methane rearrangement – Barton rearrangement – Photo-Fries rearrangement - photochemistry of an α,β -unsaturated ketones – Olefin photochemistry (Cis-Trans isomerism) – Photochemistry of conjugated dienes – Photochemistry of arenes and benzene derivatives – Cycloaddition of benzene to olefins and dienes.

TEXT / REFERENCE BOOKS

1. Eliel E. L., Stereochemistry of Carbon Compounds, Tata-McGraw Hill, 2000.
2. Kalsi P. S., Stereochemistry, 3rd Edition, New Age International Publishers, 1995.
3. March J., and Smith M., Advanced Organic Chemistry, 5th Edition, John-Wiley and Sons, 2001.
4. Carey F. A., and Sundberg R. J., Advanced Organic Chemistry Part-A and B, 4th edn, Kluwer Academic/Plenum Publishers, 2000.
5. Gill G. B., and Wills M. R., Pericyclic Reactions, Chapman Hall, 1974.

END SEMESTER EXAM QUESTION PAPER PATTERN**Max. Marks : 100****Exam Duration : 3 Hrs.****PART A :** 6 Questions of 5 Marks each-No choice**30 Marks****PART B :** 2 Questions from each unit of internal choice, each carrying 14 Marks.
(Out of 100 Marks, maximum of 10% problems may be asked.)**70 Marks**

Sathyabama Institute of Science and Technology

SCY5106: Chemistry of the Main Group Elements

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 50 Marks End-Sem (Paper): 50 Marks

Course Objectives

1. To study structure and bonding in polyhedral boranes.
2. To understand the chemistry of silicon, sulphur and phosphorous compounds.
3. To discuss the synthesis and reactivity of organometallic reagents and macrocycles.
4. To study the preparation and properties of different organyls.
5. To determine the properties and applications of lanthanides and actinides.

Course Outcomes

On successful completion of the course, student will be able to

- CO1: Explain the structure and bonding in polyhedral boranes and borazines and the concept of Styx notation, Wade's rule.
- CO2: Discuss the structural features and reactivity of Silicon, Sulphur, Phosphorous and S-N heterocycles.
- CO3: Determine the synthesis and reactivity of organo lithium, beryllium and magnesium compounds and complexation in calixarines, cryptand and crown ethers.
- CO4: Discuss the preparation and properties of various organyls and its reduction reactions.
- CO5: Discuss the magnetic and optical properties of lanthanides and actinides.
- CO6: Determine the coordination chemistry of lanthanides and actinides and its applications.

Course Contents

Unit-I	CHEMISTRY OF BORANES	9 Hrs
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Structure and bonding in polyhedral boranes and carboranes – Styx notation – Wade's rule – Electron count in polyhedral boranes – Synthesis of polyhedral boranes – Isolobal analogy – Boron halides – Phosphine-

Boron heterocycles – Borazine.

Unit-II	CHEMISTRY OF Si, S, P COMPOUNDS	9 Hrs
	Silanes, silicon halides, silicates, germanes and stannenes – Phosphorous halides, oxyacids of phosphorous, phosphazenes – Sulphur halides, oxo acids of sulphur – Structural features and reactivity of S-N heterocycles.	
Unit-III	ORGANOMETALLIC REAGENTS AND MACROCYCLES	9 Hrs
	Synthesis and reactivity of organo-lithium, beryllium and magnesium compounds – Calixarines, cryptands and crown ethers in complexation chemistry.	
Unit-IV	ORGANYLS	9 Hrs
	Preparation and reactivity of aluminium organyls – Carbalumination, hydroalumination – Chemistry of Ga(I) and In(I) – Reduction of Al, Ga and In organyls – Germanium, tin and lead organyls	
Unit-V	PROPERTIES OF F-BLOCK ELEMENTS	9 Hrs
	Lanthanides and Actinides – Contraction, coordination, optical spectra and magnetic properties.	

Max. 45 Hours

TEXT / REFERENCE BOOKS

1. Shriver D. F., Atkins P. W., and Langford C. H., Inorganic Chemistry, Oxford University Press, 1990.
2. Huheey J. E., Keiter E. A., and Keiter R. I., Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2004.
3. Carey F. A., Wilkinson G., Murillo C. A., and Bochmann M., Advanced Inorganic Chemistry, Wiley Interscience, 2003.
4. Housecroft C. E., and Sharpe A. G., Inorganic Chemistry, Prentice Hall, 2005.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 6 Questions each carrying 5 marks without choice

PART B: 2 Questions from each unit of internal choice, each carrying 14 marks.

(Out of 100 marks, maximum of 10% problems may be asked)

SEMESTER 2

Sl. No.	COURSE CODE	COURSE TITLE	L	T	P	C	PAGE No.
THEORY							
1	SCY5106	Chemistry of the Main Group Elements	3	0	0	3	19
2	SCY5108	Chemical Kinetics and Solid State Chemistry	3	1	0	4	21
3	SCY5110	Fundamentals of Stereochemistry & Organic Photochemistry	3	1	0	4	23
4	SCY5603	Spectroscopy: Applications in Inorganic Chemistry	3	1	0	4	25
5	SCY5605	Chemistry of Natural Products	3	1	0	4	27
PRACTICAL							
6	SCY6532	Organic Chemistry Lab – I	0	0	4	2	29
7	SCY6533	Inorganic Chemistry Lab – II	0	0	4	2	30
INTERNSHIP							
8	S91PT	Professional Training	0	0	0	5	

Total Credits: 28

L - LECTURE HOURS, T – TUTORIAL HOURS, P – PRACTICAL HOURS, C – CREDITS

Sathyabama Institute of Science and Technology

S91 PROJ	PROJECT	Credits	Total Marks
		12	100

Objectives

To make the student to understand and present a research finding on a topic in the subject related to Chemistry under the guidance of a department staff.

Project report: 60 Marks

Literature review

Problem Identification

Experimental / Results and Discussion

Originality, Technical and logical development

Summary and references

Viva-voce: 40 Marks

Communication

Presentation using Teaching aids

Language and diction

Interpretation of Technical data

2019 Regulations

SCYA1102	ENGINEERING CHEMISTRY	L	T	P	Credits	Total Marks
		3	1	0	3	100

COURSE OBJECTIVES:

- To understand the basic concepts of quantum chemistry for bonds to bands
- To learn the principles and applications of energy levels in molecules
- To explore the importance of functional materials for electronic devices
- To study the structure and properties of carbon materials
- To identify the significance of chemistry in engineering and technology

COURSE SYLLABUS:

UNIT 1 BONDS TO BANDS

9 Hrs.

Introduction to quantum chemistry – Motion of a quantum mechanical particle in one dimension (time-independent) – Schrödinger wave equation for hydrogen atom (No derivation) – Physical meaning of wave function - Angular and radial wave functions and probability densities – Quantum numbers – Principal, azimuthal, spin and magnetic quantum numbers – Wave functions and orbital shapes - s, p, d, f - LCAO-MO of H_2 – Band theory of solids: Conductors, semi-conductors and superconductors – Role of As and Ga doping on band structures.

UNIT 2 MOLECULAR SPECTROSCOPY

9 Hrs.

Electromagnetic spectrum – Interaction of radiation with matter – Energy levels in molecules – Microwave spectroscopy – Principle – Classification of molecules based on moment of Inertia – Rotational energy expression (J levels) – Calculation of J for CO molecule – Vibrational spectroscopy – Normal modes of vibrations – Vibrations of polyatomic molecules (CO_2 and H_2O) – Determination of Force constant – Electronic transitions in organic molecules – Mathematical derivation of Beer-Lambert's law – Stimulated Emission – Lasers in action – Excimer laser, Diode laser and Gas laser.

UNIT 3 FUNCTIONAL MATERIALS

9 Hrs.

Introduction to conducting polymers – Charge transport carriers: Exciton formation in organic solar cells and organic light emitting diodes (principle and working) – Conduction mechanism in polymers: Soliton, polaron and bipolaron formation in polyacetylene and polyaniline – Liquid crystals: Characteristic features and phases of liquid crystals – Liquid crystal displays.

UNIT 4 CARBON MATERIALS FOR HEALTH, STEALTH AND ENERGY

9 Hrs.

Introduction to carbon materials – Fullerenes – Production, properties and applications – VanderWaal's solid – Structure of graphene, graphene oxide and reduced graphene oxide – Mechanical and electrical properties of graphene – Graphene based energy storage devices for space applications – Carbon nanotubes – Single-walled and multiwalled CNTs - Synthesis of CNTs by Thermal CVD and laser ablation method – Electrical and mechanical properties of CNTs - Applications of CNTs.

UNIT 5 ENGINEERING MATERIALS

9 Hrs.

Phase equilibria: Gibbs phase rule – Terms involved in Phase rule – Phase diagram of water system – Thermal method of analysis – Construction of simple eutectic system (Lead-Silver system).

Fuels– Classification of fuels – Determination of calorific values of solid fuels by bomb calorimeter– Manufacture of synthetic petrol by Fischer-Tropsch method – Knocking in IC engines – Chemical structure – Octane and cetane rating of fuels.

Nanomaterials: Size dependent properties of nanomaterials – Synthesis of gold and silver nanoparticles by Chemical reduction method–Applications of nanoparticles in medicine.

COURSE OUTCOMES:

On completion of the course the student will be able to

CO1: Apply the principles of quantum chemistry in conduction mechanism in solids.

CO2: Analyze the spectral transitions of molecules for photonic devices.

CO3: Assess the role of charge transport carriers for functioning of electronic devices.

CO4: Analyze the properties of carbon materials for applications in health, stealth and energy sectors.

CO5: Examine the properties of engineering materials for nanodevice fabrication.

CO6: Evaluate the materials for real world applications.

TEXT / REFERENCE BOOKS

1. A.K.Chandra, Introductory Quantum Chemistry, Tata McGraw-Hill, 4th edition, 1994.
2. Ira N. Levine, Physical chemistry, 6th Edition, 2008.
3. Ira N. Levine, Quantum chemistry, 7th Edition, 2013.
4. David W. Ball and Thomas Baer, Physical Chemistry, Wadsworth Cengage Learning, 2nd Edition, 2014.
5. Donald W. Rogers, Concise Physical Chemistry, John Wiley and Sons, 2011.
6. Douglas A. Skoog and Donald M.West, Principles of Instrumental Analysis, Cengage, 6th Edition, 2014.
7. P.C. Jain and Monika Jain, Engineering Chemistry, Dhanpat Rai Publication, 2018.
8. Joel. R. Fried, Polymer Science and Technology, Prentice Hall of India Private Ltd., 3rd Edition, 2012.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. marks:100

Exam Duration:3 Hrs.

Part A: 10 question of 2 marks each – No choice

20 marks

Part B: 2 questions from each unit of internal choice, each carrying 16 marks 80 marks

SCYA 2101	ENGINEERING CHEMISTRY LAB	L	T	P	Credits	Total Marks
		0	0	2	1	50

COURSE OBJECTIVES:

- To understand the basic principle involved in volumetric and instrumental analysis.
- To acquire practical knowledge in pHmetry, potentiometry and conductometry.
- To develop the skill in water analysis.

List of Experiments

1. Estimation of mixture of acids by conductometry.
2. Estimation of ferrous ion by potentiometry.
3. Determination of pKa value of glycine by pHmetry.
4. Estimation of hardness of water by EDTA method.
5. Determination of alkalinity of water
6. Estimation of Iron by photolorimetry.
7. Estimation of copper in brass
8. Determination of high molecular weight polymer using Ostwald viscometer.

COURSE OUTCOME:

The students will be able:

- CO1** - Estimate the ionic conductance of mixture of acids.
CO2 - Construct a redox cell and measure its emf.
CO3 - Interpret the concept of Zwitter ion in amino acids
CO4 - Predict the quality of water sample for domestic and industrial applications.
CO5 - Demonstrate the validity of Beer-Lambert's law.
CO6 - Apply Poiseuille's law for molar mass measurements.

TEXT / REFERENCE BOOKS

1. G.H. Jeffery, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition. Persons Education 2004.
2. S. S. Dara, Experiments and Calculations in Engineering Chemistry, S. Chand and Co. 2010.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. marks:50

Exam Duration:2 Hrs

CAE	Evaluation of Regular Lab class	15 Marks	25 Marks
	Model practical exam	10 Marks	
ESE	University Practical exam		25 Marks

2015 Regulations

SCY 1101	ENGINEERING CHEMISTRY (Common to ALL Branches of B.E/ B. Tech.)	L	T	P	C	Total Marks
		3	0	0	3	100

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1: Comprehend the various synthetic methods and properties of nano materials.

CO2: Analyse the hardness of water

CO3: Illustrate the charging and discharging characteristics secondary batteries

CO4: Designing of materials for corrosion prevention.

CO5: Discuss the various moulding techniques and types of polymerization mechanism.

CO6: Relate the basic chemistry concepts in science and technology.

COURSE SYLLABUS:

UNIT	TOPICS COVERED	DURATION
I	SYNTHESIS OF NANOMATERIALS Introduction: Nanomaterials: Definition - Classification based on dimensions - Size dependent properties. Types of nanomaterials: Nanoparticles: Synthesis by chemical reduction method. Nanoporous materials: Synthesis by sol-gel method. Nanowires: Synthesis by VLS mechanism. Carbon Nanotubes (CNTs): Single walled and multi walled nanotubes - Mechanical and electrical properties of CNTs - Applications of CNTs - Synthesis of CNTs by electric arc discharge method and laser ablation method.	9 h
II	WATER TECHNOLOGY Introduction: Water quality parameters - Contamination of water by arsenic, lead, fluoride, mercury and their removal. Hardness: Types - Expression - Units. Estimation of hardness of water by EDTA method - Problems. Estimation of iron, calcium and magnesium: AAS method. Water softening: Zeolite process - Demineralization process. Desalination: Reverse osmosis - Electrodialysis.	9 h
III	ELECTROCHEMICAL POWER SOURCES Electrochemistry: Galvanic cell - Electrochemical cell representation - EMF series and its significance. Batteries: Terminology - Lead-acid accumulator - Nickel-cadmium batteries. Lithium batteries: Li/SOCl ₂ cell - Li/I ₂ cell - Lithium ion batteries. Fuel Cells: Hydrogen-oxygen fuel cells - Solid oxide fuel cell (SOFC).	9 h
IV	CORROSION SCIENCE Introduction: Definition. Types: Dry corrosion: Mechanism - Pilling-Bedworth rule - Wet Corrosion: Mechanism. Types: Galvanic corrosion and differential aeration cell corrosion. Galvanic series and its significance. Factors influencing corrosion. Corrosion prevention: Material selection and design - Cathodic protection. Protective coatings: Paints - Constituents. Mechanism of drying of drying oils.	9 h
V	POLYMER CHEMISTRY Introduction to polymers: Nomenclature - Functionality. Types of polymerization. Mechanism of polymerization: Free radical mechanism - Cationic mechanism - Anionic mechanism. Plastics: Types - Thermoplastics and thermosetting plastics. Properties: Strength - Crystalline and amorphous state - Average molecular weight - Polydispersity. Compounding of plastics. Moulding of plastics: Compression moulding - Injection moulding - Extrusion moulding. Introduction to conducting polymers.	9 h

TEXT/REFERENCE BOOKS:

1. Jain P.C. and Monica Jain, Engineering Chemistry, 15th Edition Dhanpat Rai Publishing Co., 2009.
2. Dara S.S., Text Book of Engineering Chemistry, S. Chand & Co, 2008.
3. Sheik Mideen A., Engineering Chemistry (I & II), 13th Edition, Shruthi Publishers, 2010.
4. Kuriakose J.C. and Rajaram J., Chemistry in Engineering and Technology". Vol.1 & 2, 5th reprint, Tata McGraw Hill Publishing Company (P) Ltd., 2010.
5. Sharma B.K., Engineering Chemistry, 2nd Edition, Krishna Prakasam Media (P) Ltd., 2001.
6. Mars G Fontana, Corrosion Engineering, 3rd Edition, Tata McGraw Hill, 2008.
7. David Linden, Thomas B Reddy, Handbook of Batteries, 4th Edition, McGraw-Hill, 2010.

SCY 4051	ENGINEERING CHEMISTRY LAB (COMMON TO ALL BRANCHES OF B.E/B.TECH)	L	T	P	Credits	Total Marks
		0	0	2	1	50

COURSE OBJECTIVES:

- To comprehend the analytical skills for the estimation of various compounds
- To familiarize with the handling of chemicals and glasswares.
- To expose the students to handle the basic analytical equipments.

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1: Estimate ionic conductance (Λ_c) in samples.

CO2: Evaluate the aminoacid content in samples.

CO3: Construct the redox cell and measure emf (E_{cell}) of the cell

CO4: Analyse the hardness in water samples.

CO5: Relate viscosity (η) in determining molecular weight of a polymer.

CO6: Assess the iron content in samples by photocolourimetry.

COURSE SYLLABUS:

1. Estimation of mixture of acids by conductometric method.
2. Estimation of glycine by Sorensen's method
3. Estimation of Ferrous ion by potentiometric method.
4. Estimation of total hardness of water sample by EDTA method
5. Determination of viscosity of polymers by using Ostwald's viscometer.
6. Estimation of Iron by photocolourimeter.

TEXT / REFERENCE BOOKS

1. Jeffery G. H., Bassett J., Mendham J., and Denney R. C.,, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearsons Education, 2004.
2. Kolthoff I. M., and Sandell E. B., Text Book of Qualitative Inorganic Analysis, 3rd Edition, The Macmillan Company, 2012.

SCY 1103	CHEMISTRY OF INDUSTRIAL MATERIALS (Common to Mech, Aero, Auto, Mechatronics, Civil)	L	T	P	C	Total Marks
		3	0	0	3	100

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1: Analyze the quality of fuels.

CO2: Construct the phase diagram of one component and two component systems.

CO3: Assess the quality of explosives and propellants for defence and aerospace applications

CO4: Illustrate the lubrication mechanism in lubrication technology

CO5: Discuss the constituents and functions of composite materials for various engineering applications.

CO6: Relate the basic chemistry concepts in science and technology.

COURSE SYLLABUS:

UNIT	TOPICS COVERED	DURATION
I	FUELS Introduction - Classification of fuels - Characteristics of a fuel - Determination of calorific value of a fuel by Bomb calorimeter. Coal: Classification of coals based on energy content. Chemistry and analysis of coal: Proximate analysis and ultimate analysis. Manufacture of metallurgical coke: Otto-Hoffmann's method. Cracking: Fluidized bed catalytic cracking. Knocking in compression ignition and spark ignition engines. Gaseous fuels: CNG - LPG - Producer gas. Ethanol as a fuel.	9 h
II	PHASE EQUILIBRIA Introduction: Definition of phase rule - Terms involved in phase rule with examples. One component system: Water system. Two component alloy systems: Classification - Reduced phase rule - Thermal analysis. Simple eutectic system: Lead-silver system. Congruent system: Zinc-magnesium system. Incongruent system: Sodium-potassium system.	9 h
III	EXPLOSIVES AND ROCKET PROPELLANTS Explosives: Requirements - Classification of explosives: Low explosives - Primary explosives - High explosives. Assessment of explosives: Sand bomb test - Drop height - Velocity of detonation. Rocket propellants: Types of rocket engines - Basic principle of rocket propulsion system - Specific impulse (I_{sp}) - Thrust: Momentum thrust and pressure thrust. Requirements of a good propellant. Classification of chemical propellants - Liquid fuels - Liquid oxidizers - Solid fuels - Solid oxidizers.	9 h
IV	LUBRICANTS Introduction: Requirements and functions of lubricants. Mechanism of lubrication: Hydrodynamic lubrication - Boundary lubrication - Extreme pressure lubrication. Properties of lubricants: Viscosity index - Cloud point - Pour point - Flash point - Fire point - Oiliness - Sligh oxidation test - Aniline point. Classification of lubricants: Liquid lubricants - Semisolid lubricants - Solid lubricants.	9 h
V	COMPOSITES AND ABRASIVES Introduction: Definition. Constituents of composites: Matrix phase and dispersed phase - Examples. Metal matrix composites: Al matrix; Mg matrix and Ti matrix composites. Ceramic matrix composites: SiC matrix and Alumina matrix composites. Polymer matrix composites: Fiber reinforced plastics (FRP) and its types. Application of composites. Cermets: Oxide base cermets - Carbide base cermets - Properties and applications. Abrasives: Definition - Properties: Moh's scale of Hardness. Classification: Natural and synthetic abrasives. Manufacture of abrasive paper and abrasive cloth.	9 h

TEXT / REFERENCE BOOKS

1. Jain P. C., and Monica Jain, Engineering Chemistry, 15th Edition, Dhanpat Rai Publishing Co., 2009.
2. Sheik Mideen A., Engineering Chemistry (I & II), 13th Edition, Shruthi Publishers, 2010.
3. Dara.S.S., Text Book of Engineering Chemistry, S.Chand & Co, 2009.
4. Kuriakose J. C., and Rajaram. J, Chemistry in Engineering and Technology, Vol.1 & 2, Tata McGraw Hill Publishing Company (P) Ltd., 2009.
5. Puri Br., Sharma Lr., Madhan S Pathania, Principles of Physical Chemistry, 41st Edition, Vishal Publishing Co., 2004.
6. Uppal M.M., Engineering Chemistry, 6th Edition, Khanna Publishers, 2006.
7. Agarwal O.P., Engineering Chemistry, 3rd Edition, Khanna Publishers., 2003.

SCY1104	BIO ORGANIC CHEMISTRY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the fundamentals of classification, synthesis, properties and structural elucidation of carbohydrates, amino acids and proteins.
- To know the classification and properties of lipids and enzymes.
- To have overall idea about the structure and biological aspects of steroids, hormones, vitamins and nucleic acids.

UNIT 1 CARBOHYDRATES

9 Hrs.

Introduction: Classification: Sugars and Non-sugars. Building up of the sugar series: Aldoses. Conversion of higher to lower homologue and vice versa: Ascending and descending series - Kiliani Fischer synthesis - Ruff degradation. Glucose: Physical properties - Chemical properties: Epimerization - Mutarotation. Structural elucidation of glucose: Open chain and closed chain structure. Structure and biological importance of disaccharides: Sucrose - Maltose - Lactose. Structure and biological importance of polysaccharides: Starch - Cellulose - Chitin - Heparin - Peptidoglycan.

UNIT 2 AMINOACIDS AND PROTEINS

Aminoacids: Classification - α , β , and γ aminoacid - acidic, basic and neutral amino acids - Essential and non essential amino acids. Preparation: HVZ reaction - Strecker synthesis - Gabriel Phthalimide synthesis. Physical properties: Isoelectric point. Chemical properties: Reaction of amino group - Carboxyl group and both. Proteins: Classification based on shape and solubility - Classification based on increasing complexity of structure. Structure of proteins: Primary - Secondary - Tertiary - Quaternary.

UNIT 3 LIPIDS AND ENZYMES

9 Hrs.

Lipids: Occurrence and classification of lipids - Simple lipids: Fats - Distinction between fats and oils - Occurrence - Properties: Hydrolysis - Auto oxidation - Addition reactions. Analysis of fats and oils: Saponification value and Iodine number. Compound Lipids and Derived lipids.

Enzymes: Classification and nomenclature - Enzyme Kinetics: Michaelis-Menton equation. Enzyme activity - Mechanism of enzyme action.

UNIT 4 STEROIDS, HORMONES AND VITAMINS

9 Hrs.

Steroids: Introduction - Nomenclature. Cholesterol: Constitution (excluding synthesis) and biological importance.

Hormones: Introduction - Difference between hormones and vitamins. Classification - Structure and functions of steroid hormones: Androsterone - Progesterone - Testosterone - Estrone. Adrenocortical hormones: Cortisone.

Vitamins: Structure and importance of Vitamin D - Folic acid - Nicotinamide.

UNIT 5 NUCLEIC ACIDS

9 Hrs.

Introduction: Purines and Pyrimidines - Nucleosides and Nucleotides - Nitrogenous bases - Structure of nucleic acids - DNA, RNA, m-RNA, t-RNA, r-RNA - 70s and 80s - Biological importance of nucleic acids - Sequencing of nucleic acids - Maxam-Gilbert's method and Sanger's method.

Max. 45
HOURS

TEXT / REFERENCE BOOKS

- Jain J. I., Nitin Jain, Sunjay Jain, Fundamentals of Biochemistry, 6th Edition, S. Chand and Sons, 2013.
- David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, 6th Edition, W. H. Freeman, 2013.
- Gurdeep R Chatwal, Organic Chemistry of Natural Products Vol II, 2nd Revised Edition, Himalaya Publishing House, 1986.
- Tewari K.S., Vishnoi N.K. and Mehrotra S.N., A Text Book of Organic Chemistry, 2nd Revised Edition, Vikas

- Publications, 2004.
5. Rastogi S.C., Biochemistry, 6th Reprint, Tata McGraw Hill Publishing Limited, 2007.
 6. Styer L., Biochemistry, . 4th Edition, W.H. Freeman & Co, 1995.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks : 80

Hrs.

Exam Duration : 3

PART A : 10 Questions of 2 marks each-No choice
Marks

20

PART B : 2 Questions from each unit of internal choice, each carrying 12 marks.

6

0 Marks(Out of 80 marks, maximum of 10% problems may be asked)

SCY1105	PHYSICAL CHEMISTRY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the fundamentals related to the phase diagrams and their applications.
- To know about the types and properties of solutions.
- To expose the students for various separation techniques for the purification of compounds.
- To provide an idea about the chemical kinetics in terms of order, molecularity and their derivations involved.
- To give an overview about the advanced electrochemical applications.

UNIT 1 PHASE RULE

9 Hrs.

Phase diagram - Information from phase diagram - Terminology used in phase diagram. Gibb's phase rule - Derivation. One component system: Water system. Two component alloy systems: Classification - Reduced phase rule - Thermal analysis. Simple eutectic system: Lead-silver system. Congruent System: Zinc-magnesium system. Incongruent system: Sodium-potassium system. Phase diagram of simple three component system.

UNIT 2 SOLUTIONS

9 Hrs.

Introduction: Solid solution - Hume Rothery's rule. Types of solid solutions: Liquid solutions: Solubility of partially miscible liquids - Phenol-water system. Colligative properties: Lowering of vapour pressure. Raoult's law: Derivation - Osmotic pressure - Isotonic solution - Relationship between osmotic pressure and vapour pressure. Depression in freezing point - Derivation. Elevation in boiling point - Derivation - Problems.

UNIT 3 SEPARATION TECHNIQUES

9 Hrs.

Distillation techniques: Fractional distillation - Steam distillation - Vacuum distillation. Chromatography: Elution analysis - Paper chromatography - Thin layer chromatography - Liquid chromatography - High performance liquid chromatography (HPLC) - Gas chromatography (GC).

UNIT 4 CHEMICAL KINETICS

9 Hrs.

Introduction: First and second order reactions: Integration - Integration of n^{th} order reaction. Methods of determining order and molecularity. Collision theory of bimolecular gaseous reactions - Activated complex of bimolecular reactions - Lindemann theory of unimolecular equation - Kinetics of complex reactions: Reversible reaction - Consecutive reaction - Chain reactions - Autocatalysis - Problems.

UNIT 5 ADVANCED ELECTROCHEMISTRY

9 Hrs.

Introduction: Cell constant - Equivalent conductance - Molar conductance. Ionic mobility: Transport number - Moving boundary method - Hittorff's method. Debye Huckel theory of strong electrolytes. Concentration cells: Types - Concentration cells without transference and with transference. Potentiometric titrations: Redox titration. Polarography - Applications of polarography.

Max. 45
HOURS

TEXT / REFERENCE BOOKS

1. Puri B.R., Sharma L. R., Madan. S.Pathania, Principles of Physical Chemistry, 41st Edition , Vishal Publishing co., 2004.

2. Keith J. Laidler, Chemical Kinetics, Third Edition, Pearson education limited, 2004.
3. Atkins P. W., Physical Chemistry, 6th edition, Oxford University press, 1998.
4. Barrow G. M., Physical Chemistry, 5th edition, McGraw-Hill, 1988.
5. Glasstone S., A Text book of Physical Chemistry, Macmillan Ltd, 1976.
6. Jayakumar V., Engineering Metallurgy, ARS publications, 2012.

**END SEMESTER EXAM QUESTION PAPER
PATTERN**

Max. Marks : 80

Exam Duration :

3 Hrs.

PART A : 10 Questions of 2 marks each-No choice	20
Marks	

PART B : 2 Questions from each unit of internal choice, each carrying 12 marks.	60
Marks	

(Out of 80 marks, maximum of 10% problems may be asked)

SCY 1102	Chemistry of Electronic Materials	L	T	P	C	Total Marks
		3	1	0	4	100

COURSE OBJECTIVES

- To learn about different types of charge carriers, conducting polymers and to understand their role in making molecular devices.
- To know about the instrumentation, working principle of spectroscopic methods, thermal methods and sensing devices and utilize them in various applications related to qualitative and quantitative analysis of compounds.
- To learn different thin layer deposition techniques, selection of suitable coating techniques for different substrates.
- To gain knowledge on the importance of electrical insulating and electrical resistivity materials.
- To understand the applications of line notations and softwares in designing chemical molecules.

COURSE SYLLABUS:

Unit-I	INTRODUCTION TO MOLECULAR ELECTRONICS Introduction: Charge transport carriers: Soliton - Polaron and bipolaron. Conducting polymers: Polyacetylene - Polyaniline. Applications of conducting polymers. Polymer Structures for LEDs: Polyphenylenes - Polythiophene. Photoresists for electronics. Molecular devices based on conducting polymers.	9 Hrs
Unit-II	INSTRUMENTAL METHODS OF ANALYSIS Introduction - Absorption of radiation. UV-Visible spectrophotometer: Instrumentation - Applications. IR spectrophotometer - Instrumentation - Applications. Thermal methods of analysis: Thermogravimetry (TGA) - Differential Thermal Analysis (DTA) - Differential Scanning Calorimetry (DSC). Sensors: Oxygen sensors – Glucose sensor. Cyclic Voltammetry for Redox systems.	9 Hrs
Unit-III	THIN FILM TECHNIQUES Introduction: Lithography. Thin-film deposition: Chemical vapour deposition - Physical vapour deposition: Pulsed laser and atomic layer deposition. Epitaxy: Vapour phase epitaxy - Liquid phase epitaxy - Molecular beam epitaxy. Evaporation: Thermal vaporization and e-beam evaporation. Sputtering techniques: Direct current (DC) sputtering and radio frequency (RF) sputtering. Preparation of Si/Ge semiconductors - Czochralski crystal growth technique: Doping of semiconductors by Ion implantation.	9 Hrs
Unit-IV	INSULATING MATERIALS Electrical Insulating Materials: Introduction - Requirements. Classification based on substances: Gaseous, liquid and solid insulating materials. Preparation, properties and applications of SF ₆ , Epoxy resin, ceramic products: white wares and glass - Transformer oil. Electrical resistivity: Factors influencing electrical resistivity of materials - Composition, properties and applications of high resistivity materials: Manganin - Constantan - Molybdenum disilicide - Nichrome.	9 Hrs
Unit-V	CHEMINFORMATICS Introduction: Computer representation of chemical compounds: Line notations - Wiswesser line notation – ROSDAL notation - SMILES coding - Advantages and disadvantages of different types of notations. Standard structure exchange formats: Structure of Mol files and SD files. Chemical structure drawing softwares. Molecule	9 Hrs

editors: CACTVS molecule editor - Chemdraw - ChemSketch - Chemwindow.
Searching chemical structure: Similarity search.

COURSE OUTCOMES

On successful completion of the course, student will be able to

CO1: Demonstrate the role of charge transport carriers for the functioning of molecular devices.

CO2: Apply the different spectroscopic techniques for sample detection and monitoring.

CO3: Assess the different thin film techniques for the development of nanomaterials.

CO4: Illustrate the insulating and resistivity properties of insulating materials.

CO5: Interpret the molecules using line notations and softwares.

CO6: Evaluate the materials for real world applications.

Max. 45 Hours

TEXT / REFERENCE BOOKS

1. Ziaie B., "Introduction to Micro/Nanofabrication", Springer, 2010.
2. Andrew Leach, "An Introduction to Cheminformatics", Springer, 2009.
3. Johann Gasteiger and Thomas Engel (Ed.), "Cheminformatics: A Textbook", Wiley-VCH, 2003.
4. Hagen Klauk, "Organic Electronics: Materials, Manufacturing and Applications", Wiley, 2006.
5. Dara S.S., "Text Book of Engineering Chemistry", S. Chand & Co, 2008.
6. Sheik Mideen A., "Engineering Chemistry (I & II)", 13th Edition, Shruthi Publishers, 2010.
7. Douglas A. Skoog and Donald M. West, "Principles of Instrumental Analysis", 6th Edition, Cengage Learning, 2006.

END SEMESTER EXAM QUESTION PAPER PATTERN

Max. Marks: 100

Exam Duration: 3 Hrs.

PART A: 2 Questions from each unit, each carrying 2 marks -No choice

PART B: 2 Questions from each unit of internal choice, each carrying 16 marks.

(Out of 100 marks, maximum of 10% problems may be asked)