Rajasthan Public Service Commission, Ajmer
Syllabus of Screening Test for the post of
Lecturer-Chemical Engineering
Technical Education Department

1. PROCESS CALCULATIONS

Units and conversions, chemical equation and stoichiometry. Ideal gas law calculations, real gas relationships, vapour pressure and liquids, saturation, partial saturation and humidity. Material balance of processes with and without chemical reaction, including recycle, purge and bypass. Energy Balances: Calculation of enthalpy changes, general balance with and without reactions, heats of solution and mixing.

2. MOMENTUM TRANSFER OPERATIONS

Continuity equation for compressible and incompressible fluids. Bernoulli's equation, Euler's equation, introduction to Navier-Stokes equation. Steady and unsteady, laminar and turbulent flows, Relationship between shear stress and pressure gradient, Hagen-Poiseuille equation. Prandtl's mixing length theory and eddy diffusivity losses in pipes and fittings, Darcy-Weisbach equation for frictional head loss, Moody diagram. Velocity profile and boundary layer calculations for turbulent flow. Flow measuring devices such as orifice meter, venturimeter and rotameter.

3. PARTICULATE TECHNOLOGY

Size Reduction: Principles of crushing and grinding, Determination of mean particle size and size distribution, Laws of crushing and grinding, Energy required for size reduction, crushing and grinding equipment, closed and open circuit grinding. Types of screens, mesh number and size distribution, different types of screening, effectiveness of screen, Particle size analysis, separation efficiency and screening equipment. Solid-Liquid Separation: Theory of filtration, filtration equipment, equations for compressible and incompressible cakes, Constant volume and Constant pressure filtration, press filter, rotary drum and vacuum filter. Fiber and fabric filters, sedimentation, classifiers and thickeners. Centrifuges- Principles and applications. Solid-Gas Separation: Cyclone separators and electrostatic precipitator- Principles and applications.

4. HEAT TRANSFER OPERATIONS

Modes of heat transfer: conduction, convection, radiation. Fourier's law, thermal conductivity, steady-state conduction of heat through a composite solid, cylinder and sphere. Steady-state heat conduction in bodies with heat sources: plane wall, cylinder and sphere. Convective heat transfer and the concept of heat transfer coefficient, overall heat transfer coefficient, heat transfer from extended surfaces, thermal contact resistance, critical insulation thickness, optimum insulation thickness. Forced convection: Flow over a flat plate, thermal boundary layer, flow across a cylinder. Dimensional analysis: Buckingham Pi theorem, Dimensional groups in heat transfer. Correlations for the heat transfer coefficient: Laminar flow through a circular pipe, turbulent flow through a circular pipe, flow through a non-circular duct, flow over flat plate, flow across a cylinder, flow past a sphere, flow across a bank of tubes, heat transfer coefficient in a packed and fluidized bed. Free convection: Introduction, heat transfer correlations for free convection: flat surface, cylinder, sphere, enclosure. Combined free and forced convection. Black body radiation, Planck's Law, Wien's Displacement Law, Stefan-Boltzmann Law, Kirchoffs Law, Gray body. Radiation intensity of a black body, spectral emissive power of a black body over a hemisphere.

5. MASS TRANSFER OPERATIONS

Molecular diffusion, fluxes and measurement of diffusivities. Mass transfer coefficients, laminar and turbulent flow situations and correlations. Two film theory and overall mass transfer coefficients, penetration and surface renewal theories. Concepts of equilibrium stage, operating line and tie line. Continuous contacting operations: Gas absorption - countercurrent isothermal, HETP, design equation, (L/G) min, NTU, HTU, calculation of NTU, packed tower distillation, flooding, AP, liquid and gas distributors, entrainment eliminators. Humidification and dehumidification, cooling towers, drying theory and design, crystallization. Binary distillation: ideal and non- ideal stages; definitions of point, stage and column efficiencies. Single stage calculations: differential (Rayleigh) and simple (flash) distillation, steam distillation. Ponchon- Savarit diagram, McCabe-Thiele diagram; plate calculations, Absorption, Liquid-liquid extraction, Adsorption and Leaching.

Membrane Separation Processes: Physical and chemical properties of membranes, Techniques of membrane preparation, membrane characterization, various types of membranes and modules. osmosis and osmotic pressure. Working principle and operation of Reverse osmosis, Ultrafiltration, Microfiltration, Electrodialysis and Pervaporation.

6. CHEMICAL ENGINEERING THERMODYNAMICS

First law of Thermodynamics and its applications. PVT behavior of pure substances, virial equation and its applications, cubic equations of state, generalized correlations for gases and liquids. Sensible heat effects, heat effects accompanying phase changes of pure substances, standard heats of reaction, formation and combustion, effect of temperature on the standard heat of reaction. Second law of Thermodynamics: Limitation of first law, Kelvin-Planck and Clausius statements, Reversible and irreversible processes, Carnot cycle, Entropy, Second Law Analysis of a control volume. Maxwell's equations, Residual properties, Clapeyroo's Equation, Gétieralized correlations for thermodynamic properties of gases. Multicomponent systems: Chemical potential, ideal-gas mixture, ideal solution, Raoult's law. Partial properties, fugacity and fugacity coefficient, generalized correlations for the fugacity coefficient, excess Gibbs' energy, activity coefficient.

Phase Equilibria: Phase rule, phase behavior for vapor liquid systems, Margules equation, Van- Laar equation, Wilson equation, NRTL equation. Dew point, bubble point and flash calculations. Effect of temperature on the equilibrium constant, evaluation of equilibrium constants. Relations between equilibrium constants and compositions: gas-phase reactions, liquid-phase reactions.

7. CHEMICAL REACTION ENGINEERING

Reaction rates, variables affecting reaction rates, classification of reactions, order, molecularity. Reaction mechanisrii & Kinetics of homogenous reactions. Temperature dependent term of a rate equation. Interpretation of batch reactor data: constant volume batch reactor, variable volume batch reactor. Ideal reactors for single reaction: Ideal batch reactor, steady state mixed flow reactor, steady state PFR, holding time and space time for flow systems. Design for single reactions: size comparison, multiple reactor systems, recycle reactor, auto catalytic reactions. Temperature and pressure effects on single reactions. Non-ideal flow: Residence time distribution of fluids, general characteristics, Measurement of RTD, RTD in ideal reactor, Tanks-in-series model.

Catalysts: Description, methods of preparation and manufacture; catalyst characterization — BET surface area, pore volume, pore size distribution. Catalyst reaction kinetic models: Physical and chemical adsorption; Determination of rate expressions using adsorption, surface reaction and desorption as rate-controlling steps. Determination of Global rate of reaction: Heterogeneous laboratory reactors; Determination of rate expressions from experimental data. Effect of intrapellet diffusion on reaction rates in isothermal pellets. Gas-liquid reactions: Effect of diffusion on rate of reaction, enhancement factor. Introduction to design of heterogeneous reactors and its parametric sensitivity.

8. PROCESS CONTROL

First-order systems: Transfer function, transient response, response of first-order systems in series: non-interacting systems and interacting systems. Second-order systems: Transfer function, step response, impulse response, sinusoidal response, transportation lag.

Linear closed-loop systems: Components of a control system, block diagram, negative feedback and positive feedback, servo problem and regulator problem. Controller and final control element: Mechanism of control valve and controller, transfer functions of control valve and controllers **(P, PI, PD, PID).** Closed-loop transfer functions: Overall transfer function for single-loop systems, overall transfer function for set-point change and load change, multi-loop control systems.

Transient response of simple control systems: P and PI control for set-point change and for load change. Concept of stability; stability criteria; Routh test for stability; Root locus. Introduction to frequency response, Bode diagrams for first and second order systems, Bode stability criteria, Ziegler-Nichols and Cohen-Coon tuning rules.

9. PLANT DESIGN & ENGINEERING ECONOMICS

Process design development and general design considerations. Process Economics: economic feasibility of project using order-of-magnitude cost estimates, plant and equipment cost estimation, product cost estimation. Time value of money, investment, costs, sales, profits, taxes, depreciation. Rate of return, payback period, discount rate of return, net present worth, internal rate of return, comparing investment alternatives.

10. INDUSTRIAL POLLUTION CONTROL

Wastewater Treatment: Characterization of industrial wastewater, primary, secondary and tertiary treatment, segregation, screening, equalization, coagulation, flocculation, precipitation, flotation, sedimentation, aerobic treatment, anaerobic treatment, absorption, ion exchange, membrane filtration, electrodialysis, sludge dewatering and disposal methods.

Air Pollution Control: Sources and classification of air pollutants, nature and characteristics of gaseous and particulate pollutants, pollutants from automobiles.

11. CHEMICAL TECHNOLOGY

Hydrogen, producer gas and water gas, ammonia, nitric acid, nitrogenous and mixed fertilizers, common salt, caustic soda, chlorine, hydrochloric acid, soda ash, sulphuric acid, oleum, portland cement, formaldehyde, ethylene oxide, ethylene glycol, acrylonitrile, styrene, butadiene, BHC, DDT, industrial alcohol, oils, fats and waxes, soaps and detergents, pulp and paper industry.

Liquid Fuels/Petroleum Refining: Origin, composition, classification, and constituents of Petroleum: Indian crudes. Processing of crude oil: distillation, cracking — thermal and catalytic, reforming - thermal and catalytic, polymerization, alkylation, and isomerisation. Purification of petroleum products, antiknock value and requisites of good quality gasoline, diesel and fuel oil, liquid fuels from coal by hydrogenation/ liquefaction.

Polymerization Reactions: Functionality, polymerization reactions, polycondensation, addition, free radical and chain polymerization. Copolymerization, block and graft polymerizations, kinetics of radical, chain and ionic polymerization and co-polymerization systems. Bulk, solution, emulsion and suspension polymerization.

Pattern of Question Paper

1. Objective type paper
2. Maximum marks- 100
3. Number of questions 100
4. Duration of paper - 2 hours
5. All question carry equal marks
6. There will be negative marking