JAI HIND COLLEGE
BASANTSING INSTITUTE OF SCIENCE
&
J.T.LALVANI COLLEGE OF COMMERCE
(AUTONOMOUS)

"A" Road, Churchgate, Mumbai - 400 020, India.

Affiliated to
University of Mumbai

Program : B.Sc.

Proposed Course : Chemistry

Semester V

Credit Based Semester and Grading System (CBCS) with effect from the Academic year 2020-21

Semester V			
Course Code	**Course Title**	**Credits**	**Lectures /Week**
SCHE501	Advanced Physical Chemistry-I	4	4
SCHE502	Advanced Inorganic Chemistry-I	4	4
SCHE503	Advanced Organic Chemistry-I	4	4
SCHE504	Advanced Analytical Chemistry-I	4	4
SCHE5PR1	Practical Coursework in Physical and Inorganic Chemistry-I	4	8
SCHE5PR2	Practical Coursework in Organic and Analytical Chemistry-I	4	8
SCHE5AC	Pharmaceutical Chemistry, Dyes, Paints & Pigments-I	2.5	4
SCHE5ACPR	Practical Coursework in Pharmaceutical Chemistry, Dyes, Paints & Pigments-I	2.5	4

Semester V – Theory

Course: SCHE501	**Advanced Physical Chemistry - I (Credits: 4 Lectures/Week: 4)** **Course description:** **Molecular Spectroscopy, Thermodynamics, Kinetics, Nuclear Chemistry and Surface Chemistry**	
	Objectives: ➢ To understand the theoretical concept of molecular spectroscopy ➢ To differentiate between different types of molecular spectroscopy ➢ To explain the various colligative properties of solutions and to determine molecular weight using this property ➢ To engage the learner in the principles and properties of thermodynamics and kinetics ➢ To introduce and explain the theory and applications of nuclear chemistry ➢ To understand the principle of adsorption and to determine the surface area of an adsorbate	
	Learning Outcomes: ➢ Learner has a grip over the theoretical principles underlying spectroscopic techniques for applications in structure elucidation. ➢ Learner is able to design experiments which measure changes in colligative properties for determination of molecular weight of analyte. ➢ Learner is capable of applying the concepts of adsorption for determination of surface area of porous adsorbate material. ➢ Learner is able to correlate the importance of kinetics and thermodynamics in a chemical reaction and hence to any industrial process.	
Unit I	**Molecular Spectroscopy:**	**15L**
	a. Dipole moment i) Introduction to dipole moment ii) Polarization of a bond, bond moment iii) Dipole moment and molecular structure	**(1L)**
	b. Rotational Spectroscopy i) Conditions for obtaining rotational spectrum of a diatomic molecule ii) Rigid rotor, moment of inertia iii) Energy levels iv) Selection rule, nature of spectrum v) Determination of internuclear distance and isotopic shift	**(4L)**
	c. Vibration Spectroscopy i) Vibrational motion, degrees of freedom ii) Modes of vibration iii) Vibrational spectrum of a diatomic molecule iv) Simple harmonic oscillator v) Energy levels vi) Zero-point energy vii) Conditions for obtaining vibrational spectrum viii) Selection rules & nature of spectrum	**(3L)**

	d. Vibrational-Rotational spectrum of diatomic molecule i) Energy levels ii) Anharmonic oscillator iii) Selection rule iv) Nature of spectrum, P and R branch lines, fundamental band, overtones v) Application of vibrational-rotational spectrum in: 1. Determination of force constant and its significance 2. IR spectra of simple molecules - H_2O and CO_2	**(4L)**
	e. Raman Spectroscopy i) Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering ii) Nature of Raman spectrum, Stokes' lines, anti-Stokes' lines iii) Raman shift iv) Quantum theory of Raman spectrum v) Comparative study of IR and Raman spectra, rule of mutual exclusion- CO_2 molecule	**(3L)**
Unit II	**Chemical Thermodynamics and Chemical Kinetics**	**15L**
	1. Chemical Thermodynamics	**8L**
	a. Colligative properties Recapitulation i) Concept of vapour pressure and relative lowering of vapour pressure ii) Measurement of lowering of vapour pressure - Static and Dynamic method	**(2L)**
	b. Solutions of Solid in Liquid i) Elevation in boiling point of a solution- Thermodynamic derivation of correlation between elevation in boiling point of a solution and the molar mass of a non-volatile solute ii) Depression in freezing point of a solution- Thermodynamic derivation of correlation between the depression in freezing point of a solution and the molar mass of a non-volatile solute Beckmann Method and Rast Method	**(4L)**
	c. Osmotic Pressure i. Introduction ii. Thermodynamic derivation of van't Hoff equation, van't Hoff factor iii. Measurement of Osmotic Pressure - Berkeley and Hartley's Method iv. Reverse Osmosis (Numericals expected on all above topics)	**(2L)**

	2. Chemical Kinetics	**7L**
	a. Methods of determination of rate laws Recapitulation-Effect of temperature on rate of a reaction, temperature coefficient, Arrhenius equation, energy of activation and its experimental determination (numericals expected)	**(1L)**
	b. Experimental methods of studying chemical kinetics i) Conductometric ii) Potentiometric iii) Optical methods iv) Polarimetry v) Spectrophotometric methods	**(1L)**
	c. Theories of reaction rates i) Collision theory of reaction rates, application of collision theory to 1) Biomolecular reaction and 2) Unimolecular reaction, Lindemann theory (derivation expected), merits and drawbacks of collision theory. ii) Activated complex theory of bimolecular reactions, expression for rate constant of bimolecular reactions (derivation not expected), comparison of collision theory and activated complex theory	**(3L)**
	d. Classification of reactions i) Slow, fast and ultra –fast ii) Study of kinetics of fast reactions by Relaxation method (Derivation expected), Stop flow method, pulse method and Flash photolysis	**(2L)**
Unit III	**Nuclear Chemistry**	**15L**
	a. Detection and Measurement of Radioactivity i. Types and characteristics of nuclear radiations ii. Behaviour of ion pairs in an electric field iii. Detection and measurement of nuclear radiations using G.M. Counter and Scintillation Counter	**(3L)**
	b. Radioactive Equilibrium i. Secular and transient ii. Determination of radioactive constants for radio-elements having: I. Moderate half-life II. Long half-life III. Extremely long or short half-life (Numerical expected)	**(3L)**
	c. Application of use of radioisotopes as Tracers i. Chemical reaction mechanism ii. . Age determination – carbon dating	**(2L)**

	d. Nuclear reactions i. Nuclear transmutation ii. Artificial radioactivity iii. Q - value of nuclear reaction, threshold energy (Numerical expected) **e. Fission Process** i) Fissile and fertile material ii) Nuclear fission, chain reaction iii) Factors controlling fission process iv) Multiplication factor and critical size or mass of fissionable material v) Nuclear power reactor and breeder reactor **f. Fusion Process:** Thermonuclear reactions occurring on stellar bodies and earth	**(3L)** **(3L)** **(1L)**
Unit IV	**Surface Chemistry**	**15L**
	1. Adsorption	**8L**
	a) Introduction to adsorption i. Adsorbate and adsorbent ii. Physical and Chemical Adsorption iii. Adsorption isotherm and its types **b)** Langmuir's adsorption isotherm (Postulates and derivation expected) **c)** B.E.T. equation for multilayer adsorption (derivation not expected) Significance of the terms involved in equation Determination of surface area of an adsorbent using B.E.T. equation. (Numerical expected on surface area) **d) Selectivity of an Adsorbent:** Equilibrium effect, Kinetic effect, Molecular sieving effect, Desorption effect. **e) Types of Adsorbents:** **i) Conventional Adsorbents:** a) Activated carbon b) Carbon molecular sieves (CMS) c) Carbonized polymers and Resins d) Bone charcoal e) Polymeric Adsorbents f) Silica gel g) Activated alumina h) Clay minerals i) Zeolites **ii) Non-conventional adsorbents:** a) Adsorbent from industrial wastes b) Adsorbent from coal c) Adsorbent from agricultural wastes and agricultural by-products d) Peat e) Oxides and related materials as adsorbents f) River sediments as adsorbent g) Adsorbent from bio-resources h) Adsorbent made from biopolymers such as chitosan i) Adsorbents from	**(1L)** **(2L)** **(2L)** **(1L)** **(2L)**

	various other materials iii) **Application of adsorption:** Solar energy conversion, storage and catalysis. Nanoelectronics, nanosensors, nanomedicine, nanobiotechnology, computational nanotechnology, Nanomagnetism, Carbon Nanotubes, Nanodevices, Spintronics, self-cleaning nanoparticles. iv) **Use of nanomaterial's in adsorption**	
	2. Colloidal State	**7L**
	a. Introduction to colloids & its properties **i.** Classification of colloids - lyophilic and lyophobic colloids Micromolecular, macromolecular and associated colloids. Emulsions, Gels and Sols. **ii. Optical Properties –** Tyndall effect **iii. Colligative properties** **iv. Mechanical properties –** Brownian movement **b. Electrical Properties** **i.** Origin of charges on colloidal particles **ii.** Concept of electrical double layer, zeta potential **iii.** Helmholtz and Stern's model **c. Electro-kinetic phenomena** **i.** Electrophoresis **ii.** Electro-osmosis **iii.** Streaming potential **iv.** Sedimentation potential: Donnan Membrane Equilibrium **d. Stability of colloids & colloidal electrolytes** **i.** Isoelectric point, **ii.** Hardy Protective colloids, **iii.** Hardy-Schulz Rule and Gold number **iv. Colloidal electrolytes -** Introduction, micelle formation **e. Surfactants-** Classification– anionic, cationic, non-ionic and amphoteric, Critical Micelle Concentration, factors affecting CMC, application of surfactants in detergents, food industry, pesticide formulation	**(1L)** **(1L)** **(2L)** **(2L)** **(1L)**

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15. Gowariker, V.R.; Viswanathan, N.V.; Sreedhar, Jayadev; *Polymer Science*, New Age International (P) Ltd., Publishers, 2005.
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Course: SCHE502	**Advanced Inorganic Chemistry - I (Credits: 4 Lectures/Week: 4)** **Course description:** **Chemical bonding, Solid State materials, Chemistry of f-block elements, Solution chemistry**	
	Objectives: ➢ To apply various symmetry operations and to recognize the optical activity phenomenon through them ➢ To understand about solid state synthesis and the properties of some important solid state materials such as high temperature superconductors ➢ To understand the basic trend of f-block elements along with its extraction and uses ➢ To understand the various types of solvents and their properties	
	Learning Outcomes: ➢ Learner can correlate the symmetry to the spectroscopic signatures of the molecule. ➢ Learner is exposed to a large number of inorganic materials which find application in electronics & is also equipped with the knowledge of industrial process underlying their synthesis. ➢ Learner is able to predict properties of rare earth elements, their significance and applications. ➢ Learner is exposed to non-aqueous chemistry and their advantages over use of water as solvent.	
Unit I	**Unit – I: Chemical Bonding:** **a) Molecular Symmetry** i . Introduction and Importance ii. Symmetry elements and symmetry operations iii. Concept of a Point Group and illustrations using the following point groups: Cαv (HCl), Dαh (H_2), C_2v (H_2O), C_3v (NH_3), C_2h (trans – trichloroethylene), D_3h (BCl_3) **b) Molecular Orbital Theory for Polyatomic Species** i. Simple triatomic species: H_3^+ and H_3 (correlation between bond angle and Molecular orbitals) ii. Introduction to the following terms: Walsh correlation diagram, Symmetry Adapted Linear Combinations (SALCs), Ligand Group orbitals (LGOs) iii. Transformation of atomic orbitals into appropriate symmetry types	**15L** **(7L)** **(8L)**

	iv. Examples of other molecules (consider only σ -bonding): BeH_2, H_2O	
Unit II	**Unit – II: Solid State materials** **a). Structures of Solid State Materials** i. Importance of solid state chemistry ii. Explanation of terms: Crystal lattice, Lattice points, Unit cells & Lattice constants iii. Classification of solids on the basis of bonding iv. Close packing of rigid spheres (HCP, CCP) packing density in simple cubic, BCC, FCC and HCP lattices, Relationship between density of unit cell, lattice parameters. v. Point defects with respect to Frenkel and Schottky defects (Numerical problems expected) vi. Tetrahedral and octahedral interstitial voids in CCP lattice, tetrahedral holes, limiting radius ratios for different coordination numbers and their significance, calculation of limiting radius ratio for coordination number 4. **b. Superconductivity** i. Superconductivity, Meissner effect ii. Different superconducting materials: conventional superconductors, organic superconductors, alkali metal fullerides (A_3C_{60}) and high temperature Superconductors iii. Applications of superconducting materials **c. Metallic Bonding** i. Band theory ii. Explanation of electrical properties of conductors, insulators and semiconductors (n and p-types) on the basis of band theory	**15L** **(9L)** **(3L)** **(3L)**
Unit III	**Unit III: Chemistry of elements** **a. Inner transition elements** i. Introduction ii. Shapes of f-orbitals	**15L** **(1L)**

	iii. Position of f-block elements iv. Comparison between lanthanides and actinides **b. Lanthanide Series** i. Chemistry of lanthanides with reference to: lanthanide contraction, oxidation states, magnetic and spectral properties ii. Occurrence, extraction and separation of lanthanides by ion exchange & solvent extraction method iii. Applications of lanthanides **c. Actinide Series** i. Chemistry of Uranium: occurrence, extraction (solvent extraction method) ii. Properties and applications	**(11L)** **(3L)**
Unit IV	**Unit IV: Solution chemistry** **a. Chemistry of Non- Aqueous Solvents** i. Introduction ii. Classification of solvents and importance of non -aqueous solvents iii. Physical and Chemical properties iv. Characteristics and study of liquid ammonia, dinitrogen-tetraoxide and acetic acid as non -aqueous solvents with respect to a. acid -base reactions and b. redox reactions c. Solvolysis d. Complex formation reactions	**15L**

References:

1. Robert L.Carter, *Molecular Symmetry and Group Theory* John Wiley and Sons(reprint 2012)
2. K. Veera Reddy, *Symmetry and Spectroscopy of Molecules,* New Age International Publishers 2nd Edition (2009)
3. P.K.Bhattacharya, *Group Theory and its Chemical Applications,* Himalaya Publishing House, 2nd Edition (Reprint 2014)
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Course: SCHE5PR1	**Practical Course work in Physical and Inorganic Chemistry – I** **(Credits: 4; Practicals/Week: 2)**

Objectives:

- To learn the method of determination of rate constant conductometrically
- To apply the theoretical knowledge of electrochemical cells in determination of k_{sp}
- To understand experimental determination of isoelectric point using pH metry
- To understand the shape and geometry of various complexes having different ligands attached to it
- To understand the set up of glassware and apparatus to conduct volumetric experiments in inorganic Chemistry
- To understand the use of various indicators for specific metal ions in titration

Learning Outcomes:

- Thorough understanding of the practical determination of reaction rates
- Hands on experience on the practical evaluation methods of adsorption phenomenon
- Development of practical knowledge for the determination of various physical parameters/constants by selection of appropriate electrometric method
- Learners will be able to describe the oxidation number of the central metal ion, shapes and structures of coordination complexes prepared with coordination numbers ranging from 4 to 12
- Learners will have the requisite technical skills to prepare a complex and drying it at an appropriate temperature and pressure
- Learners will have an understanding of role of different indicators specific for metal ions operating at different pH values

PHYSICAL CHEMISTRY PRACTICAL

Non- Instrumental Experiments

1) **Chemical Kinetics**
   i) To determine energy of activation for acid catalyzed hydrolysis of methyl acetate.
2) **Surface phenomena**
   ii) To investigate the adsorption of acetic acid on activated charcoal and to test the validity of Freundlich adsorption isotherm

Instrumental Experiments

3) **Potentiometry**
   iii) To determine amount of acetic acid and trichloro acetic acid in given solution potentiometrically.

4) Conductometry

iv) To determine the basicity of citric acid conductometrically.

5) pH-metry

v) To determine the acidic and basic dissociation constants of amino acids and hence to calculate the isoelectric point

6) Colorimetry

vi) To determine rate of reaction for bleaching of crystal violet using sodium hydroxide.

INORGANIC CHEMISTRY PRACTICAL

A. Preparations

i. Potassium diaquo bis- (oxalato) cuprate (II) $K_2[Cu(C_2O_4)_2].H_2O$
ii. Dichloro bis(dimethylsulfoxide-O)copper (II) $[CuCl_2(DMSO)_2]$
iii. Bis(ethylenediamine)iron (II) sulphate $[(C_2H_4N_2H_4)_2Fe]SO_4.4H_2O$
iv. Bis(acetylacetanato)copper (II). $[(C_5H_7O_2)_2Cu]$ or $[Cu(acac)_2]$

B. Volumetric analysis

i. Determination of magnesium from the supplied commercial sample of Milk of Magnesia tablet
ii. Estimation of Nickel (II) complexometrically using Murexide indicator (Students are expected to standardize the supplied EDTA solution using $ZnSO_4.7H_2O$)**.**
iii. Estimation of Cu by iodometric titration

Semester V – Theory

Course: SCHE503	**Advanced Organic Chemistry - I (Credits: 4 Lectures/Week: 4)** **Course description:** **Nomenclature and Stereochemistry of Organic compounds, Mechanism of Organic reactions, Photochemistry, Pericyclic reactions and Organometallic Chemistry**	
	Objectives: ➢ To understand the mechanism of varied organic reactions ➢ To visualize the stereochemical features of organic compounds ➢ To name the organic compounds on the basis of IUPAC rules ➢ To write the reactions of organometallic compounds of Magnesium, Lithium, Copper & Zinc ➢ To explain the concept of photochemical reactions ➢ To understand the types of pericyclic reactions & their applications. ➢ To study the chemistry of heterocyclic compounds ➢ To study the art of organic synthesis and the considerations thereof	
	Learning Outcomes: ➢ Learner is capable of predicting the outcome (stereochemistry, regioselectivity) of a chemical reaction of a structure based on the mechanistic pathway followed ➢ Learner is able to interpret the strain in molecules with respect to characteristic stereochemical attributes of a system ➢ Learner is able to apply the reactions involving metals in organic synthesis of commercially important products ➢ Learner is able to correlate the structures of biomolecules & drugs to characteristic heterocyclic compounds & after learning their chemistry, can design experiments for synthesis of biologically active compounds ➢ Learner is able to design an organic reaction based on yields, selectivity and green & sustainable chemistry considerations	
Unit I	**Unit – I: Mechanism of Organic Reactions** **a. Elimination reactions: mechanism & stereochemistry** i. E_1 ii. E_2 iii. Elimination vs substitution: Factors affecting E_1 & E_2; Nature of substrate, Leaving group, Structure of base, Solvent iv. Saytzeff & Hofmann elimination v. E_{1CB} vi. Pyrolytic elimination: Cope, Chugaev, Pyrolysis of acetates **b. Reaction of carbonyl groups with nucleophiles (mechanism expected)** i. Oxygen containing nucleophiles ii. Nitrogen containing nucleophiles	**15L** **(5L)** **(4L)**

	c. Rearrangement reactions i. Migration to electron deficient carbon: Pinacol-pinacolone, Benzil-benzillic acid ii. Migration to electron deficient nitrogen: Hofmann, Beckmann iii. Migration involving carbanion: Favorskii **d. Name reactions** i. Michael reaction ii. Wittig reaction	**(4L)** **(2L)**
Unit II	**Unit – II: Stereochemistry of Organic Compounds I** **1. Symmetry Elements, Symmetry Operations & Molecular chirality** **a. Symmetry elements** i. Point (inversion point of symmetry) ii. Line (proper, improper axis of symmetry) iii. Plane (plane of symmetry- vertical, horizonal & dihedral) **b. Symmetry operations** i. Rotation ii. Reflection iii. Inversion iv. Rotation-reflection **c. Asymmetry versus dissymmetry (with respect to tartaric acid-meso and the optically active isomers)** **d. Molecular chirality of:** i. Cumulenes ii. Biphenyls iii. Introduction to Spirans **2. Cycloalkanes: conformations & configurations** **a. Strains in cycloalkanes (recapitulation) & principle strains in small, normal & medium ring compounds** **a.** Baeyer's strain	**15L** **(2L)** **(2L)** **(1L)** **(2L)** **(1L)**

	ii. Pitzer strain iii. Transannular strain iv. Van der Waals strain **b. Configurations & stereoisomerism in substituted small ring cycloalkanes (3 and 4-membered)** **c. Conformations of cycloalkanes** i. Conformational analysis of cyclobutane (planar versus puckered conformation) ii. Conformational analysis of cyclopentane (planar conformation versus envelope conformation) iii. Conformational analysis of cyclohexane: Relative stabilities of conformations of mono & di- substituted cyclohexane	**(1L)** **(6L)**
Unit III	**Unit III: Nomenclature, Organometallic Chemistry, Photochemistry & Pericyclic reactions** **1. IUPAC Nomenclature** **a. Bicyclic compounds** i. Biphenyls ii. Spiro iii. Fused & Bridged ring **b. Cumulenes** **2. Organometallic Chemistry** **a. Introduction:** Carbon-metal bond: Nature, types, reactivity. **b. Organomagnesium compounds:** Grignard reagent: Preparation, structure & stability. Reaction with compounds containing acidic hydrogen, carbonyl compounds, CO_2, cyanides and epoxides. **c. Organolithium compounds:** Preparation using alkyl/aryl halides; Reactions with compounds containing acidic hydrogen, alkyl halides, carbonyl compounds, CO_2, cyanides & epoxides. **d. Organocopper compounds:** Lithium dialkylcuprates- Preparation, Reactions with aliphatic, aromatic, vinylic halides **e. Organozinc compounds:** Reformatsky reaction, Simmon-Smith reaction with mechanism & applications **3. Photochemistry** **a. Introduction:** i. Difference between thermal & photochemical reactions ii. Jablonski diagram iii. Singlet & Triplet states	**15L** **(3L)** **(5L)** **(4L)**

	iv. Allowed & forbidden transitions v. Photosensitization **b. Photochemical reactions:** i. Photoisomerisation of olefins ii. Di-π methane rearrangement iii. Norrish Type I & Type II iv. Photoreduction of benzophenone to benzpinacol **4. Pericyclic Reactions** **a.** Introduction to pericyclic reactions: Definition & characteristics **b.** Types of pericyclic reactions with examples: i. Electrocyclisation ii. Cycloaddition iii. Sigmatropic rearrangement	**(3L)**
Unit IV	**Unit IV: Synthetic Organic Chemistry, Green Chemistry & Heterocyclic chemistry I** **1. Logic of Chemical Synthesis** **a.** Concept of yield- stepwise & overall **b.** Selectivity- chemo-, regio-, stereo- (enantio- &diastereo-) **c.** Types of synthesis- linear, convergent & multicomponent with examples **d.** Introduction to retrosynthesis i. Terms- Target molecule (TM), retrosynthetic analysis, FGA, FGI, Disconnection, synthon & reagent ii. Retrosynthetic analysis of simple alcohols, carbonyls, alicyclic & aromatic compounds **e.** Protecting groups in organic synthesis: i. Alcohols ii. Amines iii. Carboxylic acid **2. Green Chemistry** **a.** Introduction, definition, need & importance **b.** Principles of Green Chemistry **c.** Atom economy, E-factor; calculation & significance **3. Heterocyclic Chemistry- I (7 lectures)** **a. Nomenclature:** Hantzsch-Widman nomenclature of heterocyclic compounds **b. Introduction:** Electronic structure and aromaticity of furan, pyrrole, thiophene & pyridine. **c. Preparation:** Paal-Knorr synthesis of furans, pyrroles and thiophenes & Hantzsch synthesis of pyridine **d. Reactivity:** i. Pyrrole, Furan & Thiophene towards ESR ii. Pyridine towards ESR & NSR	**15L** **(6L)** **(2L)** **(7L)**

	e. Basicity of nitrogen heterocycles **f. Reactions:** i. 5- membered heterocycles: Halogenation, nitration, sulfonation, Vilsmeier Haack reaction, Friedel crafts reaction; unusual reactions of furan: Diels Alder, ring opening reactions ii. Pyridine: Sulfonation; reduction; Chichibabin reaction.	

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Course: SCHE504	**Advanced Analytical Chemistry - I (Credits: 4 Lectures/Week: 4)** **<u>Course description:</u> Sampling and Treatment of Analytical Data, Methods of separation-I, Optical methods and titrimetric analysis**	
	Objectives: ➢ To provide a basic knowledge and understanding of core principles of analytical chemistry ➢ To introduce basic analytical techniques and practical aspects of classical chemical analysis ➢ To introduce stake holders to various modern instrumental methods of analysis and separation techniques ➢ To introduce different methods of sampling before the actual analysis of sample by different Analytical techniques. ➢ To understand various methods of volumetric analysis and principle behind each method. ➢ To make learners aware about the applicability of analytical chemistry in various fields	
	Learning Outcomes: ➢ Learner is equipped with the knowledge of different classes of chemical analysis and is capable of making a choice of a method based on various practical aspects of analysis. ➢ Understanding of the sampling techniques according to matrix variations and introduction to statistical treatment of data. ➢ Learner is capable of correlating the number of extractions with extraction efficiency and is able to put it to practice in experiment. ➢ Learner is able to design experiments for analysis based on specific interactions of analyte. ➢ Learner is able to extrapolate the knowledge of chemical analysis to industry and to research.	
Unit-I	**Sampling and Treatment of Analytical Data**	**15L**
	1. Sampling	**6L**
	a) Introduction to sampling: Terms involved, importance of sampling, sampling techniques **b) Sampling of gases:** i. Ambient and stack sampling ii. Equipment used **c) Sampling of liquids** i. Homogeneous and heterogeneous liquids ii. Sampling of static and flowing liquids **d) Sampling of solids** i. Methods and equipment used ii. Sampling of solids iii. Importance of particle size and sample size iv. Samples used, need for the reduction in the sample size v. Methods of reduction in sample size	

	vi. Collection, preservation and dissolution of the sample	
	2. Treatment of Analytical Data:	**9L**
	a) Error-Types of errors i) Absolute and relative error. ii) Constant and proportionate errors iii) Determinate and indeterminate errors-Types of determinate errors, their classification on the basis of source and different method of its minimization**.** **b) Accuracy and precision** **c) Methods of measurement of error-** **d) Measures of dispersion central tendency:** mean, median, average deviation, relative average deviation, standard deviation, variance, coefficient of variation **e) Gaussian distribution curve**, distribution of random errors. student's 't', confidence limits and confidence interval, criteria for rejection of results-2.5d rule and 4d rules and Q-test, F test, chi-square method, testing of significance, null hypothesis, methods of averages and least square method**.** **(Numerical problems expected)**	
Unit II	**Methods of Separation – I**	**15L**
	1. Solvent Extraction	**6L**
	a) Recapitulation b) Factors affecting extraction: Chelation, Ion pair formation and Solvation c) Effect of pH on percent extraction i) Graph of percentage extraction versus pH ii) Concept of [pH] and its significance (derivation not expected) d) Craig's counter current extraction: Principle, apparatus and applications e) Synergistic solvent extraction- principle, factors affecting f) Solvent extraction with crown ethers: Introduction g) Solid phase extraction: Principle, method and applications with special reference to water and industrial effluent analysis h) Comparison of solid phase extraction and solvent extraction	
	2. High Performance Liquid chromatography (HPLC) and High Performance Thin Layer Chromatography (HPTLC)	**9L**
	(I) High Performance Liquid chromatography (HPLC)	**(5L)**
	a) Introduction and Principle b) Instrumentation- Solvent Reservoir, Degassing system, Pumps-(reciprocating pumps, screw driven-syringe type pumps, pneumatic pumps, advantages and disadvantages of each pump), Pre column, Sample injection system, HPLC Columns, Detectors (UV – Visible detector, Refractive index detector) c) Applications of HPLC: d) Qualitative and Quantitative applications e) Introduction and Principle	

	f) Instrumentation- Solvent Reservoir, Degassing system, Pumps- (reciprocating pumps, screw driven-syringe type pumps, pneumatic pumps, advantages and disadvantages of each pump), Pre column, Sample injection system, HPLC Columns, Detectors (UV – Visible detector, Refractive index detector) g) Applications of HPLC: h) Qualitative and Quantitative applications	
	(II) High Performance Thin Layer Chromatography (HPTLC):	
	a. Introduction and Principle b. Stationary phase, Sample application and mobile phase c. Detectors d. Scanning densitometer- Components e. Types of densitometer- Single beam and Double beam. f. Fluorometric Detector g. Advantages, disadvantages and applications of HPTLC h. Comparison between TLC and HPTLC i. Optical Methods	
Unit III:	**Optical Methods**	**15L**
	1. Atomic Spectroscopy: Flame Emission spectroscopy (FES) and Atomic Absorption Spectroscopy (AAS)	**8L**
	a) Introduction, Energy level diagrams, Atomic spectra, Absorption and Emission Spectra b) Flame Photometry – i) Principle ii) Instrumentation (Flame atomizers, types of Burners, Wavelength selectors, Detectors) c) Atomic Absorption Spectroscopy – Principle, Instrumentation (Source, Chopper, Flame and Electrothermal Atomiser) d) Quantification methods of FES and AAS – i) Calibration curve method ii) Standard addition method iii) Internal standard method e) Comparison of FES and AAS f) Applications, Advantages and Limitations	
	2. Molecular Fluorescence and Phosphorescence Spectroscopy	**4L**
	a) Introduction, Principle, Jablonski diagram of energy levels b) Relationship between Fluorescence intensity and concentration c) Factors affecting Fluorescence and Phosphorescence d) Instrumentation and applications e) Comparison of Fluorimetry and Phosphorimetry f) Comparison of fluorescence with Absorption methods	

	3. Turbidimetry and Nephelometry:	**3L**
	a) Introduction and Principle b) Factors affecting scattering of Radiation: Concentration, particle size, wavelength, refractive index c) Instrumentation and Applications	
Unit IV	**Titrimetric Analysis**	**15L**
	1. Redox titrations	**5L**
	a) Introduction b) Construction of the titration curves and calculation of E_{system}^{*} in case of: i) Fe (II) v/s. Ce (IV) ii) Fe (II) v/s $KMnO_4$ iii)Fe (II) v/s $K_2Cr_2O_7$ c) Theory of redox indicators d) Criteria for selection of an indicator e) Use of diphenyl amine and ferroin as redox indicators f) Use of Iodine as redox reagent. (Iodometry and Iodimetry) (Numerical expected)	
	2. Complexometric Titrations a) Introduction b) Construction of titration curve c) Use of EDTA as titrant and its standardization d) Absolute and conditional formation constants of metal EDTA complexes e) Selectivity of EDTA as a titrant f) Factors enhancing selectivity with examples g) Advantages and limitations of EDTA as a titrant h) Types of EDTA titrations i) Metallochromic indicators- theory, examples and applications	**6L**
	3. Precipitation Titrations a) Introduction, Argentometric titrations, Construction of titration curves. b) Methods of detecting end point: i) Volhard's method ii) Mohr's method iii) Use of Adsorption indicators	**4L**

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2. Chatwal, Gurdeep R.; *Analytical Chromatography*, Himalaya publication
3. Skoog, Holler, Nieman; *Principles of Instrumental Analysis*, 5th Edition
4. Skoog, West, Holler, *Principles of Analytical Chemistry*, 7th Edition

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1. Crosby, Neil T., Patel, Indu, General Principles of Good Sampling Practice, Royal Society of Chemistry.

Harvey, David, Modern Analytical Chemistry, McGraw-Hill Higher Education, 1999.

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1. Khopkar, S. M.; *Basic Concepts of Analytical Chemistry,* New Age International Pvt Limited
2. Dean, J A, Reinhold, Van Nostrand; *Chemical methods of separation*, 1969.
3. Sethi, P.D.; *High Performance Thin Layer Chromatography*, CBS Publisher and Distribution
4. Kumar, Prem; *High Performance Thin Layer Chromatography in Food analysis,* CBS Publisher and distributer
5. Mahajan, Supriya S.; *Instrumental methods of Analysis*, Popular Prakashan Ltd
6. Sharma, B. K.; *Instrumental Methods of Chemical Analysis,* Goel Publishing House.

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1. Dean, Willard Merritt*; Instrumental methods Of Analysis,* 7th Edition, CBS Publisher and Distributors Pvt Ltd

Unit-IV

1. Jeffery, G. H.; Bassett, J.; Memdham, J., Denney, R C; *Vogel's Textbook of Quantitative Chemical Analysis,* 6th Edn, ELBS with Longmann (2009)
2. Skoog, West & Holler, *Fundamentals of Analytical Chemistry*, 8th Edition (2003)
3.

Semester V– Practical

Course: SCHE5PR2	**Practical Course work in Organic and Analytical Chemistry - I (Credits: 4 Practicals/Week: 2)**

Objectives:

- To identify the nature of the components of a binary mixture
- To separate the components of a binary mixture by chemical/physical method
- To purify the components of binary mixture by recrystallization/distillation
- To identify a component of a binary mixture
- To provide practical knowledge and hands-on training of analytical chemistry and instrumentation
- To inculcate an aptitude for experimentation and treatment of data in the learner.
- To provide knowledge on preparation of analytical reagents, solutions and their molar calculations
- To understand applications of analytical chemistry in various fields.

Learning Outcomes:

- Learner will be able to adjudge the method of separation (physical or chemical) for a given mixture of organic compounds
- Learner will gain skill at quantitative separation of organic compounds in a mixture
- Learner will be able to ascertain the extent of separation based on weights of isolated compounds, physical constants & identification.
- Learner will be equipped with standard operating procedure of basic analytical instruments
- Learner will gain the knowledge of preparation of primary standard solutions
- Learner will be acquainted with the assay of commercial samples

ORGANIC CHEMISTRY PRACTICAL

1. **Binary Mixture: Solid-Liquid Binary Mixture & Liquid-Liquid Binary Mixture**

   a. To identify the type of the binary mixture
   b. To separate the components by physical method
   c. To identify one component of the binary mixture
   d. To purify the other component of the binary mixture

	ANALYTICAL CHEMISTRY PRACTICAL **Instrumental Experiments** 1. To determine amount of Fe (II) present in given sample by titrating **against** potassium dichromate potentiometrically 2. To determine potassium content of a Fertilizer by Flame Photometry (Calibration curve method) **Non-Instrumental Experiments** 1 To determine calcium content in market samples of calcium tablets. 2. Estimation of Copper by solvent extraction methods 3. To determine the amount of persulphate in the given sample solution by back titration with standard Fe (II) ammonium sulphate solution. 4. To determine percentage of chloride present in the given sample. (Volhard's method) 5. Iodometric determination of available chlorine in a sample of bleaching powder.

Course: SCHE5AC	**Pharmaceutical Chemistry, Dyes, Paints & Pigments -I (Credits: 2.5 Lectures/Week: 4)** **Course description:** **Pharmacokinetics, Pharmacodynamics & Drug Development, and Nomenclature & Classification of Dyes & Optical brighteners; Fibres; Colour & chemical constitution; Unit Processes & Dye Intermediates**	
	Objectives: ➢ To acquaint the learner with different terms associated with medicinal chemistry, and their significance ➢ To understand the pharmacokinetics and pharmacodynamics of a given drug molecule ➢ To recollect various pharmacodynamic agents used for varied systemic disorders ➢ To reproduce the classification and nomenclature of dyes and optical brightners ➢ To analyse the colour of a dye/pigment based on the different theories of colour and constitution ➢ To write the synthesis of a given drug/dye	
	Learning Outcomes: ➢ Learner is able to associate with basic terms involved in medicinal chemistry and pharmacy ➢ Learner is able to apply the drug-receptor interactions to characteristic class of drugs, its dosage form and dose frequency ➢ Learner is able to predict the brightness of colour of dyes based on the theories of colour for its suitable application ➢ Learner is able to differentiate between various classes of dyes and the use thereof in day to day life	
	PHARMACEUTICAL CHEMISTRY	
Unit I	**Unit – I: Routes of Drug administration, Pharmacokinetics & Drug development** **1. General Introduction** a) Definitions- Pharmacology, Pharmacodynamics, Pharmacokinetics, Pharmacophore, Toxicology, Pharmacon, Prodrug, Half-life efficacy b) (i) Definition of drug (WHO) (ii) Characteristics of an ideal drug (iii) Classification of drugs (iv) Lipinski's Rule of 5 c) Drug Nomenclature: Chemical name, non-proprietary name (Generic name), proprietary (Brand) name	**15L** **(02)**

	2. Factors governing choice of routes of Drug administration **a)** Factors governing choice of route **b)** Local Routes-Topical, optic and ocular **c)** Systemic routes- oral; sublingual; rectal; nasal; parenteral- intramuscular, intravenous, intrathecal and intracardiac **d)** Dosage forms **e)** Drug Formulations; sustained release formulations and its advantages **3. Pharmacokinetics:** **a)** ADME (Absorption, Distribution, Metabolism & Excretion) **b)** Metabolism- Phase I and Phase II metabolic reactions **c)** Excretion (with correlation to drug dosage) **4. Mechanism of drug action:** a) Receptors b) Agonist c) Antagonist d) Drug-receptor interaction: e) Theories of Drug-Receptor interaction: Names (any one in detail) f) Drug Potency g) Drug Assay h) LD_{50} i) ED_{50} j) Therapeutic Index k) Bioavailability l) Log P	**(04)** **(05)** **(04)**
Unit II	**Unit – II: Pharmacodynamics & Pharmacodynamic agents** **1. Pharmacodynamic agents** **a)** <u>CNS drugs</u>: Classification based on pharmacological action (CNS depressants & its sub-classification; and CNS stimulants) i. Benzodiazepines (Diazepam) ii. Alcohols iii. Barbiturates (Classification and Mode of action) iv. Hydantoin (Phenytoin & synthesis) v. Phenothiazines (Chlorpromazine) vi. Amphetamine (Phenylethylamine) vii. Oxazolidinediones (Trimethadione) Synthesis of trimethadione **b)** <u>Analgesics, antipyretics & NSAIDs</u> i. Analgesic & antipyretic: p-Aminophenols (paracetamol) ii. Mechanism of inflammation, mode of action of NSAIDs	**15L** **(03)** **(01)**

	(COX inhibitors) & side effects Aspirin, sodium diclofenac iii. Cyclohexanols (Tramadol) Synthesis of Paracetamol and Tramadol c) <u>Antihistamines</u> i. Mechanism of histamine release & its action ii. H_1 and H_2 receptors & mode of action of antihistamines iii. First generation (sedating histamines): Diphenylhydramine (Synthesis) iv. Second generation (non-sedating histamines): Cetrizine (Synthesis from 4-chlorobenzhydryl chloride) d) <u>Antidiabetic agents</u> i. Types of diabetes mellitus (Type I & II), insulin & its mode of action ii. Insulin therapy- Recombinant DNA technology iii. Oral hypoglycemic drugs: mode of action iv. Sulfonylureas; First generation (tolbutamide) Second generation (glibenclamide) v. Biguanides (metformin) vi. Thiazolidinediones (pioglitazone) vii. α-Glucosidase inhibitor (miglitol) viii. Synthesis of tolbutamide e) <u>Anti-Parkinson Drugs</u> i. Idea of Parkinson's disease -symptoms and possible causes ii. Ethopropazine hydrochloride (phenothiazines) iii. Leva dopa (α-amino acids) iv. Synthesis of leva dopa f) <u>Anti-inflammatory drugs</u> i. Mechanism of inflammation and various inflammatory conditions ii. Steroids (Prednisolone) iii. N-arylanthranilic acids (Acelofenac) iv. Synthesis of Acelofenac g) <u>Drugs for Respiratory System</u> i. Expectorants ii. Mucolytes iii. Decongestants iv. Antitussives	**(02)** **(02)** **(02)** **(02)** **(03)**

	v. Phenyl methylamines (Bromhexine) vi. Phenyl ethylamines (pseudoephedrine) vii. Synthesis of pseudoephedrine	
	DYES, PAINTS & PIGMENTS	
Unit III	**Unit III: Nomenclature & Classification of dyes & Optical brighteners, Fibres**	**15L**
	1. Introduction to dye-stuff industry a. Definition b. Colour, chromophore & auxochrome c. Solubility, linearity, coplanarity d. Fastness, substantivity & economic viability e. Mordants with examples	**(01)**
	2. Dye nomenclature **a)** Abbreviations used in commercial dyes- G, O, R, B, K, L, C, S, H, 6B, GK, 6GK **b)** Naming of dyes by colour index	**(01)**
	3. Types of fibres **a)** Natural: cellulosic & proteinaceous (wool, silk & cotton) structures & names of dyes applied to different fibres **b)** Semi-synthetic: definition & examples **c)** Synthetic: nylon, polyesters & polyamides- structures & names of dyes applied **d)** Blended fabrics: definition & examples	**(03)**
	4. Forces binding dyes to fibres: Ionic, Hydrogen bond, van der Waal's & covalent linkages	**(02)**
	5. Classification of Dyes **a)** <u>Classification of dyes based on origin</u> i. Natural dyes- definition, limitations, examples (henna, turmeric, saffron, indigo, madder, chlorophyll) ii. Synthetic dyes- definition, milestones in development of synthetic dyes **b)** <u>Classification of dyes based on constitution</u> **c)** <u>Classification of dyes based on dyeing methods</u> i. Basic operations involved in dyeing process: preparation	**(01)** **(01)** **(01)**

	of fibres, preparation of dyebath, application of dyes, finishing ii. Dyeing method of cotton: direct dyeing, vat dyeing, mordant dyeing, disperse dyeing **d)** Classification of dyes based on application (examples with structures) i. Acid Dyes- Orange II ii. Basic dyes- Methyl violet iii. Direct cotton dyes- Benzofast yellow 5GL iv. Azoic dyes- diazo components: Fast Yellow G, Fast Orange R v. Mordant dyes- Eriochrome Black A, Alizarin vi. Vat dyes- Indanthrene Brown RRD vii. Sulphur dyes- Sulphur black T (no structure) viii. Disperse dyes- Celliton Fast Brown 3R ix. Reactive dyes- Cibacron Brilliant Red B **6. Optical brighteners** **a)** Introduction & important characteristics **b)** Classes- stilbene, coumarin, heterocyclic vinylene derivatives, diaryl pyrazolines, naphthylamide derivatives **c)** Structure of Blankophor R & Tinopal BV	**(02)** **(02)**
Unit IV	**Unit IV: Colour & Chemical constitution, Unit Process & Dye Intermediates** **1. Colour & Chemical Constitution of Dyes** **a)** Absorption of visible light, colour of wavelength absorbed, complementary colour **b)** Relation between colour and chemical constitution: i. Witt's Theory: chromophore, auxochrome, bathochromic shift, hypsochromic shift, hypochromic & hyperchromic effect ii. Armstrong theory (quininoid theory) & its limitations iii. Valence bond theory, comparative study and relation of colour in the following classes of compounds/dyes: benzene, nitrobenzene, nitroanilines, nitrophenols, benzoquinones, azo, triphenylmethane, anthraquinones iv. Molecular Orbital Theory **2. Unit process** **a)** Introduction to primaries & intermediates **b)** Unit processes: definition & reagents, examples of the following	**15L** **(02)** **(04)** **(04)**

	unit processes with reaction conditions (mechanism not expected) i. Nitration ii. Sulphonation iii. Halogenation iv. Diazotization (3 different methods & its importance) v. Ammonolysis vi. Oxidation **3. Dye Intermediates** **a)** Benzene derivatives: Preparation of: i. benzenesulphonic acid ii. 1,3-benzenedisulphonic acid iii. phenol iv. resorcinol v. sulphanilic acid vi. o-, m-, p-chloronitrobenzenes vii. o-, m-, p-nitroanilines viii. o-,m-, p-phenylene diamines **b)** Naphthalene derivatives: Preparation of: i. α, β-naphthols ii. α, β-naphthylamines iii. Schaeffer's acid iv. Tobias acid v. Naphthionic acid vi. N-W acid vii. Cleve-6-acid viii. H-acid ix. Naphthol AS ix. Naphthol ASG **c)** Anthracene derivatives: Preparation of: i. 1-nitroanthraquinone ii. 1-aminoanthraquinone iii. anthraquinone-2-sulphonic acid iv. 1-chloroanthraquinone v. 2-chloroanthraquinone vi. benzanthrone	**(05)**

References:

Unit I and II

1. Siverman, Richard, B., *Organic Chemistry of Drug Design and Drug Action*, 2nd Edition. (2005). Elsevier (Academic Press)
2. Bruice, Paula Y., *Organic Chemistry*, 8th Edition (2013). Pearson Education India.
3. Voet, Donald, &Voet, Judith G., *Biochemistry*, 4th Edition, (2011). International Student version
4. Sriram, D., Yogeeswari, P., *Medicinal Chemistry*, 2nd Edition, Pearson
5. Kar, Ashutosh, *Medicinal Chemistry*, Revised 3rd Edition, (2006).
6. Alagarsamy, V., *Textbook of Medicinal Chemistry*, Vol. 2, 3rd Edition. CBS

Course: SCHE5PR2	**Practical Course work in Organic and Analytical Chemistry - I (Credits: 4 Practicals/Week: 2)**

Objectives:

- To identify the nature of the components of a binary mixture
- To separate the components of a binary mixture by chemical/physical method
- To purify the components of binary mixture by recrystallization/distillation
- To identify a component of a binary mixture
- To provide practical knowledge and hands-on training of analytical chemistry and instrumentation
- To inculcate an aptitude for experimentation and treatment of data in the learner.
- To provide knowledge on preparation of analytical reagents, solutions and their molar calculations
- To understand applications of analytical chemistry in various fields.

Learning Outcomes:

- Learner will be able to adjudge the method of separation (physical or chemical) for a given mixture of organic compounds
- Learner will gain skill at quantitative separation of organic compounds in a mixture
- Learner will be able to ascertain the extent of separation based on weights of isolated compounds, physical constants & identification.
- Learner will be equipped with standard operating procedure of basic analytical instruments
- Learner will gain the knowledge of preparation of primary standard solutions
- Learner will be acquainted with the assay of commercial samples

ORGANIC CHEMISTRY PRACTICAL

2. Binary Mixture: Solid-Liquid Binary Mixture & Liquid-Liquid Binary Mixture

a. To identify the type of the binary mixture
b. To separate the components by physical method
c. To identify one component of the binary mixture
d. To purify the other component of the binary mixture

ANALYTICAL CHEMISTRY PRACTICAL

Instrumental Experiments

2. To determine amount of Fe (II) present in given sample by titrating **against** potassium dichromate potentiometrically
3. To determine potassium content of a Fertilizer by Flame Photometry (Calibration curve method)

Non-Instrumental Experiments

1 To determine calcium content in market samples of calcium tablets.

6. Estimation of Copper by solvent extraction methods
7. To determine the amount of persulphate in the given sample solution by back titration with standard Fe (II) ammonium sulphate solution.
8. To determine percentage of chloride present in the given sample. (Volhard's method)
9. Iodometric determination of available chlorine in a sample of bleaching powder.

Semester V – Practical (Applied Component)

Course: SCHE5ACPR	**Practical Course Work in Pharmaceutical Chemistry, Dyes Paints & Pigments -I (Credits: 2.5 Practicals/Week: 1)**

Objectives:

- To prepare drug intermediates/drugs/dye intermediates on a bench scale
- To estimate the concentration of drugs in a given sample, quantitatively
- To develop the skill of separation of the components of a natural pigment using paper chromatography
- To handle a colorimeter for estimation of dyes

Learning Outcomes:

- Learner will be able to plan a synthesis of drug or dye intermediate with respect to the unit processes and operations involved.
- Learner will be equipped with methods of assay of drugs in a given sample.
- Learner will be able to qualitatively identify the pigments in a formulation using chromatographic technique
- Learner will be exposed to basic laboratory instrumental methods for estimation of dyes

PHARMACEUTICAL CHEMISTRY PRACTICAL

1. Preparation of Paracetamol from p-aminophenol/Aspirin from Salicylic acid
2. Preparation of Phenytoin from urea & benzyl
3. Estimation of Ibuprofen (Back titration method)
4. Estimation of Tincture iodine

DYES, PAINTS & PIGMENTS PRACTICAL

1. Preparation of p-nitroacetanilide from acetanilide
2. Preparation of p-nitroaniline from acetanilide
3. Separation of components of natural pigments by paper chromatography (e.g. chlorophyll)
4. Colorimetric estimation of methyl orange (determination of λ_{max} is expected)

Evaluation Scheme

A. Evaluation scheme for Theory courses

I. Semester End Examination (SEE)- 60 Marks

II. Internal Continuous Assessment (CA) – 40 Marks

a. Knowledge and Application based: Online objective test of 20 Marks

b. Skill based (20 marks): Learner will be assessed on relevant skills pertaining to the course content of a particular paper which could involve but not limited to

(i) Review of research paper/ Worksheets/ demonstration of instruments followed by evaluation

(ii) Report writing with presentation of visit to Pharmaceutical industry/ Paints/ Pigments industry

(iii) Literature review/ survey.

B. Evaluation scheme for Practical courses

I. Semester End Examination (SEE)- 100 Marks per course [SCHE5PR1, SCHE5PR2, SCHE5ACPR]