

 MANONMANIAMSUNDARANARUNIVERSITY-TIRUNELVELI UG PROGRAMMES 					
OPEN AND DISTANCE LEARNING (ODL) PROGRAMMES					
(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023-2024 ONWARDS)					
B.SC CHEMISTRY					
Semester	Course	Title of the Course	Course Code	Course Type	Credits
V	Core-IX	Organic Chemistry-I	JMCH51	Theory	4
	Core-X	Inorganic Chemistry-I	JMCH52	Theory	4
	Core-XI	Physical Chemistry-I	JMCH53	Theory	4
	Core-XII	Research and Methodology	JMCH54	Theory	4
	Elective-V	Nano Science	JECH51	Theory	3
	Elective-VI	Industrial Chemistry	JECH52	Theory	3
	NMC/Substitute Paper	Applied Chemistry	JNCH51	Theory	3

ORGANIC CHEMISTRY-I

UNIT-I Stereo chemistry

Fischer Projection, Newman and Sawhorse Projection formulae and their inter conversions;
Geometrical isomerism: cis-trans, syn-anti isomerism, E/Z notations.

Optical Isomerism: Optical activity, specific rotation, asymmetry, enantiomers, diastereoisomers, meso structures— molecules with one and two chiral centres, racemization—methods of racemisation; resolution—methods of resolution. C.I.P rules. R and S notations for one and two chirality (stereogenic) centres.

Molecules with no asymmetric carbon atoms – allenes and biphenyls. Conformational analysis of ethane and butane.

UNIT-II

Chemistry of Nitrogen Compounds-I

Nitroalkanes

Nomenclature, isomerism, preparation from alkyl halides, halo acids, alkanes; physical properties; reactions—reduction, halogenations, Grignard reagent, Pseudo acid character.
Nitro- acid nitro tautomerism.

Aromatic nitro compounds

Nomenclature, preparation—nitration, from diazonium salts, physical properties; reactions—reduction of nitrobenzene in different medium, Electrophilic substitution reactions, TNT.

Amines: Aliphatic amines

Nomenclature, isomerism, preparation – Hofmann's degradation reaction, Gabriel's phthalimide synthesis, Curtius Schmidt rearrangement.

Physical properties, reactions— alkylation, acylation, carbylamine reaction, Mannich reaction, oxidation, basicity of amines.

UNIT-III

Chemistry of Nitrogen Compounds-II

Aromatic amines – Nomenclature, preparation – from nitro compounds, Hofmann's method; Schmidt reaction, properties - basic nature, ortho effect; reactions – alkylation, acylation, carbylamine reaction, reaction with nitrous acid, aldehydes, oxidation, Electrophilic substitution reactions, diazotization and coupling reactions; sulphanilic acid-zwitterion formation.

Distinction between primary, secondary and tertiary amines -aliphatic and aromatic Diazonium compounds.

Diazomethane, Benzene diazonium chloride -preparations and synthetic applications.

Dyes

Theory of colour and constitution; classification based on structure and application; preparation–Martius yellow, aniline yellow, methyl orange, alizarin, indigo, malachite green. Industry oriented content

Dyes Industry, Food colour and additives.

UNIT-IV

Heterocyclic compounds

Nomenclature and classification. General characteristics-aromatic character and reactivity.

Five- member heterocyclic compounds

Pyrrole – preparation –from succinimide, Paal Knorr synthesis; reactions – reduction, basic character, acidic character, electrophilic substitution reactions, ring opening.

Furan – preparation from mucic acid and pentosan; reactions – hydrogenation, reaction with oxygen, Diels Alder reactions, formation of thiophene and pyrrole; Electrophilic substitution reaction.

Thio phene synthesis–from acetylene; reactions–reduction; oxidation;

Electrophilic substitution reactions.

UNIT-V

Six-member edheterocyclic compounds

Pyridine – synthesis -from acetylene, Physical properties; reactions -basic character, oxidation, reduction, electrophilic substitution reactions; nucleophilic substitution – uses, Condensedring systems.

Quinoline – preparation – Skraup synthesis and Friedlander’s synthesis; reactions – basic nature, reduction, oxidation; electrophilic substitutions; nucleophilic substitutions – Chichibabin reaction

Iso quinoline – preparation by the Bischler – Napieralski reaction, reduction, oxidation; electrophilic substitution.

Recommended Text:

- 1.M.K.Jain, S.C.Sharma, Modern Organic Chemistry, Vishal Publishing, fourth reprint, 2009.
- 2.S.M. Mukherji, and S.P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan India Ltd., third edition, 2009.
3. Arun Bah land B. S. Bahl, Advanced organic chemistry, New Delhi, S. Chand & Company Pvt. Ltd., Multicolour edition, 2012.
- 4.P.L. Soni and H. M. Chawla, Text Book of Organic Chemistry, Sultan Chand & Sons, New Delhi, twenty ninth edition, 2007.
- 5.C.N. Pillai, Text Book of Organic Chemistry, Universities Press (India) Private Ltd., 2009.

INORGANIC CHEMISTRY-I

UNIT-I

Co-ordination Chemistry-I

IUPAC Nomenclature of coordination compounds, Isomerism in coordination compounds.
Werner's coordination theory – effective atomic number –interpretation of geometry and magnetic properties by Pauling's theory–geometry of co- ordination compounds with co-ordination number 4&6.

Chelates – types of ligands forming chelates – stability of chelates, applications of chelates in qualitative and quantitative analysis–application of DMG and oxine in gravimetric analysis–estimation of hardness of water using EDTA, metal ion indicators.

Role of metal chelates in living systems–hemoglobin and chlorophyll

Unit-II

Co-ordination Chemistry-II

Crystal field theory –Crystal field splitting of energy levels in octahedral and tetrahedral complexes ,Crystal field stabilization energy (CFSE), Spectro chemical series – calculation of CFSE in octahedral and tetrahedral complexes - factors influencing the magnitude of crystal field splitting, crystal field effect on ionic radii, lattice energies, heats of ligation with water as a ligand (heat of hydration), interpretation of magnetic properties, spectra of $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ - Jahn – Teller effect. Stability of complexes in aqueous solution, stability constants - factors affecting the stability of a complex ion, thermodynamic and kinetic Stability (elementary idea). Comparison of VBT and CFT.

UNIT-III

Organo metallic compounds

Metal Carbonyls

Mono and polynuclear carbonyls, General methods of preparation of carbonyls – general properties of binary carbonyls – bonding in carbonyls– structure and bonding in carbonyls of Ni, Fe, Cr, Co, Mn, Ru and Os. EAN rule as applied to metal carbonyls.

Ferrocene–Methods of preparation, physical and chemical properties.

UNIT-IV

Inner transition elements (Lanthanoids and Actinoids)

General characteristics of f-block elements - Comparative account of lanthanoids and actinoids - Occurrence, Oxidation states, Magnetic properties, Colour and spectra –Lanthanoids and Actinoids, Separation by ion-Exchange and Solvent extraction methods - Lanthanoids contraction- Chemistry of thorium and Uranium-Occurrence, Ores, Extraction, properties and uses - Preparation, Properties and uses of ceric ammonium sulphate, thorium dioxide and uranyl acetate.

UNIT-V

Inorganic polymers

General properties – classification of inorganic polymers based on element in the backbone (Si, S, B and P) – preparation and properties of silicones (poly dimethyl siloxane and poly methyl hydrosil oxane) phosphorous based polymer (poly phosphazines and poly phophonitrilic chloride), sulphur based polymer (poly sulfide and polymeric Sulphur nitride), boron based polymers (borazine polymers) – industrial applications of inorganic polymers.

Recommended Text:

1. Puri. B. R, Sharma. L. R, Kalia. K.C. (2011), Principles of Inorganic Chemistry, 31th Edition, Milestone Publishers & Distributors, Delhi.
2. Satya Prakash, Tuli. G. D., Basu. S.K., Madan. R.D.(2009),

Advanced Inorganic Chemistry, 18th Edition, S. Chand & Co., New Delhi

3. Lee. J.D, (1991), Concise Inorganic Chemistry, 4th Edition, ELBS William Heinemann, London.
4. W.V. Malik, G.D. Tuli, R.D. Madan, (2000), Selected Topics in Inorganic Chemistry, S. Chand and Company Ltd.
5. A.K. De, Textbook of Inorganic Chemistry, Wiley East Ltd, seventh edition, 1992.

PHYSICAL CHEMISTRY - I

UNIT-I

Thermodynamics-III

Free energy and work functions – Need for free energy functions, Gibbs free energy, Helmholtz free energy – their variation with temperature, pressure and volume, criteria for spontaneity; Gibbs-Helmholtz equation – derivations and applications; Maxwell relationships, thermodynamic equations of state; Thermodynamics of mixing of ideal gases, Ellingham Diagram-application.

Partial molar properties – chemical potential, Gibbs Duhem equation, variation of chemical potential with temperature and pressure, chemical potential of a system of ideal gases, Gibbs-Duhem – Margules equation.

UNIT-II

Chemical Kinetics

Rate of reaction – Average and instantaneous rates, factors influencing rate of reaction - molecularity of a reaction - rate equation - order of reaction. Order and molecularity of simple and complex reactions, Rate laws- Rate constants – derivation of rate constants and characteristics for zero, first order, second and third order (equal initial concentration) – Derivation of time for half change with examples. Methods of determination of order of Volumetry, manometry and polarimetry.

Effect of temperature on reaction rate – temperature coefficient – concept of activation energy – Arrhenius equation. Theories of reaction rates – Collision theory – derivation of rate constant of bimolecular gaseous reaction – Failure of collision theory. Lindemann's theory of unimolecular reaction. Theory of absolute reaction rates–Derivation of rate constant for a bimolecular reaction – significance of entropy and free energy of activation. Comparison of collision theory and ARRT.

Complex reactions–reversible and parallel reactions (no derivation and only examples)
–kinetics of consecutive reactions–steady state approximation.

UNIT-III

Adsorption – Chemical and physical adsorption and their general characteristics – distinction between them. Different types of isotherms – Freundlich and Langmuir. Adsorption isotherms and their limitations – BET theory, kinetics of enzyme catalyzed reaction – Michaelis-Menten and Briggs-Haldane equation – Lineweaver-Burk plot – inhibition – reversible – competitive, non competitive and uncompetitive (no derivation of rate equations)

Catalysis – general characteristics of catalytic reactions, autocatalysis, promoters, negative catalysis, poisoning of a catalyst – theories of homogeneous and heterogeneous catalysis – Kinetics of Acid-base and enzyme catalysis. Heterogeneous catalysis.

UNIT-IV

Colloids and Surface Chemistry

Colloids: Types of Colloids, Characteristics of Colloids (Lyophilic and Lyophobic sols), Preparation of Sols - Dispersion methods, aggregation methods, Properties of Sols - Optical properties, Electrical properties - Electrical double layer, Electrokinetic properties- Electro-osmosis, Electrophoresis, Coagulation or precipitation, Stability of sols, associated colloids, Emulsions, Gels-preparation of Gels, Applications of colloids,

Macromolecules: Molecular weight of Macromolecules - Number average molecular weight – average molecular weight, Determination of Molecular weight of molecules

UNIT-V

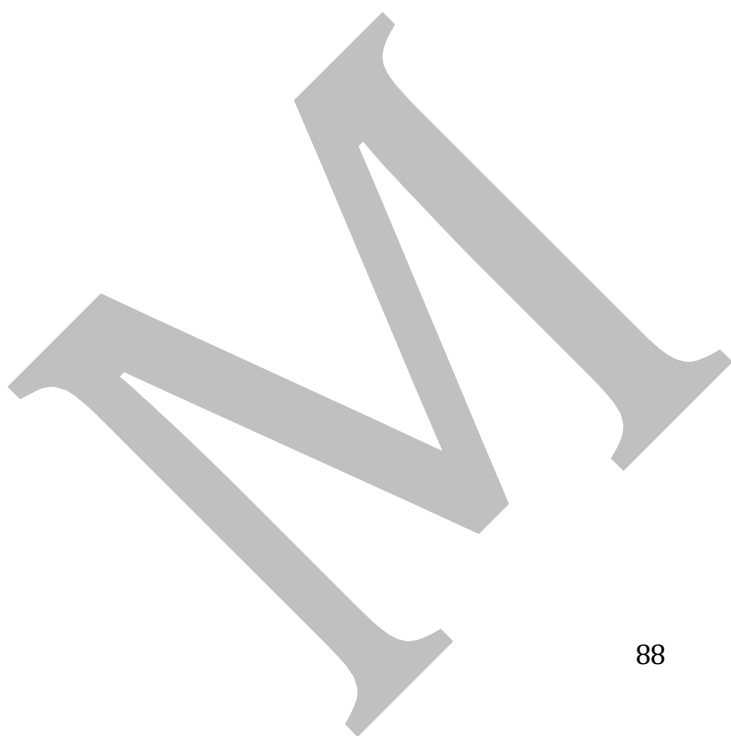
Photo chemistry

Laws of photo chemistry – Lambert – Beer, Grotthaus – Draper and Stark – Einstein. Quantum efficiency. Photochemical reactions – rate law – Kinetics of $\text{H}_2\text{-Cl}_2$, $\text{H}_2\text{-Br}_2$ and $\text{H}_2\text{-I}_2$ reactions, comparison between thermal and photo chemical reactions.

Fluorescence-applications including fluorimetry – sensitised fluorescence, phosphorescence – applications – chemiluminescence and photo sensitisation- examples Chemistry of Vision-11cis retinal- vitamin A as a precursor colour perception of vision.

Recommended Text:

1. B.R. Puri and L.R. Sharma, Principles of Physical Chemistry, Shoban Lal Nagin Chand and Co., forty eighth edition, 2021.
2. Peter Atkins, and JuliodePaula, James Keeler, Physical Chemistry, Oxford University press, International eleventh edition, 2018.
3. Arun Bahl, B.S. Bahl, G.D. Tuli Essentials of physical chemistry, 28th edition, 2019, S.Chand & Co.
4. S.K. Dogra and S. Dogra, Physical Chemistry through Problems: New Age International, fourth edition, 1996.
5. J. Rajaram and J.C. Kuriacose, Thermodynamics, Shoban Lal. Nagi Chand and CO., 1986.



NANO SCIENCE
UNIT I Introduction to nanoscience Definition of terms– nano science, nano particles, clusters, quantum dots, nano structures and nano composites. Electron behavior in free space, bulk material and nano materials. Synthesis and stabilization of nano materials Topdown approach (physical methods), mechanical dispersion–ball milling, methods based on evaporation of a precursor–inert gas condensation, ions pattering, spray pyrolysis, aerosol synthesis–nanolithography. Bottom–up approach (chemical methods) – solvo thermal synthesis, photo chemical method, gamma radiolysis, sonochemical synthesis, electro deposition, sol-gel method, nano materials via chemical routes– solvents reducing agents, capping agents–stabilization of nano particles–electrostatic and steric
stabilization, common stabilizers, nano particle growth in solution, Template growth, Langmuir–Blodgett(L-B)method ,reverse micelles- Emulsion method.
Unit II Properties of materials on a nanoscale Optical properties of metal and semiconductor nanomaterials–surface Plasmon resonance (SPR), surface enhanced Raman spectra (SERS), Quantum on finement effect, tuning of optical spectrum. Magnetic properties–Fe₃O₄ particle, supramagnetic properties, electronic properties, Chemical properties– chemical process on the surface of nano particles, catalysis, mechanical properties.
UNIT III Techniques employed for characterisation of nano materials Spectroscopy–UV- visible, Photoelectron spectroscopy–Electron microscopy–Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning probe microscopy (SPM)– Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM),Optical microscopy–confocal microscopy, X-ray diffraction (XRD)[Principle and Block diagram only].
UNIT IV Special nanomaterials Carbon Nano Structures Carbon nanotubes: Introduction–types–zigzag, Armchair, helical, synthesis by CVD, Functionalization of Carbon Nanotubes, Reactivity of Carbon Nanotubes, Field emission, Fuel Cells, Display devices. Other Important Carbon based materials: Preparation and Characterization Fullerene, Graphene, properties, DLC and Nanodiamonds and Applications Semiconductor nanoparticles: Quantum dots, synthesis–chemical Synthesis using clusters, properties, porous silicon–electrochemical etching, aerogel–types–silica aerogel, resorcinolformaldehyde (RF) aerogels, zeolites–applications. Self-Assembled Nanomaterials: Self Assembled Monolayers (SAMS)– inorganic, organic molecules.

UNIT V

Application of nanomaterials

Biomedical Applications-drug, drug delivery, bio labelling, artificial implants, cancer treatment. Sensors– Natural nanoscale sensors, Chemical sensors, biosensors, electronic noses. Optics & Electronics–Nanomaterials in the next generation computer technology, high-definition TV, flat panel displays, quantum dot laser, Single electron transistors [SET]. Nanotechnology in agriculture–Fertilizer and pesticides nanomaterials for water purification, nanomaterials in food and packaging materials, fabric industry. Impacts of Nanotechnology–human & environmental safety risks.

Recommended Text:

1. Sulabha K. Kulkarni, *Nanotechnology: Principles and Practices*, Capital Publishing Co., New Delhi.
2. Pradeep. T, *Nano: The Essentials, Understanding Nanoscience and Nanotechnology*; Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
3. Shah. M.A.; Tokeer Ahmad, *Principles of Nanoscience and Nanotechnology*; Narosa Publishing House, New Delhi, 2010.
4. Murthy. B.S; Shankar. P, Baldev Raj.; Rath. B.B. James Murday, *Textbook of Nanoscience and Nanotechnology*; Universities press, India Ltd, Hyderabad. 2012.

INDUSTRIAL CHEMISTRY

UNIT-I

Survey of Indian Industries and mineral resources in India

Fuels: Classification, characteristics of fuels. Solid fuels: coal - classification; analysis of coal - proximate analysis and ultimate analysis; calorific value - determination, carbonization of coal.

Liquid fuels: Petroleum - characteristics; Gasoline aviation petrol- knocking in internal combustion engines, anti knock agents; unleaded petrol-octane number, cetane number.

Gaseous fuel: advantages over solid and liquid fuels; water gas, producer gas, carbureted water gas - preparations-uses.

Natural gas: LPG-composition, advantages, application; gobar gas- production, composition, advantages, application. Propellants – rocket fuels (basic idea)

UNIT-II

Cosmetics

Skin care: powders, ingredients; creams and lotion-cleansing, moisturising, all purpose shaving cream, sunscreen; make up preparations.

Dentalcare: toothpastes-ingredients.

Haircare: shampoos- types, ingredients; conditioners-types, ingredients. Perfumes: natural-plant origin-parts of the plant used, chief constituents;

animal origin - amber gries, civetone and musk; synthetic classification- esters – amyl salicylate alcohols -citronellol; terpeneols -geraniol and nerol; ketones - muskone, coumarin; aldehydes - vanillin.

Soaps and Detergents

Soaps-properties, manufacture of soap- batch process; types- transparent soap, toilet soap, powder soap and liquid soap – ingredients.

Detergents - definition, properties – cleansing action; soap less detergents - anionic, cationic and non-ionic (general idea only); uses of detergents as surfactants. Biodegradability of soaps and detergents.

UNIT-III**Sugar Industry**

Manufacture from sugar cane; recovery of sugar from molasses; testing and estimation of sugar.

Food Preservation and processing

Food spoilage—causes; Food preservation—methods—high temperature, low temperature, drying, radiation; Food additives – preservatives, flavours, colours, anti-oxidants, sweetening agents; hazards of using food additives; Food standards – Agmark and Codex alimentarius.

UNIT-IV**Abrasives**

Definition, characteristics, types - natural and synthetic; natural abrasives – diamond, corundum, emery, garnet, quartz – composition, uses; synthetic abrasives – carborundum, aluminium carbide, boron carbide, boron nitride, synthetic graphite – composition and uses.

Leather Industry

Structure and composition of skin, hide; Manufacture of leather—pre-tanning process – curing, liming, beating, pickling; methods of tanning- vegetable, chrome—one bath, two bath process; finishing.

Paper Industry

Manufacture of pulp - mechanical, chemical processes; sulphate pulp, rag pulp; manufacture of paper- beating, refining, filling, sizing, colouring, calendaring; cardboard.

UNIT-V**Lubricants**

Definition, classification-liquid, semi-solid, solid and synthetic; properties – viscosity index, flash point, cloud point, pour point, aniline point and drop point; greases - properties, types; cutting fluids,

Selection of lubricants.

Cement Industry

Cement – types, raw materials; manufacture – wet process, constituent of cement, setting of cement; properties of cement-quality, setting time, soundness, strength; mortar, concrete, RCC; curing and decay of concrete.

Intellectual Property Rights

Introduction to Intellectual Property Rights – Patents - Factors for patentability - Novelty, Nonobviousness, Industrial applications - Patent offices in India: Trademark - Types of trademarks- Certification marks, logos, brand names, signatures, symbols and service marks.

Recommended Text:

1. Sharma, B.K. *Industrial Chemistry*, 9thed.; Goel Publishing House: Meerut, 1998.
2. Wilkinson. J. B. E, Moore. R. J, *Harry's Cosmeticology*, 7thed.; Chemical Publishers: New York, 1982.
3. Alex. V. Ramani, *Food Chemistry*, MJP publishers: Chennai, 2009.
4. Jayashree Ghosh, *Applied Chemistry*, S. Chand: New Delhi, 2006.
5. Srilakshmi, B. *Food Science*, 4thed.; New Age International Publication, 2005.

• APPLIED CHEMISTRY
Naan Mudhalvan (substitute)
UNIT-I FUEL CHEMISTRY Fuels- Definition-Classification - Combustion and Chemical Principles – Calorific Value- Characteristics of a good fuel. Solid fuel: Coal - Types - Gross and Net calorific values- Proximate and Ultimate analysis of coal - High and low temperature of carbonization - Uses. Liquid fuels: Petroleum and its Chemical Composition- Cracking of heavy oil residues- Thermal and catalytic cracking, Knocking, Anti-knock and Chemical structure, Octane and Cetane numbers - Significance - Petroleum products and their applications. Gaseous fuels: Preparation and Specific uses of Producer gas, Water gas. LPG and Gobar gas. Advantages and Disadvantages of Solid, Liquid and Gaseous fuels. Rocket fuels- Classification of Solid Propellants, Liquid Propellants’ - Combustion -Spontaneous ignition temperature (SIT) - Combustion calculation. UNIT-II: PAINTS, LUBRICANTS, ADHESIVES AND PIGMENTS Paints: Classification- Primary constituents, Manufacturing of paints, Emulsion paint- Constituent and advantages-Latex paints and Fire retardant paints, Solvents and Thinners. Lubricants: Functions of lubricants-Properties and Classifications - Additives for lubricating oil, Lubricants of mineral origin. Lubricating grease and Solid lubricants. Adhesives: Classification and preparation of adhesives. Synthetic resin adhesives and Rubber based adhesives -Uses of adhesives. Pigments: Characteristics and uses of TiO_2 , Ultramarine Blue and Red lead. UNIT-III: AGRICULTURAL CHEMISTRY Fertilizers: Raw material, manufacture (flow chart)- Chemical process (with equation) of ammonium nitrate, ammonium sulphate, urea, ammonium phosphate, super phosphate, triple super phosphate, NPK fertilizers. Pesticides: Classification of pesticides, examples. Insecticides: Stomach poisons, Contact insecticides, Fumigants, Manufacture and uses of Insecticides: DDT, BHC, Pyrethrin, Aldrin and Pentachlorophenol. Fungicides: Bordeaux mixture, Lime Sulphur, Creosote oil. UNIT-IV: OILS, SOAPS AND DETERGENTS Oils: Definition: Fats and Oils- Constituents-Sources- Difference between oils and fats, Manufacture of Cottonseed oil, Sunflower oil and Soyabean oil. Soaps: Definition, Manufacture of soaps- Types of soaps -Specific uses. Detergents: Difference between soaps and detergents, Synthetic detergents- Surface active agents and their classification- Anionic, Cationic and Non - ionic detergents - Applications including cleaning action. UNIT-V: MATCH AND SILICATE INDUSTRIES

Match Industry; Types of Matches- Composition of match head and striking surface- Manufacture of safety matches-Coloured matches- Pyro techniques and explosives, Classification of good explosives TNT, RDX, Gun powder, Ammonium nitrate.

Silicate industry; Cement: Types of cements, composition, manufacture of Portland cement and setting of cement.

Ceramics: Introduction, Types, Manufacture, and Applications, Refractory materials.

Glass: Definition, Composition, Types, Manufacturing of glass products, Physical and Chemical properties, Applications.

Text Books

1. B.K. Sharma, Industrial Chemistry, Goel Publishing House, Meerut, 2003.
2. James A. Kent, Riegel's Handbook of Industrial Chemistry, Springer Science, 2013.

B.Sc CHEMISTRY
Research and Methodology

Category: Core XII

Year: III / V Semester

Credits: 3

Course Objectives:

The course aims to introduce the basic concepts of research at undergraduate level. It familiarizes students with the process of scientific writing, data collection, analysis, and reporting. It provides exposure to research ethics, referencing styles, plagiarism awareness and helps in building skills for mini-projects, internships, and preparing for higher studies.

Unit I: Introduction to Research

This unit explains the definition, scope, and objectives of research, highlighting its role in Chemistry. Different types of research including basic, applied, qualitative, and quantitative approaches are introduced.

Unit II: Research Process

Students learn to identify research problems and conduct literature surveys using books, journals, and databases. The formulation of hypotheses, objectives, and planning of research designs are also covered.

Unit III: Data Collection and Analysis

This unit deals with methods of collecting primary and secondary data and the use of sampling techniques. Basic data representation using tables and graphs, along with simple statistical tools, is emphasized.

Unit IV: Research Tools and Techniques

Students are introduced to laboratory methods, digital tools like MS Excel and reference managers, and the importance of documentation. Laboratory safety and research ethics are also highlighted.

Unit V: Report Writing and Presentation

This unit discusses the structure of research reports and projects with reference to APA, MLA, and ACS styles. Theoretical aspects of preparing mini-project proposals along with an understanding of concepts of effective presentation in academic and professional contexts.

Course Outcomes (CO)

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

CO1: Explain the basic concepts, scope, and types of research.

CO2: Identify research problems and prepare objectives with a proper literature survey.

CO3: Apply appropriate tools for data collection, representation, and simple analysis.

CO4: Demonstrate use of digital and laboratory tools in research with awareness of ethics.

CO5: Prepare a structured research report and present findings effectively.

Reference Books:

1. Kothari, C. R. Research Methodology: Methods and Techniques, New Age International Publishers, 2004.
2. Kumar, Ranjit. Research Methodology: A Step-by-Step Guide for Beginners, Sage Publications, 2019.
3. Day, Robert A. and Gastel, Barbara. How to Write and Publish a Scientific Paper, Cambridge University Press, 2012.
4. Creswell, J. W. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Sage Publications, 2018.
5. Gurumani, N. Scientific Thesis Writing and Paper Presentation, MJP Publishers, 2010.