Syllabus for Ph.D. Entrance Exam: Chemical Engineering

Thermodynamics: First and Second Laws of Thermodynamics, Carnot Cycle and other Heat Engines/Refrigeration Cycles, Efficiency of Heat Engines and Coefficient of Performance of Refrigerators, Ideal Gas Equation of State, Cubic Equations of State for Real Gas and their application in finding Residual Properties, Clausius Clapeyron Relation, Single & Multiphase Vapor Liquid Equilibrium, Activity Coefficient Models, Liquid-Liquid Equilibrium, Chemical Equilibrium.

Chemical Reaction Engineering: Chemical Kinetics, Power Law Models, Idealized Reactors: CSTR and PFR, Reactors in Series and in Parallel, Chemical Reaction with Heat Effects, Residence time Distribution, Concept of Elementary Reactions and Reaction Mechanism, Multi-Step Reactions in Parallel and in Series, Reaction Yield and Selectivity Analysis, Reactor Sizing, Homogenously Catalyzed Reactions, Mass Transfer and Chemical Reactions, Hatta Number and its Application, Thiele Modulus and Reaction in Catalyst Pellet, Damkohler Number and its Application, , Batch and Semi-batch Reactors with Heat Effects, Biological Reactions with Michalis-Menten/Monod Kinetics

Transport Phenomena: Fick's Law of Diffusion, Fourier's Law of Heat Conduction, Newton's Law of Viscosity, Bernoulli's Equations and Analysis of Piping Networks, Pressure Drop through Pipes and Fittings, Heat Transfer by Conduction through Complex Media, Critical & economic thickness of insulation ,Heat and Mass Transfer Coefficients, Dimensionless Analysis and Use of Dimensionless Numbers, Setting Up Differential Equations by Shell Balances, Navier Stokes Equation, Equation of Continuity, Cocurrent and Countercurrent Heat Exchange, Flow Through Packed Bed and Ergun Equation, Criterion for Fluidization, Drag Coefficient and Terminal Settling Velocity, Working of Orifice and Venturi Meters, Log Mean Driving Force Analysis, NTU-HTU Analysis of Contacting Equipment, Loading and Flooding of Countercurrent Equipment, Power of Pumps and Compressors, , boiling & condensation heat transfer, Heat exchanger & their design, reboiler, evaporators

Environmental Engineering:

Wastewater treatment; Groundwater and surface water pollution, removal of specific water contaminants; Solid waste; Hazardous waste.

Municipal solid waste management: Sources, generation, characteristics, collection and transportation, waste processing and disposal (including reuse options, biological methods, energy recovery processes and landfilling). Hazardous waste management: Characteristics, generation, fate of materials in the environment, treatment and disposal.

Air pollution; Air pollutants: sources, effects, and dispersion modelling, pollutants minimization and control, fugitive emissions (source and control),.

Unit Operation:

Absorption: Solubility, choice of solvent, concept of rate approach and stagewise approach, countercurrent and co-current multistage operations, dilute and concentrated systems, process

design of absorption equipment's, performance evaluation of absorbers. Plate and packed columns, packing characteristics / selection.

Distillation: Fundamentals of vapors - liquid equilibrium, Henry's, Raoult's and Dalton's laws; boiling point and dew point curves, X - Y and T-X-Y diagram, partial vaporization / condensation, performance evaluation of distillation columns including reboilers and condensers Flash; differential and steam distillation, staged calculation using McCabe -Thiele method. Batch distillation - Binary systems, constant product / constant reflux operation. Advanced topics in batch distillation. Distillation: Staged calculations using enthalpy - concentration diagram, multicomponent distillation Design aspects of packed columns: sizing, packing selection, design of other internals, efficiency calculations, Design aspects of tray columns: regime of operation in tray towers, sizing of tray towers, efficiency, and entrainment calculations.

Drying: Wet bulb, dry bulb and adiabatic saturation temperatures, humidity, drying mechanism, drying rate curves, estimation of drying time and process design of dryers e.g., spray, rotary, tunnel, tray, fluid bed and thin film, performance evaluation of dryers.

Humidification/Dehumidification and Cooling Tower: Definitions, usage of psychometric chart, temp/humidity, enthalpy/humidity chart, air conditioning, method of changing humidity and equipment's, cooling tower process design, counter-current, co-current and cross current, mass and heat balances in bulk and interfaces, estimation of air quality, performance evaluation of cooling towers.

Filtration and Centrifugation: Mechanism of filtration, basic equation, constant volume, constant pressure filtration, rate expressions with cake and filter cloth resistances, compressible and incompressible cakes, process design of filtration equipment's and their performance evaluation, plate and frame, Nutsch, rotary, vacuum. Theory of centrifugal separation, design equations, centrifuge types, and performance evaluation.

Crystallization: Theory of solubility and crystallization, phase diagram (temp/solubility relationship), population balance analysis, method of moments for rate expressions for, volume, area and length growth, CSD distribution, MSMPR operation, evaporative and cooling (rate expressions) , most dominant size, ideal classified bed, melt crystallization, process design of crystallizers and their operation.

Process Control:

Measurement of process variables; sensors and transducers; P&ID equipment symbols; process modeling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; transducer dynamics; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.

A working knowledge of differentiation, integration, vector and matrix operations, ordinary and partialdifferential equations is expected.