

**FURTHER DETAILS REGARDING MAIN TOPICS OF
PROGRAMME No. 02/2020(Item No.7)**

CHEMIST

FACTORIES AND BOILERS

(Category No.014/2019)

I. Inorganic Chemistry

Metallurgy : Occurrence of metals based on standard electrode potential – concentration of ores – calcination, roasting and smelting – reduction using carbon and other reducing agents – electrolytic reduction – hydrometallurgy – Ellingham diagram. Refining of metals – electrolytic refining – oxidative refining – zone refining – Van Arkel method. Extractive metallurgy of Li, Ni, Ti and U – Ferrous metallurgy – manufacture of steel by open hearth process – Alloys – composition and uses of German silver, Brass, Bronze, Gunmetal, Alnico.

Inorganic Polymers: Synthesis, structure and applications of silicones, phosphazenes, S-N compounds, S-P compounds. Silicates, zeolites.

Some industrially important inorganic materials : Cement – Manufacture, composition and setting. Glass – Manufacture – annealing – types of glasses – uses. Ceramics – Definition, traditional and new ceramics – structure of ceramics – uses – Inorganic fertilizers – essential nutrients for plants – nitrogenous, phosphatic and potash fertilizers. Role of selenium in Xerography. Refractory materials – carbides and borides.

Non Aqueous Solvents: General properties- classification- self ionization and levelling effect- reaction in non-aqueous solvents- protic and aprotic non aqueous solvents- examples- solutions of metals in liquid ammonia- self ionization of liquid ammonia- liquid SO₂, liquid HF.

II. Physical Chemistry

Properties of liquids: Surface tension and its measurement by capillary rise and stalagmometer method, factors affecting Surface tension, Viscosity, Poiseuille's equation, Determination of viscosity by Ostwald's viscometer, Refractive index and its determination by Abbe refractometer.

Dilute solutions: Molarity, Molality, Normality and Mole fraction. Colligative properties, relative lowering of vapour pressure, Osmotic pressure, van't Hoff equation and molecular mass, Isotonic solutions, Determination of molecular mass of solutes by Beckmann's method, Rast's method and cooling curve method. Abnormal molecular mass, Van't Hoff factor, Determination of degree of dissociation and association.

Surface Chemistry & Adsorption : Physical and chemical adsorption – Adsorption isotherms – Langmuir, Freundlich– Gibbs adsorption equation — Mathematical derivation – Surface films - Determination of surface area using Langmuir and B.E.T. equations.

Colloids: Types and classification – preparation of colloids – purification – protective colloids – kinetic, optical and electrical properties – surfactants – Gels – Emulsions. Properties and applications. Zeta potential, Donnan membrane equilibrium – Dorn effect.

Ionic Equilibrium : Theories of acids and bases: Arrhenius, Lowry-Bronsted and Lewis theories – Levelling and differentiating solvents – pKa, pKb and pH. Applications of common ion effect and solubility product – Hydrolysis of salts of all types – Degree of hydrolysis and hydrolysis constant and its relation with k_w . Buffer solutions – Mechanism of buffer action-buffer index – Henderson equation..

Thermodynamics: Basic concepts- system, surroundings, types of systems. Extensive and intensive properties, macroscopic properties. State functions and path functions. Types of Processes, Zeroth law of thermodynamics Definition of internal energy and enthalpy. Heat capacities at constant volume and at constant pressure, relationship between C_p and C_v . Mathematical statement of first law. Reversible process and maximum work. Calculation of work, heat, internal energy change and enthalpy change for the expansion of an ideal gas under reversible isothermal and adiabatic condition.

The Joule-Thomson effect –Sign and magnitude of Joule-Thomson coefficient, inversion temperature.

Thermochemistry – standard states. Enthalpies of formation, combustion and neutralization. Integral and differential enthalpies of solution. Hess's law and its applications. Kirchoff's equation.

III . Industrial aspects of Organic Chemistry

Raw materials for organic compounds-Petroleum, natural gas, fractionation of crude oil, cracking, reforming, hydroforming, isomerisation Coal Types, structure, properties , distillation of Coal and chemicals derived from them.

Separation and Purification Techniques :General principles involved in the separation of precipitates, standards of purity, mixed melting point and boiling point; purification of solid organic compounds – extraction, use of immiscible solvents, solvent extraction, crystallization, fractional crystallization, sublimation, desiccants, vacuum drying. Purification of liquids – distillation, vacuum distillation, fractional distillation, steam distillation, azeotropic distillation – principles and techniques.

Chemical constitution of Plants,. isolation procedure and quality control Chemical constitution of plants-including carbohydrates, aminoacids, proteins, fats, waxes , volatile oils, terpenoids, steroids and alkaloids. Various isolation procedures for active ingredients with example for alkaloid eg. Vinca alkaloids, reserpine, for steroids- sapogenin, diosgenin. Parmaceutical quality control- sterility testing, pyrogenic testing, glass testing.

Analytical Chemistry

Theoretical principles of qualitative and quantitative analysis: Applications of solubility product and common ion effect in the precipitation of cations–Interfering acid radicals and their elimination (oxalate, fluoride, borate, phosphate, chromate, arsenite and arsenate). Primary and

secondary standards – standard solutions – theory of titrations involving acids and bases, KMnO_4 , $\text{K}_2\text{Cr}_2\text{O}_7$, I_2 and liberated I_2 . Indicators – Theory of acid-base, redox, adsorption indicators – complexometric titrations. Precipitation methods: Gravimetric Analysis - Mechanism of precipitate formation - Factors affecting solubility of precipitates – coprecipitation and post precipitation - Effect of digestion - washing, drying and ignition of precipitates.

Chromatography - classification of methods - Elementary study of adsorption, paper, thin layer, ion exchange and gas chromatographic methods.

Instrumental Methods of Analysis: Atomic absorption spectroscopy- flame emission spectroscopy- applications spectrophotometry- laws of spectrophotometry- applications of spectrophotometry-colorimetry, thermal methods- introduction to TG, DTA and DSC-instrumentations and applications.

Research in Science Selecting a topic – hypothesis-design of experiment: variables, correlation and causality, sampling, use of controls, experimental bias, analysis, results, discussion of results, models. Summary of the scientific methods. Writing Science.

Environmental Chemistry

Environment, nature of environmental threats and the role of chemistry. Chemistry of the air, water and soil environment. Factors affecting environment.

Water pollution, air pollution and Soil pollution, factors controlling and monitoring pollutions.

Industrial Chemistry

Unit process, unit operations, flow diagrams, Energy balance and material balance (basic concepts only.) Fuels, calorific value, Basic concepts of I S O. Fluid flow, stream line flow. Turbulent flow, viscosity –Reynold's number. Newtonian and non Newtonian liquids.

Heat transfer. Types of heat exchangers. (Shell type and plate type.) Refrigeration cycles. Safety in chemical industry. First aids.

Basic concepts –branched and network polymers. Classification and nomenclature. Properties of polymers. Mol wt. glass transition temperature solubility and viscoelasticity. Manufacture and users of PF resins. Importance of polymers in controlled drug delivery and packaging. Polymer processing, compounding. Composites classification, micro and nano composites. Conducting polymers. PA, PPP, PPg(SN)_x etc.

Soaps and detergents-Basic chemical compositions of soaps, manufacture Surface active agents, builders, additives, fillers. Basic concepts of perfuming and colouring. Bio-degradability.

Cosmetics –basic concepts –composition –production and classification of creams –sunscreen and suntan lotions –deodorants talcum powder –dentifiers, lipsticks.

Food processing –colouring and flavouring agents, food preservation –viscosity builders – bulking agents, artificial sweeteners – food adulteration –packaging and catering.

An overview of technical sampling of solids, liquids and gases. Fundamental concepts or theory and industrial application of particle size analyzer.

spectrophotometry –flame, photometry –AAS -Xray fluorescence ion selective electrodes – chromatography.

Basic Concepts, Classification –methods of dyeing –acid –direct -reactive –disperse –vat cationic sulphur indigo –azo phthalocyanine –dyes. Synthetic Dyes A brief idea of metal complex dye stuffs. (introduction to natural dyes and it's importance in cotton textile dyeing) fluorescent and brightening agents –hair dyes –dyeing standards and Health hazards.

Paints –varnishes and lacquers.

Polymers- Types of polymerization- addition, condensation and coordination polymerization. Ziegler –Natta catalyst. Synthesis and applications of urea – formaldehyde resins, Bakelite, polythene, PVC, PMMA, Nylon-6,6. Natural and synthetic resins. Buna-N, Buna-S, Neoprene, Polystyrene. Biodegradable polymers- two examples- starch and cellulose. Number average molecular weight and weight average molecular weight of polymers. Composites

Catalyst in Petrochemical Industry : Various catalysts used in petrochemical industry, their preparation , structure, applications and selectivity, importance of petroleum and petroleum industry in the context of Indian economy.

Green Chemistry

Role of Chemical Industries in polluting the environment-Limitations of conventional waste management-pollution prevention-birth of green chemistry- introduction to the principles of green chemistry-atom economy calculation(simple reactions)-production of Ibuprofen-less hazardous chemical syntheses, designing safer chemicals-Bhopal gas t ragedy- new greener syntheses, safer solvents and auxiliaries, ionic liquids-super critical fluids CO₂ and H₂O, advantages of SCFs.

Design for energy efficiency-principle of microwave oven, microwave assisted organic syntheses, simple examples- renewable feedstock- biodiesel, preparation, advantages, catalysis, green catalysts- inherently safer chemistry for accident prevention. Green chemistry practices in research, educational and commercial laboratories- lab safety signs- introduction to micro scale experiments.

NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper