

**DETAILED SYLLABUS FOR THE POST OF LECTURER IN CHEMICAL
ENGINEERING (GOVT. POLYTECHNICS) IN Technical Education
(Polytechnics) - Direct Recruitment**

(Category Nos.:237/2023)

Total : 100 Marks

SECTION A: BASIC ENGINEERING AND MATHEMATICS (20 MARKS)

Module I: Basic Civil , Mechanical, Electrical and Electronics Engineering – 10 marks

Basic Civil Engineering (3 marks)

Materials: Brick – varieties and strength, characteristics of good brick. Cement – varieties and grade of cement and its uses. Steel – types of steel for reinforcement bars, steel structural sections. Aggregates – types & requirements of good aggregates. Concrete – grades of concrete as per IS code, water cement ratio. Workability, mixing, batching, compaction and curing.

Construction: Parts of building – foundation – types of foundations – spread footing, isolated footing, combined footing, Raft, pile and well foundations. Masonry – types rubble masonry, brick masonry, English bond and Flemish bond. (One brick wall).

Basic Mechanical Engineering (2 marks)

Steam generation – steam power plants – layout- study of various systems- water and fire tube boilers – Types of boilers – boiler efficiency

Air cycles – carnot cycle – Otto and Diesel cycle – principle of operation of 2 stroke and 4 stroke engines – SI and CI engines – Ignition systems – Lubricating systems – Gas turbine cycles – refrigeration cycles – Mechanical power transmission – belt, rope, gear and chain drives – speed ratio – simple problems

Basic Electrical Engineering (3 Marks)

Review of electric current, potential difference, power, EMF, resistance and its laws, Ohms law – series, parallel circuit, electromagnetism, generation of AC and DC supply.

Idea of Basic electrical circuit: Electrical supply and load and its functioning, division of voltage and current in a parallel and series circuit – simple problems, units of power and energy, solution of DC circuit with calculation of energy consumption in an installation.

Circuit parameters: Resistance, Capacitance and inductance. AC circuit with R, L, C. Simple solution of typical AC circuit with resistance, impedance, power and power factor.

Earthing, lightning protection.

Basics of Electronics Engineering (2 Marks)

Basic electronics: Atom - Energy level diagram - Work function - Emission, motion of electrons in electric and magnetic fields - Description of simple CRO tubes - Structure of semiconductor materials - P-type & N-type semiconductors - Junction diodes - Transistors - Construction, operation and characteristics

Principle of rectification and amplification - Different types of amplifiers - RC & transformer coupled amplifiers - Class A, B, C, voltage and current feedback amplifiers - Oscillators - Basic principles, -Transistor oscillators

Industrial electronics: Induction heating - Principle of induction heating - Applications - Power sources for induction heating - Dielectric heating - Dielectric properties of materials - Electrodes used in dielectric heating - Application with emphasis on chemical process - Ultrasonics - Principles and operations

Introduction to Computers: CPU, Memory, input-output devices, secondary storage devices, Processor Concepts - Evolution and comparative study of processors. Machine language, assembly language, and high level language. Inside a PC, Latest trends and technologies of storage, memory, processor, printing etc. Concept of Program and data, System software - BIOS, Operating System-Definition-Functions-Windows, and Linux. Compilers and assemblers, Computer networks, LAN, WiFi.

Module II: Engineering Mathematics - 10 marks

Linear Algebra:

Matrices – Rank, systems of linear equations, consistency, eigen values, eigen vectors, Cayley Hamilton Theorem, diagonalization, linear dependence and independence of vectors., Determinants – Evaluation of second and third order, minors and cofactors, solutions of simultaneous linear equation in three unknown using Cramer’s rule.

Calculus: Functions of single variable, Limit, continuity and differentiability, Taylor series, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy’s and Euler’s equations, Initial and boundary value problems, Laplace transforms, Solutions of one-dimensional heat and wave equations and Laplace equation.

Complex variables: Complex number, polar form of complex number, triangle inequality. Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions, Linear regression analysis.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations. Integration by trapezoidal and Simpson’s rule. Single and multi-step methods for numerical solution of differential equations.

SECTION B: CHEMICAL ENGINEERING - 80 MARKS

Module III – 20 Marks

Fluid Mechanics

Properties of Fluids: Density, Specific gravity, Viscosity, Newton’s law of viscosity, Newtonian and Non-Newtonian fluid, Viscosity Index, Red wood viscometer

Types of Flows: Viscous, Turbulent Flow, Critical Velocity, Reynolds Number, Transition range & Velocity distribution in pipes

Basic equations of fluid flow-Continuity, Bernoulli's and Momentum equation-Toricelli equation. Kinetic energy and Momentum correction factors-Correction for fluid friction and pump work for Bernoulli's equation. Laminar flow of incompressible fluids in pipes and conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy Wiesbach equation-Definition of Friction factor on Reynolds number in laminar flow. Churchill, Darcy and Fanning friction factor. Turbulent flow of incompressible fluids in pipes and conduits- Universal velocity distribution equation-Friction factor and Reynolds number relationship- Prandtl one seventh power law- Friction factor chart-Friction from changes in velocity or direction-Sudden expansion and contraction-Fittings and valves. Flow through Non circular cross section-Equivalent length

Transportation of fluids: Flow rate equation for Venturi, Orifice, Mouth piece, Pitot tube, Rectangular, Triangular & Trapezoidal weir, Rotameter. Transportation of liquid through pipes- Economic pipe diameter- Pipes and tubes. Different types of fittings and Valves- pressure drop and equivalent length.

General description, classification, selection and application of Centrifugal, Reciprocating, Gear and Lobe pumps. Various losses-Characteristic curves- NPSH-Cavitation- Specific speed- Priming of Centrifugal pumps. Fans, Blower, Compressor-Different types-Compressor efficiency, Ejector-Principle and different types.

Fluidization: Flow past immersed bodies-Drag, Drag coefficient for typical shapes. Stream lining, Stagnation point-Friction in flow through bed of solids-Ergun, Kozney Carman and Blake Plummer equation.

Motion of particle through fluids in gravity and centrifugal field. Terminal settling velocity in Stokes law. Intermediate law, and Newton's law range-Free and Hindered settling. Fluidization- Minimum fluidization velocity, Minimum porosity, Pressure drop calculation, Different type of fluidization. Slugging. Industrial application.

Particle Technology

Particle diameter and shape factor - particle size analysis - sieve analysis - particle size distribution - cumulative and differential methods of analysis - mean diameters - specific surface area and number of particles - sub-sieve analysis - pipette analysis - beaker decantation - Screening - effectiveness and capacity of screens and factors affecting them - types of industrial screens

Particle separation

Principles of free and hindered settling - equal settling particles - classifiers - types of classifiers - mechanical and non-mechanical, pneumatic classifiers - principles of mineral beneficiation methods - jigging - Wilfley table - heavy media separation - magnetic and high-tension separation - Froth flotation, principles, additives, and flotation cell arrangements batch and continuous thickening - Kynch theory

Filtration - theory of constant pressure and constant rate filtration - cake porosity and compressibility - filter aids - optimum filtration cycle - types of batch and continuous filters - washing of filter cakes - centrifugal methods of separation including centrifugal filtration - continuous centrifuge - gas cleaning methods - gravity settling - cyclone separation - electrostatic precipitation - scrubbing

Size reduction

Laws of comminution - mechanism and efficiency of size reduction - principles of important size reduction equipment - types and selection of equipment for all ranges - closed circuit and open circuit grinding - free crushing and choke feeding - wet and dry grinding –

Mixing, Storage and conveying

Purpose of agitation – agitation equipment – propellers, paddles and turbines - Flow pattern in agitated vessels – prevention of swirling – draft tubes and baffles – their power consumption in agitated vessels – simple problems in determination of power.

Mixing of granular solids and pastes - degree of mixing - type and selection of equipment - storage and conveying of solids - silos, bins and hoppers - different types of conveyors - selection of conveyors

Storage of fluids:

Storage of liquid – storage tanks

Storage of volatile liquids – floating roof

Storage of gases: Horton sphere – pressure cylinders – gas holders – wet and dry specifications.

Module IV – 20 Marks

Stoichiometry

Units and dimensions, conversion of units, dimensional analysis, conversion of empirical equations, mole concept and mole fraction, weight fraction and volume fraction, concentration of liquid solutions – molarity, molality, normality, ppm, density and specific gravity, specific gravity scales, use of mole concept in chemical reaction stoichiometry, ideal gases and gas mixtures, various gas laws, average molecular weight and density of gases, critical properties and compressibility of gases.

Material balances with and without chemical reactions, material balance in unit operations such as evaporation, crystallization, drying, absorption, distillation etc.

Energy balances: Heat capacity, specific heat and enthalpy, heat capacities of gases and gaseous mixtures, estimation of heat capacity – relevant rules and laws, calculation of enthalpy changes, Estimation of latent heat of vaporization, heat balance calculations in processes without chemical reaction, heat of reaction, standard heats of formation, combustion and reaction, heat of solution and heat of mixing, adiabatic and non-adiabatic reactions, theoretical and actual flame temperatures.

Vapour Pressure: vapour pressure of pure liquids and immiscible liquids, ideal solutions and Raoult's law, non-volatile solutes, humidity: Humidity and saturation: various term associated with humidity and saturation. Material and energy balance problems involving vaporization and condensation, fuels and combustion, heating value of fuels, proximate and ultimate analysis, Orsat analysis of flue gases.

Chemical Engineering Thermodynamics and Energy Engineering:

Fundamental concepts and definitions of thermodynamics – various systems – intensive and extensive properties – Zeroth law of thermodynamics – First law of thermodynamics – applications – limitations. Second law of thermodynamics – general statements of 4 second law – concept of entropy – calculation of entropy changes – Carnot's principle – Clausius inequality — Third law of thermodynamics. Thermodynamic properties of pure fluids – Gibbs free energy, work function – Joule Thomson coefficient

Properties of solutions – partial molar properties and methods of determination – Lewis-Randall rule – Raoult's law – Henry's law – activity and activity coefficients in solutions – effect of temperature

and pressure on activity coefficients – Gibbs-Duhem equations, property changes on mixing – heat effects of mixing processes.

Chemical reaction equilibria – reaction stoichiometry – equilibrium constant – standard free energy change – standard state – feasibility of reaction – effect of temperature on equilibrium constant – presentation of free energy data – evaluation of K – equilibrium conversion in gas-phase reactions – effect of pressure and other parameters on conversion

Energy engineering: Non-conventional energy resources-solar-biogas and biomass-ocean and tidal energy, geothermal-wind Solar radiation-solar collector-solar trough systems-solar power towers-solar dish/engine system-solar thermal power plant-solar pond-solar water heater- solar cooker. Biogas and biomass-availability -biomass conversion processes- biogas generation-biogas production plants(batch ,continuous, movable drum type, fixed dome type)

Geothermal energy-resources of geothermal energy- vapor dominated power plant-liquid dominated system-total flow geothermal plant-merits and demerits of geothermal power generation- applications of geothermal energy.

Wind energy-wind turbine- wind power- power and velocity duration characteristics of wind-airfoil construction and types-types of wind power plants-types of wind genitor units with its construction-site selection-merits and demerits of wind power generation.

Ocean thermal energy conversion (OTEC)- working principle- types of OTEC systems advantages and limitation. Ocean wave energy and tidal energy- tidal power plants. Hydraulic energy-hydel power- principle of operation- hydro electric power systems

Module V – 20 Marks

Process Heat Transfer

Heat Transfer by Conduction and Convection:

Fourier's law, thermal conductivity of solids, liquids and gases. Steady state heat conduction in systems without generation of heat having constant and varying thermal conductivity, steady-state conduction through single resistance and composite resistances in series.

Newton's law of cooling, Thermal insulation: analysis of critical thickness of insulation for cylindrical and spherical system, concept of optimum thickness of insulation, heat transfer in extended surfaces.

Boundary layer concepts – thermal and velocity boundary layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness, dimensional analysis – Rayleigh and Buckingham's pi theorem, its limitations, principle of similarity, application of dimensional analysis.

Forced Convection: General methods for estimation of convection heat transfer coefficient, flow in a circular tube (both developing and developed flows with constant wall temperature – its analysis and constant heat flux conditions) and noncircular tubes, flow over flat plates, flow over cylinder, spheres and tube banks. Analogy between momentum and heat transfer, Reynold's and Prandtl analogy, comparison of different analogy expressions.

Natural Convection: Natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates, cylinders under constant heat flux and wall temperature conditions, physical significance of Grashoff and Rayleigh numbers.

Heat transfer by Radiation: Theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission – total emissive power, emissivity, radiative properties, concept of black and grey body, radiation intensity, laws of black body radiation, non-black surfaces, Lambert's cosine law, radiation between black surfaces and gray surfaces, radiation shape factor.

Heat Transfer with Phase Change: Boiling and condensation – dimensionless parameters in boiling and condensation, pool boiling – modes of pool boiling, nucleate pool boiling – correlations – parametric effects on pool boiling, forced convection boiling (flow boiling) – brief overview of external forced convection boiling and internal forced convection boiling – regimes

Mass Transfer

Molecular diffusion – Fick's law – diffusivity and estimation – Mass transfer coefficients – film theory – F-type and k-type coefficients – dimensionless groups and dimensional analysis – elementary treatment of theories of mass transfer: penetration and surface renewal theories – interphase mass transfer – equilibrium – diffusion between phases – two-film theory – local and overall k-type coefficients.

Gas absorption, absorption equipment, multistage absorption, tray towers, continuous contact equipment, venturi scrubbers, packed columns, packing materials and characteristics, general constructional details of packed columns, solubility of gases in liquid, choice of solvent, material balance in counter current and concurrent absorption and stripping, multistage operation, tray efficiency, design of packed columns, dilute solutions and simplified design methods.

Humidification and dehumidification, wet-bulb temperature and adiabatic saturation temperature, types of cooling towers, enthalpy transfer unit, general design procedure,

Drying, equilibrium moisture content, batch drying, rate of drying, cross-circulation drying, mechanism of moisture movement, continuous drying, parallel and counter current, material and enthalpy balances, industrial dryers for batch and continuous drying.

Distillation – types of distillation – fractionation – plate columns for distillation – condensers – reboilers – principles of rectification – material and energy balance – reflux ratio and its importance – enthalpy-composition diagrams – difference points and L/G ratio – number of plates – feed plate location – minimum reflux conditions.

Extraction – applications – mixer rule – distribution curve – choice of solvent – single-stage and multistage operations – extraction with reflux – construction and working of mixer – settler cascades, sieve-tray columns and baffle towers for extraction – continuous contact extraction – design for insoluble liquids – construction and working of agitated towers, pulse columns and centrifugal extractors.

Leaching – factors affecting rate of leaching – stage efficiency – working principles of leaching equipment – thickeners, classifiers and moving bed leaching equipment,

Description of adsorption processes and their application – agitated vessels for solid liquid adsorption – multistage fluidised bed adsorber for recovery of vapour – continuous contact adsorption: steady state moving bed adsorber – counter current adsorption of one component

Module VI – 10 Marks

Chemical Industrial Processes:

Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

Chlor-alkali : Diaphragm cell – mercury cell – membrane cells – manufacture of solid caustic soda. Chlorine

Hydrochloric Acid: - Properties and uses and commercial grades – manufacture of Hydrochloric acid

Sulphuric Acid: Importance of Sulphuric acid – properties and uses – raw materials – sulphur pyrites – production of sulphur dioxide, sulphur burners – cleaning

Nitric Acid: – Properties and uses – reaction – catalyst – manufacturing process – concentration

Phosphoric Acid:- Properties, uses and grades, raw materials manufacturing process.

Fertilizers: ammonia - nitric acid - urea - fertilizer industries - ammonium sulphate - ammonium nitrate - nitrolime - MAP, DAP and nitrophosphates - mixed and complex fertilizers

Glass – manufacturing method; different grades – uses. Alumina brick, carbon ceramics – raw material – main unit operation and process

Oils And Fats: Of rancidity – acid value, saponification value and iodine value. Extraction of oils – oil expellers - Refining of vegetable oils, neutralization, bleaching and deodorization

Catalysts - Materials, manufacturing process for toilet & laundry soaps. Batch and continuous process, comparison with soap. Biodegradability of detergents, detergent additives and formulation

Pulp & Paper : Paper – Paper industry in India and its future - Soda mechanical pulping – details of process and plant - Paper manufacture - Details of paper machine

Sugar: Manufacture from sugarcane and sugar beet, refining of crude sugar, byproducts of sugar industry. Starch: Raw materials, manufacture from corn, maize, tapioca. Manufacture of Dextrin and Dextrose. Fermentation Products: Manufacture of alcohol, alcoholic beverages and High Fructose Corn Syrup (HFCS).

Petroleum: Classification of crude, characteristics of crude, chemical composition of crude, processing of crude – sweetening, atmospheric and vacuum distillation of crude, cracking and coking, refining, reforming, hydro-cracking and isomerisation. Production of lubricating oils, lube additives, Motor gasoline, kerosene, aviation turbine fuel and aviation gasoline.

Petrochemicals: Primary processes for olefins, acetylenes, higher homologues, aromatics and their derivatives, propylene, acetylene, methanol and its derivatives.

Module VII – 10 Marks

Instrumentation & Process Control:

Functional elements and functions of an instrument – classification of instruments, performance characteristics of an instrument like static and dynamic type

Temperature measuring instruments - Principle and working of – Thermometers, filled system and vapor pressure thermometers – Thermocouples, types, materials - Resistance thermometers, thermistor – Pyrometer, radiation and optical.

Pressure measuring instruments - Principle and working of - Bourdon tube, bellows, diaphragm gauge, resistance transducer and piezo electric pressure sensors.

Flow measuring devices: Area flow meters, Coriolis mass flow meter, Ultra sonic flow meter, and positive displacement flow meters – Differential pressure transducer used in venturi and orifice meters.

Level measuring devices: Float level indicator, Magnetic level indicator, radar tank gauging system, guided wave radar tank gauging, differential pressure cell.

pH measurement, pH scale, reference and measuring electrode - Conductivity measurement, electrical conductivity meter - Density measurement, online density meter, hydrometer. Humidity measurement, dew point method, wet bulb method, hygrometer.

Chromatographic analysis – Working and applications of - Liquid solid chromatography - Gas solid chromatography - Liquid liquid chromatography - High performance liquid chromatography. Spectroscopy –classification of spectrometers –working of UV-visible absorption spectrometer - Atomic emission spectrometer - Mass spectrometer. Structure analysis – Working principles of SEM (scanning electron microscope), TEM (Transmission electron microscope), XRD (X-ray diffraction).

Process Control: Dynamics of first order and second order systems (Temperature, liquid level and mixing), open loop and closed loop systems, feedback control systems –servo and regulatory control - Proportional (P), integral (I), derivative (D) and PID control - Behavior of different modes of control.

Computerized Control in process plants: (Descriptive treatment of the following) Programmable logic controllers - Supervisory control and data acquisition (SCADA) - Distributed control system (DCS). Final control elements - Mechanism and working principle of pneumatic control valve, positioner, solenoid valve, motor operated valves, I to P converter - Variable frequency drive [VFD], Safety Instrumentation System – Emergency shutdown system – Safety interlocks.

Environmental Engineering

Water Pollution: Sources and classification of water pollutants and their effects. Sampling and analysis. Water and Waste water treatment: Softening methods, Lime soda process, Preliminary, primary, secondary and tertiary treatment of waste water, recovery of materials from process effluents – anaerobic and aerobic sludge treatment and disposal – methods of physiochemical and biological treatment of industrial effluents from fertilizer, petrochemical, pulp and paper, caustic soda, tanning and sugar industries

Air Pollution and Control: Nature of air pollution classification, properties and sources of pollutants, acid rain – Green house effect – Ozone depletion – Effects of man, animal, vegetation and material dangers, Air quality criteria and standards, methods of pollutant sampling and measurement.

Control methods for particulate emulsions and pollutants –Cyclone separator, Electrostatic precipitator – Bag house filter – Scrubbers - Indoor Air pollution control.

Noise Pollution – Solid Waste – Radioactive Pollution: Noise – pollution control programme – TLV, SIL, NEI – Noise barriers – Composition of earth – methods of disposal. Sources of radioactive waste – effects of radioactive pollution – monitoring

Safety, Fire Engineering:

Definitions of the terms – factory, accident, hazard, risk, frequency rate, accident proneness - - 4 E's of accident prevention technique - Precautions to be observed while working in hazardous

environment - explosive limit – Flammable limit – Inflammable limit – characteristics of hazardous material – TLV, STEL, TLV – C, LD 50, LC 50 (definitions)– flammable liquids - Fire and Explosion. Fire hazards. Fire pyramid. Types of fires. Types of fire extinguishers and its handling. Types of built in extinguishing systems. Fixed fire protection systems. Fire fighting techniques. UVCE and BLEVE. NFPA standards. Emergency procedures. Types of alarm systems. Emergency communication procedures. Containment of chemical spills or leaks. Purpose of first – aid, contents of a typical first aid kit. First aid procedures for Artificial resuscitation, bleeding, electrical shock, poisoning, fractures and burns.

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.