

## **B. Tech. in CHEMICAL ENGINEERING**

### **Syllabus of Paper – 1**

#### **CHEMICAL PROCESS CALCULATIONS**

Engineering Calculations: Units and dimensions, Conversion of units; Chemical reactions: excess reactant, limiting reactant, conversion, extent of reaction, yield and selectivity in multiple reactions; Composition of mixtures and solutions. Flow-sheeting: degrees of freedom and its importance in flow-sheeting. Material balance with and without chemical reactions: Recycle, bypass, and purge calculations, calculations for unit operations like mixing, evaporation, crystallization and distillation; Combustion reactions; Behaviour of ideal gases: Various equations of state, Law of Dalton and Amagat, Densities of gaseous mixture; Real gases: Critical properties, various equation of state, Law of corresponding states; Vapour pressures: Liquefaction, Vaporization, Cox Chart, Duhring Plot; Psychometric calculation; Energy balance: Heat capacity of gases, liquids, solids and solutions, Heats of fusion and vaporization, heat of reaction, heat of combustion, heat of formation.

#### **CHEMICAL ENGINEERING THERMODYNAMICS**

Evaluation of PVT properties of fluids, Law of corresponding states, Residual volume, Compressibility factor, Equations of state, phase behaviour of pure fluids, Clausius Clepeyren equation; First law of thermodynamics and enthalpy; Second law: Entropy, Work function, Free energy, thermodynamic efficiency, Heat engine, Refrigeration, and Heat pump; Second law for open system: thermodynamic efficiency analysis of steady state devices like pumps, compressor, turbine, nozzles, and throttles; Introduction to third law; Phase rule: Theoretical and experimental aspects of phase rule and its use in study of multi-component system, Solution thermodynamics, Partial molar properties, Chemical potential, Fugacity; Solution non-ideality: excess properties, residual properties, activity coefficient (Gibbs energy based liquid models); Gibbs-Duhem equation, Chemical reaction equilibria, VLE and LLE calculations.

#### **FLUID DYNAMICS**

Fluid Statics: Definition of Fluid, Properties and classification of fluids, buoyancy, pressure measurement; Kinematics of fluid flow: velocity field; stream function; Nature and classification of flow, irrotational flow, Dynamic properties of fluid; Flow measurement: Orifice meter, Venturi meter, Pitot tube, and Rota meters; Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Differential balances of fluid flow: derivation of continuity and momentum (Navier-Stokes) equations for a Newtonian fluid; Applications to plane Couette, plane Poiseuille and pipe flows; High-Reynolds number flows; Pipe flows and fittings: laminar and turbulent flows; friction factor charts, losses in fittings, Dimensional analysis and similitude: Buckingham Pi theorem and applications, Model analysis; Fluid transportation: Valves, Pumps and Compressors; Agitation and mixing: power consumption, mixing times, scale up, Mixing in pipe flow; turbulent and free jets; Flow past immersed bodies: flow past a sphere and other submerged objects, fluid friction in porous media, Flow through packed beds and fluidized beds; Boundary Layer Theory; Introduction to turbulent flows, Transition to turbulence, Fluctuations and time-averaging, Basic equations of turbulent flow.

## **HEAT TRANSFER OPERATIONS**

Conduction: Fourier's law, Steady state conduction of heat through plane, cylindrical and Spherical solids single and in series; Convection– Steady state heating and cooling of fluids without phase change; Heat transfer from condensing vapours; film wise and drop wise condensation, Boiling; Radiation: Kirchhoff's law, Stefan-Boltzman law, Simple case of radiation heat transfer between surfaces; Evaporation: Single and multi- effect evaporation, Types of evaporator, Performance of single effect evaporation, Multiple effect evaporation – forward, backward, mixed and parallel feed, Performance of multiple effect evaporation in comparison to that of single effect evaporation, Vapour compression evaporation, Calculations for single effect evaporators; Different types of Heat Exchangers; Heat transfer augmentation.

## **PROCESS EQUIPMENT DESIGN**

Detailed design of the following process equipment's; Heat exchangers: concentric tube, shell and tube types; Condensers –condenser coolers and superheater condensers for single vapour, Evaporators single and multi-effects, Absorbers for binary systems without reactions, Distillation columns for binary mixtures along with tray hydraulics, Rotary dryers, Multi- component Distillation Column Design, Storage tanks, Pressure vessels, accessories like nozzles, flanges, head and supports such as bracket, skirt and saddle support.

## **PROCESSING AND HANDLING OF MATERIALS**

Characteristics of a single particle: Size, shape, surface area, volume; Characteristics of a collection of particles: Particle Size Distribution, Specific surface of mixture, average particle size, Number of particles; Screen analysis: Effectiveness of screen, Industrial screening equipment's; Size reduction: Factors affecting comminution, Laws of comminution, Particle Dynamics: Settling velocity, Effect of shape, Wall effect, hindered settling; Separation of particles: Classification, Jigging, Magnetic and Electrostatic separations, Sedimentation, Filtration, Hydro-Cyclones, Flotation ; Mixing and Agitation: Phenomena of mixing and agitation, Circulation, velocities and power consumption in agitated vessels; Particle transport and storage: Hopper, Bins & Silos, Mechanical conveyers, Pneumatic transport in horizontal and vertical pipelines.

## **TRANSPORT PHENOMENA**

Momentum transport: Viscosity and mechanism, Temperature and pressure dependence of viscosity (gases at low density); Shell momentum balances: Velocity distributions in laminar flow, Equations of changes for isothermal system, Unsteady flows; Shell energy balances: Heat conduction through composite walls and in cooling fin forced and free convection; Equations of change for non-isothermal systems, Equations of change for energy; Mass transport: Diffusivity and mechanism, Temperature and pressure dependence of mass diffusivity; Concentration distributions in solids and in laminar flow; Shell mass balances, diffusion through a stagnate gas film, Diffusion with homogeneous and heterogeneous chemical reactions, diffusion into a falling liquid film, Diffusion and chemical reaction inside a porous catalyst. Equations of continuity for a binary mixture.

## **Syllabus of Paper – 2**

### **ENGINEERING MATHEMATICS**

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and eigenvectors. 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, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems. 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.

### **MASS TRANSFER OPERATIONS**

Molecular diffusion: Fick's law of diffusion, Steady state diffusion, Multicomponent diffusion, Measurement and prediction of diffusion coefficients, Diffusion in variable area, Molecular diffusion in liquids, solids and gel, Knudsen diffusion; Convective Mass Transfer: Mass transfer coefficient, dimensionless groups in mass transfer and various correlations, Turbulent or eddy diffusion; Theories of mass transfer: Film theory, Penetration theory, Surface renewal theory; Analogies in mass, heat and momentum transfer: Reynolds analogy, Chilton-Colburn analogy; Interphase Mass Transfer: Phase equilibrium, Raoult's and Henry's law, Local and overall mass transfer coefficients, Two phase resistance theory; Gas absorption and stripping: Graphical Equilibrium-Stage method and algebraic method for determining number of stages, stage efficiency, design of packed tower, height equivalent to a theoretical plate (HETP); Distillation: Vapor-Liquid Equilibrium (VLE), Flash, steam and batch distillation, McCabe-Thiele and Ponchon-Savarit graphical method for calculating equilibrium stages in trayed towers for binary system, Distillation in a packed tower, Tray efficiency, Multi component Distillation, Azeotropic and extractive distillation; Humidification and dehumidification: Wet bulb and adiabatic saturation temperatures, Psychrometric chart and its use, Cooling tower calculations and design; Drying: Drying equilibria, Drying rate curve, Classification of drying equipments and their design methodologies; Solid-Liquid extraction: Solid-liquid contacting strategy and equilibrium, Supercritical fluid extraction; Liquid-Liquid extraction: Liquid-Liquid equilibria (LLE), Solvent selection, Design calculations of stage wise extraction, Triangular diagram; Adsorption: Adsorption isotherms, Heat of adsorption, Breakthrough analysis, Pressure swing and temperature swing adsorption, Simulated moving bed systems, Crystallization: Nucleation and crystal growth, Crystal size distribution, Equipment for solution crystallization; Membrane separation: Materials, Types and preparation of membranes, membrane characterization, Transport in membranes, Microfiltration, Ultrafiltration, Nano filtration, Reverse Osmosis and Pervaporation.

### **FUELS AND COMBUSTION**

Solid fuels: Coal origin, Chemical composition, Calorific value, Classifications, Characteristics and Distribution of Indian coals, Coal storage, Coal washing and blending, Petrographic

constituents of coal, Carbonization of coal, Manufacture and properties of metallurgical coke, Recovery of by products; Liquid fuels: Origin and composition of crude oil, distillation of crude oil and properties of gasoline, kerosene and diesel oil, Breaking and rebuilding processes like Cracking, Reforming, Polymerization, Coal tar distillation, Shale oil; Gaseous fuels: Natural gas, Coal gas, Coke oven and blast furnace gas, Manufacture of water gas and producer gas, Carburetted water gas; Synthetic fuels: Hydrogenation of coal, Fischer-Tropsch synthesis; Introduction to nuclear fuels and nuclear reactors; Combustion of solid fuels, Calorific values, Adiabatic flame temperatures, Combustion calculations, Gas analysis, Furnace design.

## **CHEMICAL REACTION ENGINEERING**

Introduction: Reaction rate laws and stoichiometry, Classifications of reactions, order and molecularity of reaction and its determination; theory on reaction: collision theory and activated complex theory; Isothermal Reactor Design: Design of Batch reactor (BR), continuous stirred tank reactor (CSTR), plug flow reactor (PFR), packed-bed reactor (PBR) for single ideal reactions; reaction mechanism and pathways; introduction to enzyme kinetics; Non-isothermal reactors; Catalysts and catalytic reactions: classification of catalysts, catalyst deactivation, external diffusion effects on heterogeneous reactions, diffusion and reaction in solid catalysts; Multiphase reactions; Non-ideal Reactors: causes of non-ideality; residence time distribution (RTD), Measurements and characteristics of RTD, models for non-ideal reactors.

## **CHEMICAL PROCESS TECHNOLOGY**

Introduction of CPT with reference to Indian resources, industries, trade and export potential, small scale industries and rural development, Preparation of process flow diagrams, Instrumentation diagrams and Process symbols; Introduction to the following industries lying emphasis on process flow sheet, material requirements, process conditions, material of construction and design aspects; Chlor-Alkali Industries: Soda ash, Caustic soda and Chlorine; Acids: Sulphuric acid, Hydrochloric acid and Nitric acid; Electro thermal Industries: Silicon Carbide and Calcium Carbide; Extraction and Refining of edible oil; Fat splitting and Hydrogenation of oil; Soaps and Detergents; Glycerine; Production of Pulp, Paper and Rayon; Fermentation Industries: Manufacture of Industrial alcohol, Absolute alcohol and allied products; Manufacture of Sugar, Starch and its derivatives; Coal based Chemical Industries.

## **PROCESS DYNAMICS AND CONTROL**

Control of Chemical Processes, Incentives and need of process control, design aspects and hardware for a process control system, Modeling the dynamic and static behaviour of chemical process, Process variables and process degrees of freedom, state equations, Analysis of the Dynamic behaviour of chemical processes, Linearization, Laplace transforms: solution of linear differential equations; Transfer functions and input output model, Dynamic behaviour of first, second and other order and higher order systems, Analysis and design of Feedback control systems, concept and types of feedback control, measuring devices, final control element, block diagram, effect of various control action on processes; Stability analysis: design of feedback controllers, frequency response analysis, Analysis and design of Advanced control systems, systems with large dead time and inverse response, control systems with multiple loops, feed forward and ratio control, adaptive and interfacial control systems; Multivariable processes, MIMO control system, interaction and decoupling of control loops, control systems for complete plant; Digital computer control loops, continuous to discrete system, z-transformation, discrete time response, design of digital feedback controllers.

\*\*\*\*\*