Resolution Number: AC/II(23-24).2.RPS5

S.P.Mandali's

Ramnarain Ruia Autonomous College

Program: M.Sc.

Course: M.Sc. Physical Chemistry

Course code: RPSCHEP

Syllabus for Semester III & IV

Academic year 2024-25

GRADUATE ATTRIBUTES

GA	Description
A student after completing Master's in Science program will be able to	
GA 1	Demonstrate in depth understanding in the relevant science discipline. Recall, explain, extrapolate and organize conceptual scientific knowledge for execution and application and also to evaluate its relevance.
GA 2	Critically evaluate, analyse and comprehend a scientific problem. Think creatively, experiment and generate a solution independently, check and validate it and modify if necessary.
GA 3	Access, evaluate, understand and compare digital information from various sources and apply it for scientific knowledge acquisition as well as scientific data analysis and presentation.
GA 4	Articulate scientific ideas, put forth a hypothesis, design and execute testing tools and draw relevant inferences. Communicate the research work in appropriate scientific language.
GA 5	Demonstrate initiative, competence and tenacity at the workplace. Successfully plan and execute tasks independently as well as with team members. Effectively communicate and present complex information accurately and appropriately to different groups.
GA 6	Use an objective, unbiased and non-manipulative approach in collection and interpretation of scientific data and avoid plagiarism and violation of Intellectual Property Rights. Appreciate and be sensitive to environmental and sustainability issues and understand its scientific significance and global relevance.
GA 7	Translate academic research into innovation and creatively design scientific solutions to problems. Exemplify project plans, use management skills and lead a team for planning and execution of a task.

GA 8	Understand cross disciplinary relevance of scientific developments and relearn and reskill so as to adapt to technological advancements.

PROGRAM OUTCOMES

PO	Description
A student completing Master's degree in Science Program in the subject of chemistry will be able to :	
PO1	Acquire in-depth knowledge of the advance concepts in the branch of specialization viz, Physical, Inorganic, Organic & Analytical.
PO2	Design and carry out analysis as well as accurately record and analyse the results.
PO3	Explain the findings and share the results with scientists and non scientist with the help of the written and oral communication skills acquire during the course.
PO4	Apply the skills to do specialized research in the core and applied areas of chemical sciences.
PO5	Explore new areas of research in chemistry and allied fields of science and technology.
PO6	Demonstrating the developed skills such as problem solving approach , critical thinking , analytical reasoning ,team work and effective communication for solving the applied research problems related to their field.
PO7	Explain why chemistry plays an integral role in addressing social , economic and environmental problems.

PO8	Become professionally skilled for higher studies in research institutions and to work in industries.

SEMESTER III			
Course Code	**Unit**	**Course Title/Unit Title**	**Credits**
DSC-I		**POLYMER, PHOTO, AND NUCLEAR CHEMISTRY**	
	I	Polymer Chemistry	**3**
	II	Photo Chemistry	
	II	Nuclear Chemistry	
		Practical	**1**
DSC-II		**ADVANCED INSTRUMENTAL TECHNIQUE**	
	I	Spectral Methods	**3**
	II	Radioanalytical & Thermal methods	
	II	Electroanalytical methods	
		Practical	**1**
DSC-III		**QUANTUM CHEMISTRY**	
	I	Atomic structure	**3**
	II	Molecular Structure	
	II	Computational Quantum Chemistry	
		Practical	**1**
DSE-I		**ENVIRONMENTAL ANALYSIS**	
	I	Air Pollution	**3**
	II	Water Quality Standards	
	II	Other Types of Pollutions	
		Practical	**1**
DSE-II		**PHARMACEUTICAL AND COSMETIC CHEMISTRY**	
	I	Pharmaceutical Legislation	**3**
	II	Drugs	
	II	Cosmetics and Perfumes	
		Practical	**1**
		RESEARCH PROJECT	**6**

SEMESTER IV			
Course Code	**Unit**	**Course Title/Unit Title**	**Credits**
DSC-I		**SOLID STATE AND THERMODYNAMICS**	
	I	Solid State Chemistry	**3**
	II	Non-equilibrium thermodynamics	
	II	Statistical Thermodynamics	
		Practical	**1**
DSC-II		**MOLECULAR SYMMETRY AND SPECTROSCOPY**	
	I	Symmetry in Chemistry	**3**
	II	NMR & ESR Spectroscopy	
	II	Atomic & Molecular spectroscopy	
		Practical	**1**
DSE-I		**ENVIRONMENTAL AND INDUSTRIALLY IMPORTANT MATERIALS**	
	I	Effluent Treatment	**3**
	II	Solid Waste Management	
	II	Industrial Materials	
		Practical	**1**
DSE-II		**SELECTED TOPICS IN ANALYTICAL CHEMISTRY**	
	I	Chemistry of Fuels & Agrochemicals	**3**
	II	Green Chemistry	
	II	Metallurgy	
		Practical	**1**
		INTERNSHIP / RESEARCH PROJECT	**10**

Course Code: DSC-I

Course Title: POLYMER, PHOTO, AND NUCLEAR CHEMISTRY

Academic year 2024-25

Course Outcomes:

After the completion of this course, the learner will be able to:	
CO 1	Determine the molar mass of polymers using different methods.
CO 2	Distinguish the various types of polymers.
CO 3	Illustrate the various deactivation processes of molecular excited states.
CO 4	Describe the photochemical reactivity of ethenes and carbonyl compounds.
CO 5	Build knowledge of particle accelerators work viz. Linear, cyclotron
CO 6	Comprehend the concept of nuclear model's Liquid drop, Fermi gas, Shell, Optical etc.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
		POLYMER, PHOTO, AND NUCLEAR CHEMISTRY	**3**
	I	**Polymer Chemistry** **1.1 Introduction**: Polymer Science, fundamental terms, historical outline, classification based on: the origin (natural, semi-synthetic, synthetic etc.), the structure(linear, branched, network, hyperbranched, dendrimer, ladder, cross linked, IPN), the type of atom in the main chain (homochain, heterochain), the formation(condensation, addition), homopolymers, copolymers(random, alternate, block, graft), the behaviour on the application of heat (thermoplastic and (thermosetting), the form and application (plastics, fiber, elastomers and resins). **1.2 Molar Mass**: Molecular weight averages, fractionation, molecular weight determination by GPC/SEC, end group analysis, viscometry, vapour phase osmometry gradient elution, and molecular weight distribution curve.	**(15L)**

		1.3 Types of polymerization: condensation, addition (cationic and anionic) and copolymerization (with kinetics), chain transfer reactions.	
	II	**Photo Chemistry** **2.1 Photo chemical principles**: Environmental effect on absorption and emission spectra, properties of excited states, excited state acidity constants, dipole moments and redox properties, Importance of photochemistry, origin of life. **2.2 Photo physical processes in electronically excited molecules:** Types of photophysical pathways, types of radiation-less transitions, fluorescence emission, fluorescence, and structure. Triplet state and phosphorescence emission, delayed fluorescence–e type and p-type delayed fluorescence. **2.3 Photochemical reactions**: ketones, olefins conjugated olefins and aromatic compounds, photosynthesis.	**(15L)**
	III	**Nuclear Chemistry** **3.1 Charged particle accelerator-** linear accelerator, cyclotron, Betatron, Synchro- cyclotron, synchrotron **3.2 Nuclear forces-** characteristics and Meson field theory of nuclear forces **3.3 Nuclear Models-**Liquid drop model**,** Fermi Gas Model, Shell Model, Collective Model, Optical Model. **3.4Applications of Nuclear radiations- g**eological applications of radioactivity, age of minerals and rocks, age of the earth and solar system, medical, industrial, and Agricultural applications of radiochemistry, positron emission tomography, Radio immune assay.	**(15L)**
		Practical 1. Determination of the chain linkage in poly (vinyl alcohol) from viscosity measurements. 2. Determination of energy of n to Π* transition in acetone and study of the effect of solvent on the energy of this transition by recording absorbance spectra in n-hexane and water. 3. To study the kinetics of the decomposition of hydrogen peroxide in the presence of ferric chloride solution and hence to study the effect of the catalyst on the decomposition reaction. 4. Molecular weight of a polymer by end group estimation. 5. To measure the radius of the glycerol molecule.	**Credits-01**

References:

1. V.R. Gowarikar, H.V. Vishwanathan and J. Shreedhar, Polymer Science, New Age International Pvt. Ltd., New Delhi, 1990.
2. K.K. Rohatgi- Mukherjee, Fundamentals of Photochemistry, Reprint 2002, New Age International Publisher, 1978.
3. P. Bahadur and N.V. Sastry, Principles of Polymer Science, 2nd Edition, Narosa Publishing House, 2005.
4. G. Friedlander, J. W. Kennedy, Nuclear and Radio Chemistry.Third. John Wiley and sons,(1981).
5. H. J. Arnikar, Essentials of Nuclear Chemistry. Wiley Eastern Ltd.,(1989).

Semester-III
Course Code: DSC-II

Course Title: ADVANCED INSTRUMENTAL TECHNIQUES

Academic year 2024-25

Course Outcomes:

After completion of this course, the learner will be able to,	
CO 1	Make use of the surface analytical techniques for obtaining information about the surfaces while characterizing the samples.
CO 2	Describe the sources & different methods used for the enhancement of signal to noise ratio.
CO 3	Elaborate on the essential principles underlying the applications of thermal methods and radiochemical methods.
CO 4	Develop a working knowledge of various methods used in polarography.
CO 5	Explain anodic , cathodic and adsorptive stripping methods in voltammetry.
CO 6	Select a suitable method of voltammetry for the analysis of a particular sample.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
DSC-II		**ADVANCED INSTRUMENTAL TECHNIQUES**	**4**
	I	**Spectral Methods -I**	
		1.1 Measurement Basics: Signal to noise ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction and software methods for noise reduction. (05L) **1.2. Surface Analytical Techniques:** Preparation of the surface, difficulties involved in the surface analysis. (1L)	**(15L)**

		1.2.1. Principle, instrumentation, and applications of the following: **a.** ATR-FTIR spectroscopy (2L) **b.** X-Ray Photoelectron Spectroscopy (XPS) (2L) **c.** Scanning Probe Microscopy including AFM, CFM (3L) **1.3** Nuclear Quadrupole Resonance (NQR), ENDOR, ELDOR**.** (3L)	
	II	**Radiochemical And Thermal Methods**	
		3.1 Enthalpimetric methods and thermometric titrations. **3.2 Thermal analysis-** Principle, Interfacing, instrumentation and Applications of (a) Simultaneous Thermal Analysis- TG-DTA and TG-DSC **3.3 Evolved gas analysis**- TG-MS and TG-FTIR (7L) **3.4**. **Activation analysis**- NAA, radiometric titrations and radio-release methods, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. **(Numercials are expected).** **3.5** PET scan and CT scan (7L). **3.6.** Radio chromatography (1L)	**(15L)**
	III	**Electroanalytical Methods**	
		4.1 Coulometry: Introduction, principle, instrumentation, coulometry at controlled potential and controlled current. (02L) **4.2.** Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography, Differential double Pulse Polarography (02L) **4.3. Potential Sweep methods-** Linear Sweep Voltammetry and Cyclic voltammetry. (02L) **4.4.** Chronoamperometry and Chronopotentiometry (03L) **4.5. Stripping Voltammetry-** anodic, cathodic, and adsorption (02L) **4.6**. Chemically modified electrodes and ultra-microelectrodes in voltammetry. (01L) **4.7. Ion selective potentiometry:** Ion selective field effect transistors, biocatalytic membrane electrodes and enzyme-based biosensors. (03L)	**(15L)**
		Practical **1.** To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant.	**Credits-01**

		2. To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base. **3.** To study the effect of the extended conjugation on the λmax of p-nitro phenol by recording spectrum in acidic and alkaline medium **4.** To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of the complex. (Potentiometrically) **5.** To measure the radius of glycerol molecule.	

References:

1. D. A. Skoog, F. J. Holler and J.A. Niemann, Principles of Instrumental Analysis, 5th Edition (1998).
2. H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr Instrumental Methods of Analysis, 7th Ed CBS (1986).
3. R. D. Braun, Introduction to Instrumental Analysis, Mc Graw Hill (1987).
4. G. D. Christian, Analytical Chemistry, 4th Ed. John Wiley, New York (1986).
5. D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders, Fundamentals of Analytical Chemistry, 6th Edition (1992).
6. A. J. Bard and Marcel Dekker, Electroanalytical Chemistry, New York, (A series of volumes).
7. J.J. Lingane, Electroanalytical Chemistry, 2nd Ed Interscience, New York (1958).
8. A. M. Bond, Marcel Dekker, Modern Polarographic Methods in Analytical Chemistry, New York, (1980).
9. KamlaZutski, Introduction to polarography and allied techniques,(2006).
10. R. V. Parish. Ellis Horwood,Chichester, NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry.

Course Code: DSC-III
Course Title: QUANTUM CHEMISTRY
Academic year 2024-25

Course outcomes:

After completion of this course, the learner will be able to	
CO 1	Solve the Schrodinger equation for complex system
CO 2	Compare different theories of Molecule formation
CO 3	Account for the fundamental background of Density Functional Theory
CO 4	Prove Hohenberg-Kohn theorems and their application.

DETAILED SYLLABUS

Course Code	Unit	Course Title/Unit Title	Credits/ Lectures
		QUANTUM CHEMISTRY	**3**
	I	**Atomic structure** Introduction to approximate methods in Quantum Mechanics- **1.1 Variation Method**: Variation Theorem, extension of the variation method, determinants, simultaneous linear equations, linear variation functions. **1.2 Perturbation Theory**: Nondegenerate Perturbation Theory, first order wave function correction, first order and second order energy correction. Perturbation treatment of the Helium atom ground state, Variation treatment of the Helium atom ground state, Perturbation Theory for a degenerate energy level **1.3 Multielectron atoms**: Independent electron approximation, electron spin, spin statistic theorem, symmetric and antisymmetric wave function, the Pauli exclusion principle, slater determinants.	**(15L)**
	II	**Molecular Structure** **2.1 Chemical Bonding:** The Born–Oppenheimer approximation, LCAO method-molecular orbital formation	**(15L)**

		2.2 Molecular Orbital theory: MO theory of bonding in hydrogen molecule ion and hydrogen molecule, physical interpretation of bonding and antibonding molecular orbital, calculation of ground state energy, excited state of H_2 singlet and triplet state. **2.3 Valence bond theory:** Heitler-London treatment to hydrogen molecule, resonance, antisymmetric wave function, and nature of bonding. Heitler-London Slater Pauling theory. **2.4 Principle of hybridisation:** Directed valence & hybridization in simple polyatomic molecules. (sp, sp^2 and sp^3 hybridisation). **2.5 Hückel theory:** Hückel molecular orbital's Theory for– ethylene, Allyl system, cyclopropenyl, linear butadiene, cyclobutadiene, and benzene system.	
	III	**Computational Quantum Chemistry** **3.1** Introduction to computational chemistry: the tools of computational chemistry including molecular mechanics, ab initio calculations, semiempirical calculations, and density functional calculations; concept of potential energy surfaces and stationary points, Born–Oppenheimer approximation, geometry optimization **3.2** Computational quantum chemistry – ab initio methods: The Schrodinger equation for an N-electron system, Born–Oppenheimer approximation, Hartree approximation, Hartree–Fock self-consistent field method, Roothan–Hall equations and basis functions, basis sets: their types and uses **3.3** Density functional theory: Thomas–Fermi model, Hohenberg–Kohn theorem, Kohn–Sham equations, exchange-correlation energy functional, applications of density functional theory.	**(15L)**
		Practical **1.** Use DFT software to plot the Morse potential energy curve for a hydrogen molecule taking bond lengths from 0.1 Å to 4 Å. **2.** Electronic properties of graphene: Plot a unit cell of graphene and perform geometry optimization using a DFT software. Obtain the ground state energy, plot the total density of states and report the band gap. **3.** Electronic and magnetic properties of a metal: Plot a unit cell of a metal (Al, Fe, Ni, Cu) and perform geometry	**Credits-01**

		optimization using a DFT software. Obtain the ground state energy, total density of states, band gap, and magnetic moment of the metal. Introduce a vacancy defect in the system and obtain above parameters for the defected system. Comment on the results. **4.** Adsorb a molecule (H_2O, NH_3, H_2, or CO_2) on the surface of relaxed graphene. Obtain the favourable adsorption configuration and adsorption energy. **5.** Electron-electron repulsion for the first two rows of atoms in the periodic table using ChemCompute – GAMESS: For atoms from H to Ne, write the electronic configuration, electron spin, and spin multiplicity. Obtain the binding energy of each atom after geometry optimization.	

References:

1. Atkins P.W, Physical Chemistry, Oxford University Press,6th edition,(1998). 2.
2. R. K. Prasad, Quantum Chemistry,3rd Ed., New Age International Publishers,(2006).
3. McQuarrie, Quantum Chemistry, Viva Books Private Limited, New Delhi, first Indian ed., (2003).
4. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, (2001).
5. A.K.Chandra, Introductory Quantum Chemistry,McGrawH edition(1994),Tata McGraw-Hill, New Delhi.
6. I.N. Levine, Quantum Chemistry, 5th Edition (2000), Pearson Educ. Inc., New Delhi.
7. James E. House, Fundamentals of Quantum Chemistry, Second Ed., Academic Press,(2005)

Course Code: EC-I

Course Title : ENVIRONMENTAL CHEMISTRY

Academic year 2024-25

Course outcomes:

After completion of this course, the learner will be able to	
CO 1	List the major sources of different types of pollutants.
CO 2	Classify the different types of pollutants.
CO 3	Estimate the pollutants present in air.
CO 4	Outline the role of pollution control boards in monitoring and controlling pollution.
CO 5	Apply the methods learned in sampling of these pollutants to procure a sample for analysis.
CO 6	Indicate appropriate measures to reduce/or minimize the effects of these pollutants on environment.
CO 7	Evaluate the quality of potable water based on the guidelines laid down by the regulatory bodies.

DETAILED SYLLABUS

Course Code	Unit	Course Title/Unit Title	Credits/ Lectures
EC-I		**ENVIRONMENTAL CHEMISTRY**	**3**
	I	**Air Pollution** **1.1.** Sources, classification, pollutants and permissible limits. (2L) **1.2** Sampling methods for air, flew gas, Industrial Exhaust, stag samples etc. (2L) **1.3.** Importance of automobile exhaust control and its limits New BS VI regulations. (2L) **1.4.** Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors. SPM analysis on ESP (3L) **1.5**. Carbon credit and global issues related to air pollution. (3L) **1.6.** Greenhouse gases and their substitutes. (1L) **1.7.** Environmental Legislation: role of pollution control boards, article 48A and 51A, Motor Vehicle Act and method of analysis with respect to PUC. (2L)	**(15L)**
	II	**Water Quality Standards** **2.1** Water: quality and requirements of potable water, direct and indirect pollutants for potable water	**(15L)**

		reservoirs, quality of potable water from natural sources. (4L) **2.2.** Bore well water quality and analytical parameters. Quality of bottled mineral water (3L) **2.3**. Process of purification of bore well water to bottled mineral water. (2L) **2.4** Regulatory requirements for packaged drinking water (4L)	
	III	**Other Types of Pollution** **3.1 Soil pollution and Soil Analysis:** sources of soil pollution and their control, sampling of soil, determination of water holding capacity, determination total nitrogen, ammonia and nitrates, fertility of soil and effect of pollution on it, synthetic fertilizers and their long term effect on soil quality. (6L) **3.2 Noise Pollution:** sources, effects, methods of measurements and control measures. (2L) **3.3 Thermal Pollution:** definition, source, impact, control measures, working of cooling towers and cooling ponds, involved economy (3L) **3.4 Radioactive pollutants:** source, exposure hazards, precautions in handling and safety, Long term effects. (2L) **3.5 Environmental Audits:** concept of audit, authorities, evaluation methodology, benefits and certification. (2L)	**(15L)**

References:

1. A. K. De, Environmental Chemistry, 2nd Edition. Wiley (1989).
2. S. M. Khopkar, Environmental Pollution Analysis, John Wiely (1993).
3. Sharad Gokhale, Air Pollution Sampling And Analysis, IIT Guwahati, May (2009).
4. S. M. Khopkar, Environmental Pollution Analysis, New Age International publication (2011).
5. Seonard Ciacere, Water And Water Pollution (hand book) Ed.,Vol I to IV, Marcel Dekker inc. New.York(1972).
6. Arvindkumar, Water pollution, APH publishing (2004)
7. Simon Parsons, Bruce Jefferson, Introduction to Potable Water Treatment Processes, Paperback publication.
8. Guidelines for drinking-water quality, Third edition, (incorporating first and second addenda). WHO report.
9. S.G. Misra and Dinesh Mani, Soil pollution, APH Publishing Corporation, (2009).
10. Abrahim Mirsal, Soil Pollution: origin, monitoring and remediation, Springer (2010).
11. Donald F Anthrop, Noise Pollution, Lexington Books, (1973)
12. N. Birsen, Kairat K. Kadyrzhanov, Environmental Protection Against Radioactive Pollution Springer publication , (2003).

Practical's:

EC-I		Environmental Chemistry	Credits-01
	1.	Determination of NOx & Sox from ambient air by spectrophotometry using high volume sampler.	
	2.	Determination of CO_2 & O_2 by Orsat apparatus.	
	3.	Estimation of residual chlorine in water sample by iodometric method.	
	4.	Determination of sulphate in water sample by Nephelometry.	
	5.	Determination of soil type, texture, pH, conductivity, moisture, Nitrogen, Potassium & Phosphorous.	
	6.	Measurement of noise levels.	

Course Code: EC-II

Course Title : PHARMACEUTICAL AND COSMETIC CHEMISTRY

Academic year 2024-25

Course Outcomes:

After completion of this course, the learners will be able to,	
CO 1	Categorize the different types of drugs and dosage forms.
CO 2	Outline the role of FDA in pharmaceutical industry.
CO 3	Make use of the different methods learned to estimate the amount of drug present in a sample.
CO 4	Apply the concept of impurity profiling, stability studies, limit tests, bioavailability and bioequivalence while ensuring the uniformity in standards of quality , efficacy & safety of pharmaceutical products.
CO 5	Evaluate the quality of the cosmetic products by carrying out their analysis using the methods learned.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Lectures**
EC-II	**PHARMACEUTICAL AND COSMETIC CHEMISTRY**		**3**
	I	**Pharmaceutical Legislation**	**(15L)**
		1.1 General idea regarding the Pharmaceutical Industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries. (04L) **1.2** Sources of impurities in pharmaceutical products and raw materials. (01L) **1.3** Standardization of finished products and their characteristics, official methods of quality control. (01L) **1.4. Pharmaceutical Legislation:** Introduction to drug acts, drug rules (schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration. (05L)	

		1.5. Introduction to Intellectual Property Rights (IPR): Introduction and Types of IPR- Patent, copyright, designs, Trademarks, Trade secrets, Geographical indications. **Patents:** History of Indian patenting system, WIPO, PCT system, criteria for patenting an invention, Routes & Procedure to file patents in India, Basic and associated right of owners, Infringements of patents rights & offences. (04L) **(Discussion on case studies involving IPR is expected).**	
	II	**Drugs** **2.1 Introduction to drug design:** Stages of drug discovery and development. Various approaches used in drug design. Lipinski rule of 5, Physicochemical parameters used in quantitative structure activity relationship (QSAR), such as partition coefficient, Hammet's electronic parameter, Taft's steric parameter and Hansch's analysis. Pharmacophore modelling and docking techniques. (04L) **2.2.** Pharmacopoeias: Introduction to IP, BP, USP (2L) **2.3.** Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, assays involving chromatographic separations, assays of enzyme containing substances, biological and microbiological assays and tests. (03L) **2.4.** Limit tests, solubility tests, disintegration tests, stability studies (2L) **2.5.** Bioequivalence and bioavailability studies. (2L) **2.6.** Impurity profile of drugs (1L) **2.7.** Polymers in pharmaceuticals and novel drug delivery systems. (1L)	**(15L)**
	III	**Cosmetics and Perfumes** **4.1. Cosmetics:** Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis. (01L) **4.1.2. Deodorants and antiperspirants:** Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methanamine, phenolsulphonates and urea. (02L) **4.1.3. Face powder:** Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total). (02L) **4.1.4. Hair tonic:** 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers). (02L)	**(15L)**

		4.1.5 Creams and Lotions: Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) (02L) **4.1.6 Lipsticks:** General analysis, determination of - nonvolatile matter, lakes and fillers, trichloroethylene-acetone soluble contents. (02L) **4.2. Perfumery:** Introduction – Definition of perfumes, deters, ottos and aromatic waters. Classification of perfumes. (01L) **4.2.1.** Essential oils: Introduction, Production (Raw materials, processing, purification and isolation of essential oils), reconstitution of oil. Study of various physical & chemicals properties of essential oil. (01L) **4.2.2.** Methods of preparation & manufacture of perfumes: Including (natural & synthetic) general operation flow sheets, statistics. (01L) **4.2.3.** Analysis & standardization of perfumes: Includes analysis of essential oils and various physicochemical tests & parameters used for analysis of various perfumes. (01L)	

References:

1. Kenneth Antonio Connors, Text book of Pharmaceutical Analysis, Wiley, (2001).
2. Indian Pharmacopeia, Volume I and II.
3. M L Mehra, The Handbook of Drug Laws, University Book Agency, Ahmedabad,(1997).
4. Takeru Higuchi, Chemical Analysis of Drugs, Interscience Publishers, (1995).
5. Foster Dee Snell et al, Encyclopedia of Industrial Chemical Analysis, Interscience Publishers,(1967).
6. Official methods of analysis of AOAC international,18th edition 2005,AOAC international.
7. Vivien Irish, Intellectual Property Rights for Engineers, 2nd Edition, British Library, (2008).
8. David I. Bainbridge, Intellectual Property, 8th Edition, Pearson, (2010).
9. Stephen Elias and Richard Stim, Patent Copyright & Trade Mark, 8th Edition, Nolo and Richard, (2013).
10. Harry's Cosmetology, 7th Ed, Longman Scientific Co.
11. Edward Sagarin, Cosmetic Technology, Interscience Publishers,(1957).
12. Edgar George Thommsen, Francis Chilson, Modern Cosmetics, Drug and Cosmetic Industry,(1947).
13. Government of India Publications of Food, Drug and Cosmetic Act and Rules.
14. Encyclopedia of Analytical Chemistry, Volume 3, Academic Press,(1995).

Practical's:

EC-I	Pharmaceutical & Cosmetic Chemistry		Credits-01
	1.	Determination of partition coefficient of medicinal compounds by shake flask method.	
	2.	Limit test for chloride, sulphate, Iron and lead.	
	3.	Determination of neutralizing capacity of aluminum hydroxide gel / Analysis of Whitefield's ointment.	
	4.	Simultaneous estimation of Ibuprofen and Paracetamol by UV spectroscopy.	
	5.	Determination of water by Karl Fischer method-Rifamycin sodium.	
	6.	Identification of components of essential oils by GCMS.	
	7.	Estimation of drugs by non-aqueous titration: Pyridoxine hydrochloride, Mebendazole.	
	8.	Estimation of Aspirin by conductometry.	
	9.	Estimation of Ca in Ca-pantothenate/calcium lactate tablets**.**	

MODALITY OF ASSESSMENT

Theory Examination Pattern:

A) Internal Assessment - 40% (30 Marks)

Presentation: 20 Marks

Continuous Internal Assessment (CIA): 10 Marks

For each paper, learners are evaluated from their presentation based on the topic selected from syllabus. The assessment of presentation is as follows:

Sr. No	Evaluation type	Marks
1.	Presentation content	10
2.	Presentation skills	05
3.	Viva	05
4.	Continuous Internal Assessment (CIA) e.g. Test, Group discussion, assignment, open-book tests etc.	10
	Total	30

B) External examination - 60 %

Semester End Theory Assessment - 45 marks

1. Duration - These examinations shall be of 2 hours duration.

2. Paper Pattern:

2.1 There shall be 03 questions each of 15 marks. On each unit, there will be one question.

2.2 All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions on
Q.1) A)	*Any 3 out of 5*	12	Unit I
Q.1) B)	*Any 1 out of 2*	3	
Q.2) A)	*Any 3 out of 5*	12	Unit II
Q.2) B)	*Any 1 out of 2*	3	

Q.3) A)	***Any 3 out of 5***	**12**	**Unit III**
Q.3) B)	***Any 1 out of 2***	**3**	

Practical Examination Pattern:

Semester End Practical Examination: 25 marks

Experimental work	**20**
Viva	**03**
Journal	**02**

PRACTICAL BOOK/JOURNAL the students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination. In case of loss of Journal, a Lost Certificate should be obtained from Head/ Coordinator / In-charge of the department; failing which the student will not be allowed to appear for the practical examination.

RESEARCH PROJECT: 6 credits (150 M)

Overall Examination and Marks Distribution Pattern

Course	**DSC-I**			**DSC-II**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**30**	**45**	**75**	**30**	**45**	**75**	**150**
Practical		**25**	**25**		**25**	**25**	**50**
Course	**DSC-III**			**DSE**			
Theory	**30**	**45**	**75**	**30**	**45**	**75**	**150**
Practical		**25**	**25**		**25**	**25**	**50**
Course	**RESEARCH PROJECT**					**150**	**150**

			550

SEMESTER IV
Course Code: DSC-I
Course Title: SOLID STATE AND THERMODYNAMICS
Academic year 2024-25

Course outcomes:

After completion of this course, the learner will be able to	
CO 1	Relate the concept of bonding to the structure of crystalline solids.
CO 2	Explain different types of lattices, unit cells, and defects in crystals in detail.
CO 3	Explain the second law of thermodynamics at non-equilibrium i.e. entropy production and rate. Also, comprehend the principle of microscopic reversibility and transport phenomena across membranes.
CO 4	Apply the concept of probability to the thermodynamic properties at the micro level
CO 5	Prove derivation of Maxwell-Boltzmann, Fermi-Dirac statistics

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
DSC-I	**SOLID STATE AND THERMODYNAMICS**		**3**
	I	**1.1.** Bonding and Structure: Classification of solids based on nature of force.(ionic, metallic, van der Waal's, hydrogen bonded), crystal structures. **1.2**.Symmetry and choice of unit cell, Bravais lattice, Miller indices, Point groups and space groups, Close packing, Lattices and unit cells. **1.3**. Crystalline solids, ionic radii, radius ratio rule, lattice energy, lattice energy, crystal structure determination by powder diffraction, and single crystal X-ray diffraction. **1.4**. Defects and non-stoichiometry: point defects, plane defects, line defects. Solid solutions Diffusion in solids: Mechanisms, Steady state and non-steady state diffusion, factors affecting diffusion.	**(15L)**
	II	**STATISTICAL THERMODYNAMICS**	**(15L)**

		2.1Thermodynamic probability: combinatorial problems, Stirling approximation**,** Lagrange's method, macro and microstates, ensembles, Boltzmann distribution law. **2.2 Partition functions**: Translational, rotational, vibrational, electronic and nuclear partition functions, Expressions for the thermodynamic functions in terms of partition function -Internal energy, heat capacity, the Helmholtz and Gibbs functions, Enthalpy, entropy and equilibrium constants. Sackur –Tetrode equation for the entropy of a monoatomic gas. Molecular partition function. **2.3** Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics. **2.4** Debye and Einstein's theory of specific heats of solids	
	III	**NON-EQUILIBRIUM THERMODYNAMICS** **4.1** Features of non-equilibrium thermodynamics, the second law of thermodynamics, uncompensated heat, and its relation to thermodynamics function. **4.2** Entropy production and its rate. Entropy production in the heat transfer process and during the mixing of gases. Entropy production and efficiency of galvanic cell. **4.3** Onsager's theory: Reciprocal relation, the principle of microscopic reversibility. **4.4** Coupled and uncoupled reactions and their condition. **4.5**Transport phenomena across membranes. Electro kinetic effect and thermomechanical effects.	**(15L)**
		Practical 1. To determine K_1 and K_2 of a dibasic acid by titration with a base. 2. To estimate the amount of a salt of an organic acid/ sparingly soluble salt like magnesium carbonate by ion exchange chromatography. 3. To determine the composition of a mixture of hydrochloric acid, potassium chloride and ammonium chloride by titration with sodium hydroxide and silver nitrate. 4. Hydrolysis constant of aniline hydrochloride **5.** To determine the ionization constant of bromophenol blue.	**Credits-01**

References:

1. B. K. Agarwal and M. Eisner, Statistical Mechanics,(1988)Wiley Eastern, New Delhi.

2. John M. Seddon & Julian D. Gale, Thermodynamics and Statistical mechanics, Tutorial Chemistry Texts series,Vol.10,Royal Society of Chemistry,(2001).
3. C.Kalidas and M.V.Sangaranarayan, Non-Equilibrium Thermodynamics, Principlesand Applications, McMillanIndia Ltd.,(2002).
4. Keer H.V, Principles of the Solid State, first reprint, Wiley Eastern Limited,(1994).

SEMESTER IV
Course Code: DSC-II
Course Title: MOLECULAR SYMMETRY AND SPECTROSCOPY
Academic year 2024-25

Course outcomes:

After completion of this course, the learner will be able to	
CO 1	Able to determine the point group of the molecule
CO 2	Describe the selection rule for infrared-active transitions.
CO 3	Determine whether the molecular vibrations of a triatomic molecule are Raman active.
CO 4	Analyse the hybridization of given compounds
CO 5	Assess effect of structure on chemical shift and coupling constants.
CO 6	Elucidate the electronic structure of free radicals and paramagnetic transition metal complexes.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
DSC-II	**MOLECULAR SYMMETRY AND SPECTROSCOPY**		**3**
	I	**Symmetry in Chemistry** **1.1** Recapitulation of Points groups and Character tables. **1.2** Applications of Group theory in Infrared and Raman spectroscopy. Molecular Vibrations, determining the Symmetry Types of the Normal Modes; symmetry-based Selection Rules of IR and Raman, application in Infrared and Raman spectroscopy for molecules belongs to point group C_{2v}, C_{3v}, C_{4v}, D_{2h}, D_{3h}, $D_{\infty h}$ and T_d. **1.3** Group theory and quantum mechanics. Wave function as bases for irreducible representation. **1.4** Symmetry Adapted Linear Combinations - (SALC) - projection operators and their use to construct SALC.	**(15L)**

		1.5 Molecular Orbital Theory. Transformation properties of atomic orbitals, MO's for Sigma and pi - molecular orbitals in AB_n molecules, AB_4 (tetrahedral) and AB_6 (octahedral) molecules, Hybrid orbitals.	
	II	**NMR AND ESR SPECTROSCOPY** **2.1 NMR Spectroscopy** Theory and Instrumentation- recapitulation, FTNMR, 2D NMR,- FID signal generation mechanism, Techniques in 2D NMR- homo nuclear correlation spectroscopy (COSY), total correlation spectroscopy (TOCSY), heteronuclear correlation (HETCOR).Application of NMR in structural elucidation Solid-state NMR. Application of NMR to other nuclei ^{13}C, ^{31}P and ^{15}N spectroscopy. **2.2 Electron spin resonance spectroscopy** Basic principle, hyperfine splitting (isotropic systems); g-value and the factors affecting there of; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); an isotropic effect (the g-value and the hyperfine couplings); The EPR of triplet states; Structural applications to transition metal complexes.	**(15L)**
	III	**Atomic and Molecular spectroscopy** **3.1** Angular momentum, orbital and spin, total angular momentum, total angular momentum (J) of many-electron atoms, Russell Saunders (L-S) coupling and J-J coupling**,** Term symbols, term symbols for multi-electron atoms like He, Li, Be, B etc. Exchange of interactions and multiplicity of states. Anomalous Zeeman Effect and Paschen Back effect. **3.2 Rotational spectroscopy:** Classification of poly atomic Molecules spherical top, symmetric top and asymmetric top molecules, intensity of spectral lines, non-rigid rotor, spectrum of non-rigid rotor, rotational Spectra of polyatomic molecules, Stark effect, Information derived from the rotational spectra. **3.3 Raman Spectroscopy:** Theory of Raman scattering, quantum theory classical theory of	**(15L)**

		molecular polarizability, pure Rotational Raman spectra, Vibrational Raman spectra, polarization and depolarization of Raman lines, structure determination using IR and Raman spectroscopy (example: XY_2, XY_3 and XY_4), instrumentation.	
		Practical: **Interpretation of spectra** 1. Interpretation of vibrational-rotational spectra of rigid and non-rigid diatomic molecules 2. Interpretation of electronic spectra of diatomic molecules. 3. Interpretation of electronic spectra of simple polyatomic molecules. 4. Interpretation of NMR, ESR spectra. 5. Analysis of XRD pattern of cubic system	

References:

1. G.Aruldas, Molecular Structure and Spectroscopy, Prentice-Hall of India, (2001).
2. F.A.Cotton, Chemical applications of Group Theory, Wiley Learner Ed., 2006, John Wiley and Sons,(Asia) Pvt.Ltd.
3. R.L.Carter, Molecular symmetry and Group theory, Wiley Learner Ed., 1996, John Wiley and Sons, (Asia) Pvt.Ltd.
4. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, (2001)
5. C.N.Banwell and E.M.McCash, Fundamentals of Molecular Spectroscopy, 4thEd., TataMcGraw-Hill, (1994)

Semester-IV
Course Code: DSE-I
Course Title: ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS
Academic year 2024-25

Course Outcomes:

After completion of this course, the learner will be able to,	
CO 1	Elaborate on the various physical , chemical and biological processes which are used in CETP to remove the contaminants from wastewater.
CO 2	Apply the concept of recycling, reuse & reclamation in managing solid waste in real life.
CO 3	Classify the different types of plastics.
CO 4	Outline the importance of additives in plastic.
CO 5	Estimate the amount of metallic impurities in plastics.
CO 6	Describe the composition of paints.
CO 7	Make use of the methodologies learned to carry out the analysis of each and every component present in paints.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title/Unit Title**	**Credits/ Lectures**
DSE-I		**ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS**	**3**

	I	**Effluent Treatment** **1.1. Effluent treatment:** primary secondary and tertiary (2L) **1.2** Plant general construction and process flow charts(3L) **1.3** Treatment and disposal of sewage.(3L) **1.4.** Effluent parameters for metallurgical industry Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent. (2L) **1.5** Recycle and reuse of process and treated (effluent) water. (2L) **1.6** Recovery of metals from effluent, modern methods – electrodialysis, electrodeposition and Ion Exchange etc.(3L)	**(15L)**
	II	**Solid Waste Management** **2.1.** Solid waste types and characteristic (2L) **2.2.** Solid waste management: objectives, concept of recycle, reuse and recovery (3L) **2.3.** Methods of solid waste disposal. (2L) **2.4.** Treatment and disposal of sludge / dry cake (3L) **2.5** Managing non-decomposable solid wastes (2L) **2.6** Bio- medical waste: Introduction, Classification and methods of disposal (3L)	**15 L**

	III	**Industrial materials** **3.1. Plastics & Polymers:** Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride, ethylene, acrylic and cellulosic plastics. (03L) **3.1.2** Metallic impurities in plastic and their determination (02L) **3.1.3** Impact of plastic on environment as pollutant. (01L) **3.1.4.** Recycling of plastic: International universal recycling codes and symbols for identification. Biodegradable plastics and alternatives. (02L) **3.2 Paints and pigments:** Types of paints and pigments, determination of volatile and non - volatile components, Flash point (significance and method of determination), separation and analysis of pigments, binders and thinners. (03L) **3.2.1.** Role of Organo silicones in paints and their impact on environment. (01L) **3.3. Soaps and Detergents:** Classification and composition with role of ingredients, properties, qualitative and quantitative analysis of ingredients of detergents- alkalinity, anionic matter and oxygen releasing capacity. Environmental hazards of common detergent chemicals. Biodegradable detergents. (03L)	**(15L)**

References:

1. H.R.Singh, Environmental Biology, S.Chand& Company Ltd.
2. P.S.Sindhu, Environmental Chemistry, New age international (P) limited Publishers.
3. Balram Pani, Textbook of Environmental Chemistry, I.K. International Publishing House Pvt.Ltd (2007).
4. Sameer. K.Banerji, Environmental Chemistry, 2nd edition, Prentice Hall of India Private Limited.
5. K Sasikumar and Sanoop Gopi Krishna, Solid waste management, PHI publication (2009).
6. Surendrakumar, Solid waste management, Northen Book Center (2009).
7. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry 2nd edition, Alpha Science, (2005).

Practical:

DSE-I	**Environmental & certain industrially important materials**	**Credits-01**

	1.	Determination of Silica by molybdenum blue method.	
	2.	Estimation of copper by extractive photometry.	
	3.	Separation of Ni(II) and Co(II) using anion exchanger column.	
	4.	Analysis of mixture of carbonate and bicarbonate using pH metry.	
	5.	Analysis of detergents: Oxygen releasing capacity, alkalinity, active anionic matter.	
	6.	Determination of dissolved oxygen in water sample with nitrite as impurity by Winkler's (Azide modification) method.	

Course Code: DSE-II

Course Title: SELECTED TOPICS IN ANALYTICAL CHEMISTRY

Academic year 2024-25

Course Outcomes:

After the completion of this course, the learner will be able to:	
CO 1	Recommend methods for the biodegradation of insecticides and pesticides.
CO 2	Judge the quality of the detergents by making use of the various methods which are used in industries for carrying out their analysis.

CO 3	Enlist properties of an ideal fuel.
CO 4	Determine the calorific value of fuels using the methodologies learned.
CO 5	Acquire awareness of the principles of green chemistry.
CO 6	Plan out the synthesis of a sample by incorporating benign and environmentally safe solvents.
CO 7	Develop an understanding of zone refining and vacuum fusion and extraction techniques.
CO 8	Classify the kinds of elements that can be purified by the process of zone refining.
CO 9	Suggest a method for analyzing different elements present in ores & alloys.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
DSE-II	**SELECTED TOPICS IN ANSLYTICAL CHEMISTRY**		**3**
	I	**Chemistry of fuels & agrochemicals** **1.1. Petrochemical products:** Crude oils, fuels, and calorific values, fractional distillation process and fractions, properties of fuel, composition of fuel, flashpoint, fire point, corrosion test, carbon residue and impact on environment. (05L) **1.2. Insecticides and Pesticides:** Definition, classification, and determination as pollutant. Biodegradation of insecticides and pesticides. (05L). **1.3. Fertilizers:** Introduction, Types - Nitrogen, Phosphorous, Potash and compound fertilizers, Analysis of fertilizers for its constituents, Impact of fertilizers on environment, Biofertilizers. (05L)	**(15L)**
	II	**Green Chemistry** **3.1** Principle and concepts of green chemistry: Sustainable development and green chemistry, Atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity (4L) **3.2** Organic solvents: environmentally benign solutions, solvent free systems, supercritical fluids (only introduction) Ionic liquids as catalysts and solvents (4L) **3.3** Emerging green technologies, photochemical reactions (advantages and Challenges) examples, Chemistry using microwaves, sonochemistry, electrochemical synthesis (4L) **3.4** Designing Greener processes: Inherently safer designs (ISD), Process intensification (PI) in-process monitoring. (3L)	**(15L)**

	III	**Metallurgy** **3.1. Ores and minerals:** Hydrometallurgy, Pyrometallurgy, Electrometallurgy. (One example in case for extraction of metals is to be discussed). Pollution due to metallurgical processes. (3L) **3.2.** Chemical analysis of ores for principal constituents : Galena, Pyrolusite, Bauxite, Hematite, Monazite (4L) **3.3 Alloys:** definition, analysis of Cupronickel, Magnelium, Steel and Stainless Steel, Bronze, Gun metal. (4L) **3.4 Techniques of purification:** Zone refining, analysis of high purity materials like silicon, vacuum fusion and extraction techniques. (4L).	**(15L)**

References:

1. Green chemistry An Introductory text, Mzike Lancaster, Royal Society of Chemistry (2002).
2. K. G. Das, Dekker, Pesticide Analysis, (1981).
3. S. L Chpra, J.S Kanwar, Analytical, Agricultural Chemistry Kalyani publication.
4. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau of Mines,(1979).
5. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).
6. Zone refining and allied techniques, Norman L. Parr, G. Newnes Technology &Engineering (1960).

Practical's:

DSE-II	**Selected topics in analytical chemistry**		**Credits-01**
	1.	Determination of calorific value, cloud point and pour point of fuels.	
	2.	Analysis of pesticides by HPLC.	
	3.	Elemental analysis of fertilizer.	
	4.	Microwave assisted synthesis of industrially important material.	
	5.	Analysis of Bauxite ore for Ti (by colorimetry), Al by gravimetry / Fe (volumetry).	
	6.	Analysis of Cupronickel alloy by electrogravimetry.	

	7.	TGA/DTA analysis of polymer.	

References:

1. G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3 rd Edition, Longman Scientific & Technical,1989.
2. Official methods of analysis of AOAC international,18th edition 2005,AOAC international.

MODALITY OF ASSESSMENT

Theory Examination Pattern:

A) Internal Assessment - 40% (30 Marks)

Presentation: 20 Marks

Continuous Internal Assessment (CIA): 10 Marks

For each paper, learners are evaluated from their presentation based on the topic selected from syllabus. The assessment of presentation is as follows:

Sr. No	Evaluation type	Marks
5.	**Presentation content**	**10**
6.	**Presentation skills**	**05**

7.	**Viva**	**05**
8.	**Continuous Internal Assessment (CIA) e.g. Test, Group discussion, assignment, open-book tests etc.**	**10**
	Total	**30**

B) External examination - 60 %

Semester End Theory Assessment - 45 marks

1. Duration - These examinations shall be of 2 hours duration.

2. Paper Pattern:

2.1 There shall be 03 questions each of 15 marks. On each unit, there will be one question.

2.2 All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions on
Q.1) A)	***Any 3 out of 5***	**12**	**Unit I**
Q.1) B)	***Any 1 out of 2***	**3**	
Q.2) A)	***Any 3 out of 5***	**12**	**Unit II**
Q.2) B)	***Any 1 out of 2***	**3**	
Q.3) A)	***Any 3 out of 5***	**12**	**Unit III**
Q.3) B)	***Any 1 out of 2***	**3**	

Practical Examination Pattern:

Semester End Practical Examination: 25 marks

Experimental work	**20**
Viva	**03**
Journal	**02**

PRACTICAL BOOK/JOURNAL the students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination. In case of loss of Journal, a Lost Certificate should be

obtained from Head/ Coordinator / In-charge of the department; failing which the student will not be allowed to appear for the practical examination.

On Job Training (OJT) / Internship: 10 credits (250 M)

Overall Examination and Marks Distribution Pattern

Course	DSC-I			DSC-II			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	30	45	75	30	45	75	150
Practical		25	25		25	25	50
Course	DSE			On Job Training (OJT)/ Internship			
Theory	30	45	75	250			325
Practical		25	25				25
						Total:	550