

**FACULTY OF SCIENCE  
DEPARTMENT OF CHEMISTRY  
A.M.U., ALIGARH  
M.Sc. (Industrial Chemistry)**

**The Test Syllabus will comprise all papers being thought at B.Sc. (Hons) Industrial Chemistry.**

**Industrial aspects of Organic Chemistry & Inorganic Chemistry:**

Raw materials for organic compound: Petroleum Natural gas, Fractional of crude oil, cracking, reform, hydroforming, isomerisation. **Coal:** Types, structures, properties, distillation of coal, chemicals derived from them.

**Renewable natural resources:** Cellulose, Starch - Properties, modification, important, ind. chemical derived from them, Alcohol and alcohol based chemicals, oxalic acid, furfural.

**Basic Metallurgical operations :** Pulverisation, Calcinations, Roasting, Refining.

Physicochemical principles of extraction of; Iron, copper, lead Silver, Sodium ,aluminium, magnesium zinc, chromium. Inorganic materials of industrial importance : Their availability, forms structure and modification, Alumina, silica, silicates, clays, mica, carbon, zeolites.

**Industrial Aspects of Physical Chemistry & Materials and Energy Balance**

Adsorption isotherm, Sols, Gels Emulsions, Microemulsions, Micellers, Aerosols, Effects of Surfactants Hydrotropes, Introduction, Types - Homogeneous and Heterogeneous, Basic principles, mechanism, factors, affecting the performance

introduction to phase transfer catalysis, Enzyme, catalysed reactions - rate model, industrially important reactions.

Basic Chemical Calculations - Atomic weight, molecular weight, equivalent weight, mole, composition of (i) liquid mixtures and (ii) gaseous mixture. Flow diagram for material balance, simple material balance

or without recycle or by-pass for chemical engineering operations such as distillation, Concept of limiting reaction conversion, yield, Liquid phase reaction, gas phase reactions, with/without recycle or by-pass. Heat capacity of pure gases and gaseous mixtures at constant pressures, sensible heat change ion liquids, enthalpy changes.

**Analytical Techniques**

Classification of Analytical methods; Types of instrumental methods, Instruments for Analysis, selecting an Analytical method, Factors affecting Analytical methods, calibration of instrumental methods Separation techniques: solvent extraction, Ion-exchange separations, Instrumental separations. Chromatography: TLC, LC, GC, HPLC methodology, equipment and Industrial Applications. Titrimetric Analysis: Classification of reactions, principles of potentiometric titrations. Mechanical-physical separation process: introduction, classification and Filtration in solid-liquid separations.

**Pollution**

Introduction to Pollution, Significant of dissolved oxygen and its estimation, Bio – accumulation, Bio magnification and Eutrophication of pollutants. Pollutants and their types. Chemical oxygen demand and biological oxygen demand. Air pollution and air quality monitoring, water pollution and water quality monitoring, Soil/Land pollution and soil quality monitoring. Thermal Pollution Noise Pollution

Formation and break down of ozone in the atmosphere, ozone depletion Green house effect. Pollution aspects of cement industry. Pollution aspects of paper & Pulp Industry. Pollution aspects of thermal power plant Management and disposal of various types of waste. Bhopal gas disaster. Sevazo disaster. Minimata disaster. Better Industrial Process.

**Industrial Waste Treatment & Management**

Industrial Waste Water Treatment Technology, types of treatment physical, chemical and biological. Treatment levels Primary (Sedimentation, Filtration, Grit removal etc), Secondary (Trickling filter, rotary drum reactor, aerobic and anaerobic treatment), Tertiary Treatment (Adsorption, advanced oxidation etc). Strategies for Industrial water recycle and reuse.

Solid Waste Management

Types of waste, management of solid waste, treatment and disposal of non-hazardous solid waste (landfills, scrubbing, flue gas cleaning, incineration, heat drying, wet oxidation, biodegradation etc), treatment of hazardous waste, E-waste treatment.

### **Industrial Pharmaceuticals**

Pharmaceuticals Chemistry – Introduction – nature and sources of drugs–Study of drugs- classification and nomenclature of drugs- Mechanism of drug action and metabolism of drugs.Clinical Chemistry – determination of sugar in serum- estimation of glucose in urine- detection of cholesterol in urine – detection of diabetes- estimation of hemoglobin- red cell count. Causes of common diseases and their treatment by drugs Insect borne, air- borne and water borne diseases- disorder of digestive system-diseases of respiratory system- disorder of nervous system.

### **Elementary Spectroscopy**

**Mass Spectroscopy:** basic principal of mass spectrum- molecular peak – base peak- isotopic peak-meta stable peak – factors influencing the fragmentation – nitrogen rule - ring rule determination of molecular formulae with examples – instrumentation.

**Infra red spectroscopy :** molecular vibration- **Hooke's law** –vibration frequencies – factors affecting vibration frequencies- instrumentation – block diagram- source – monochromator – cell sampling techniques- detector recorders- solvent shift

**NMR spectroscopy :** Principle of nuclear magnetic Resonance- basic instrumentation- shielding mechanism – chemical shift- number of signals-spin- spin coupling and coupling constant – splitting of signals.

**Ultraviolet Visible Spectroscopy :** Lambert Beer's Law, Types of transitions and types of bands, concept of chromophores and auxochromes, calculation of wavelength maximum based on Woodward Fieser rule, Fluorescence and phosphorescence.

### **Agrichemicals**

**Introduction:** General introduction to Agrichemicals. Introduction and types of pesticides. Stomach poisons, contact poisons, systemic poisons, fumigants. **Insecticides:** Synthesis and manufacture, mode of action and uses of insecticides in the following classes: Inorganic insecticides (acid lead arsenate and calcium arsenate), **Fungicides** General introduction and classification of fungicides. Synthesis and manufacture, mode of action and uses of: Inorganic fungicides (copper sulphate and bordeaux mixture), Organomercuric compounds (ethylmercuric chloride and cerasan-M), Dithiocarbamates (zineb and maneb) and Miscellaneous fungicides (captan and folpet). **Herbicides, Fumigants, Nematicides, Rodenticides and Plant growth regulators** General introduction. Synthesis and uses of the following: Herbicides (2,4-D and MCP), Fumigants (ethylene halides and methyl halides)

**Polymer Science:** Brief history of macromolecular science, general characteristics of polymers in comparison to common organic compounds, some basic definitions (functionality, polymer, polymerization, homopolymer, copolymer terpolymer etc.).Classification of polymers: Natural synthetic, inorganic, organic, thermoplastics, thermosets, glasses, elastomers, fibres, commodity engineering, speciality, linear, branched, cross-linked copolymers (random, alternative, block and graft), tacticity (isotactic, and atactic polymers), crystallinity (crystalline, semi-crystalline and amorphous polymers. Addition polymerization (mechanism of free-radical, anionic and cationic polymerization), initiators, inhibitors, retarders, living polymers, condensation polymerization copolymerization, coordination polymerization (bulk, suspension, emulsion, solution).

Average molecular weight, number - average and weight-average molecular weights, sedimentation and viscosity average, molecular weights, practical significance of molecular weight and molecular weight distribution, size of polymer molecules, determination, of molecular weight (viscosity, osmometry, light scattering).

### **PETROCHEMICALS**

Origin and formation of Petroleum, Petroleum Reserves and Deposits, Composition of crude oil, Non-hydrocarbon components in Petroleum, Asphaltenes and Resins.

Characterization of crude oil: TBP and ASTM distillation, Classification by chemical composition, Correlation Index, Density, API gravity, Viscosity, UOP characterization factor, etc. Physical & Thermal properties of petroleum, Petroleum products and their quality control. Thermal conversion processes: Visbreaking, Delayed Coking, Fluid coking, Flexicoking, etc Catalytic conversion processes: Fluid Catalytic Cracking, RFCC, DCC, Hydrocracking, Hydrotreating Processes, etc.

Catalytic Reforming, Alkylation, Polymerization, Isomerisation etc. Technology for the production of Methanol, Ethylene oxide, Ethylene glycol and Vinyl Chloride, Acetic acid Technology for the Production of acetone, acrylonitrile, linear alkyl benzene Technology for the production of benzene, toluene, xylenes, phenol, styrene Technology for the production of isopropanol, butadiene, isobutene, isobutene Indian Petrochemical Industry: Indian reserves, Indian Refining Scenario, Quality control and Petroleum Distribution, Environmental concern and Emission Norms, Refinery waste Disposal Practices.

### Inorganic Chemistry

Idea of de Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrodinger wave equation, significance of  $\Psi$  and  $\Psi^2$ , quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d orbitals. Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Electronic configurations of the elements. Atomic and ionic radii, ionization energy, electron affinity and electronegativity definition, effective nuclear charge, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour. Lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule, Metallic bond-free electron, valence bond and band theories

Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds. Comparative study

Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concepts of acids and bases Classification of acids and bases as hard and soft, Pearson's HSAB concept, acid-base strength and hardness and softness, Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness. Physical properties of a solvent, types of solvents and their general characteristics, reaction in non-aqueous solvents with reference to liquid  $\text{NH}_3$  and liquid  $\text{SO}_2$

### **Organic Chemistry**

Hybridization and its effect on bond length and bond angles, bond energy, localized and delocalized chemical bond, inductive, resonance, hyperconjugation, hydrogen bonding, van der Waals interactions Homolytic and heterolytic bond breaking. Types of reagents-electrophiles and nucleophiles, Types of organic reactions. Energy considerations. Reactive intermediates-carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples). Assigning formal charges in intermediates and other ionic species. Concept of isomerism. Optical isomers, enantiomers and diastereomers, chiral and achiral molecules with two stereogenic centres, absolute configuration, sequences rules, D & L and R & S systems of nomenclature. Geometrical isomerism - E & Z system of nomenclature, in alkenes oximes and cyclopropane derivative compounds. Alkanes: Methods of formation (with special reference to Wurtz reaction, Kolbe reaction, Corey-House reaction and decarboxylation of carboxylic acids), Mechanism of free radical halogenation of alkanes- orientation, reactivity and selectivity. Methods of formation, dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration. The Saytzeff rule, Hofmann elimination, Relative stabilities of alkenes. Chemical reactions-mechanisms involved in hydrogenation, electrophilic and free radical additions.

Markownikoff's rule. Hydroboration-oxidation, oxymercuration-demercuration, epoxidation, ozonolysis, hydration, hydroxylation with  $\text{KMnO}_4$ . classification- isolated, conjugated and cumulated dienes. Structure, method of formation and reactions (1,2- and 1,4-additions, Diels-Alder reaction) of butadiene. Methods of formation, chemical reactions and acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reaction. Methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters. Grignard synthesis: Grignard reagent and its use for synthesis of alcohol. Reactions of alcohols. Distinction between Primary, Secondary and Tertiary alcohols., Oxidative cleavage [ $\text{Pb}(\text{OAc})_4$  and  $(\text{HIO}_4)$ ] and Pinacol-Pinacolone rearrangement. Structure of benzene-molecular formula and Kekule structure. Stability and carbon-carbon bond lengths of benzene, resonance structure, MO picture. Aromaticity- the Huckel rule, aromatic ions. Aromatic electrophilic substitution general pattern of the mechanism, role of  $\sigma$ - and  $\pi$ -complexes. Mechanism of nitration, halogenation, sulphonation and Friedel-Craft reactions.

## Physical Chemistry

Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waals equation of state. *Critical Phenomena*: PV isotherms of real gases, continuity of states, the isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state.

Problems Molecular velocities: Root mean square, average and most probable velocities. Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. liquification of gases (based on Joule-Thomson effect). Problems Definition of space lattice, unit cell. Laws of crystallography - (i) Law of constancy of interfacial angles (ii) Laws of rationality of indices (iii) Law of symmetry. Symmetry elements in crystals.

### **Solid State**

X-ray diffraction by crystals. Derivation of Bragg equation. Determination of crystal structure of NaCl, KCl and CsCl. Definition of colloids, classification of colloids.

*First law of thermodynamics*: statement, definition of internal energy and enthalpy, Heat capacity. Heat capacities at constant volume and pressure and their relationship. Joule-Thomson coefficient and inversion temperature. Calculation of  $w, q, dU$  &  $dH$  for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process. Problems.

*Thermochemistry*: Enthalpy of neutralization. Bond dissociation energy and its calculation from thermochemical data, temperature dependence of enthalpy. Kirchhoff's equation.

*Second law of thermodynamics*: Different statements of the law. Carnot cycle and its efficiency, Carnot theorem. Thermodynamic scale of temperature. *Concept of entropy*: entropy as a state function, entropy as a function of  $V$  &  $T$ , entropy as a function of  $P$  &  $T$ , entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium. Entropy change in ideal gases and mixing of gases. Gibbs and Helmholtz functions: Gibbs function ( $G$ ) and Helmholtz function ( $A$ ) as thermodynamic quantities,  $A$  &  $G$  as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, Variation of  $G$  and  $A$  with  $P$ ,  $V$  and  $T$ .

Thermodynamics of ideal solution and Raoult's law, deviations from Raoult's law – non-ideal solutions. Partial miscibility of liquids: Critical solution temperature; Nernst distribution law and its applications, Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient, Problems.

### **Solution**

Dilute solution, Colligative properties, relative lowering of vapour pressure, law of osmotic pressure and its measurement, Elevation of boiling point and depression of freezing point. Phases, components and degrees of freedom of system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clapeyron equation and its importance in phase equilibria.

### **Statistics and Mathematics**

Graphical representation of data, measure of central tendency and dispersion, skewness, kurtosis, correlation, Regression, Probability, Sampling and sampling distribution, Discrete & continuous distribution, Test of significance, time series analysis, Index numbers, analysis of variance, Matrix and Determinants, Partial Differentiation and elementary partial differential equation. Algebra and Complex numbers, Functions, limit and continuity, differentiability, differential Calculus, Integral Calculus, Ordinary differential equations, Introduction to numerical methods or analysis and their application in chemistry.