CM-501 CHEMICAL ENGINEERING THERMODYNAMICS – II

UNIT I -Non-Ideal behavior: Thermodynamic properties of homogeneous mixtures; property relationship for systems of variable compositions, partial molar properties their evaluation, Fugacity and fugacity coefficient of pure substances and components in solution, Generalized correlations for the fugacity coefficient, Lewis Randall rule, excess properties

UNIT II - Fundamentals of Phase Equilibria: Concept of equilibrium in phases, The theory of ideal and non ideal solutions, Thermodynamic equations of Vapor Liquid Equilibrium for ideal and non-ideal solutions, Liquid Liquid and Solid Liquid equilibria.
Reaction Equilibria: Concept of reaction equilibria, single and multiple reactions, Degrees of freedom for single and multiple reactions.

UNIT III - Refrigeration and Liquefaction: Principles of refrigeration, Theory of refrigeration, Vapor Absorption Refrigeration, Vapor Absorption Refrigeration, Carnot refrigerator, vapor-compression cycle, absorption refrigeration.
Liquefaction processes: Linde liquefaction process, Claude liquefaction process.

UNIT IV - Duct flow of compressible fluids: pipe flow, nozzles, throttling process, Turbines. Compression processes: compressors, pumps, introduction to ejectors.
Chemical potential & its physical significance, effect of pressure & temperature on heatof reaction, concept of free energy Vant-Hoffs equation, Claussions-Clapeyron equation, Gibbs-Buem relationship of free energy with equilibrium constant, equilibrium & its applications.

UNIT V - Methods for estimation of Thermodynamics properties: Estimation methods for critical parameters, Estimation method for Mixture Enthalpy and Entropy. Elements of statistical thermodynamics, counting the number of microstates for a given macro-state, the most probable macrostate, Boltzman distribution, evaluation of Lagrangian constants alpha, statistical interpretation of work & heat.

REFERENCES

1. Rao .Y.V.C, "Chemical Engineering Thermodynamics", University Press (I) Ltd., Hyderabad, 1997.
2. Kyle,B.G"Chemical and Process Thermodynamics", 3rd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 20000.
3. Smith J.M and Van Ness- Introuction to Chemical Engg Thermodynamics – 6th edition
4. Daubert; chemical engg thermodynamic; TMH
5. Rathakrishnan E; Fundamentals of Engg Thermodynamics; PHI
6. Dodge B.F. Chemcail Engineering –Thermodynamics –McGraw Hill
7. Balzhiser Samules and Eliassen-Chemical Engg- Thermodynaics Prentic Hall
8. Sandler S.I Chemical Engg-Thermodynamics-John Wiley and son
9. Rastogi and Mishra-Chemical Engg Thermodynaics

CM-502 ORGANIC CHEMICAL PROCESS INDUSTRY

Unit I Soaps and detergents: Difference between soaps and detergents, Classification of cleansing compounds, process of soap manufacture, Glycerol recovery, Manufacture of detergents: sulphated fatty alcohols and alkyl – aryl sulphonates.

Unit II Important features of Indian sugar industry, Major unit operation of sugar industry, Alcohol fermentation, Production of 95% alcohol and anhydrous or absolute alcohol from fermentation broth, Pollution problems. Raw materials for pulp making, Kraft and Sulphite pulping methods, Semi-chemical pulping, Pulp and paper, pulping process, chemical recovery, stock
preparation and paper making,

Unit III Important petrochemicals, Feed stock, Common unit processes: cracking, alkylation-dealkylation and hydroalkylation, halogenation, oxidation, hydrogenation-dehydrogenation; hydration-dehydration, nitration, amination, esterification, hydrolysis, hydroformylation process.

Unit IV Basic principles of polymerization reactions: bulk, solution, suspension and emulsion polymerisation, Synthesis of phenol formaldehyde, polyethylene, polystyrene and PVC, Rubbers, their classification and processing, Dyes and Dye intermediates, insecticides and pesticides, nitration and nitrating agents.

Unit V Natural and synthetic fibres, Fibre properties important in textile production, Fibre spinning processes: melt, dry and wet spinning, Manufacture of nylon 6,6 and nylon 6 fibres, viscose rayon and polyester fibres, polyamides, acrylics, cellulose and acetate,

References:

1. Dryden C.E; Outlines Of Chemical Technology; Affilicted. East West press, New Delhi, 1997
2. G.T. Austin, Shreve's Chemical Process Industries, Mc Graw Hill.
3. Gupta VB & Kathari VK; Manufacturing Fibre Technology; Chapman Hall, Newyork I Edition
4. Kathari V.K.; Progress In Textile, Sciences Technology, Vol I & II; IAFL Publications, S-351 Greater Kailash part I New Delhi – 48 I Ed.
5. Austin, G.T; Shreeves Chemical Progress Industries; . Mc. Graw Hill New York

CM-503 COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING

Unit I Treatment of engineering data – Graphical representation. Empirical equations, Integration, graphical Integration, Graphical Construction of Integral curves, Numerical Integration.
Interpretation of Engineering Data- Significant figure, Classification of Measurements, Propagation of Errors, Variation and Distribution of Random Errors, Properties of Variance, Confidence limits for small samples.

Unit II. **Non-linear algebraic equation**: Newton-Raphson Method, Secant method, Method of False Position (Molar Volume of non-ideal gases, Settling velocity, Heat loss from pipes, Vapor pressure estimation etc.
non-linear difference equations, Optimization, types of methods, its application relating to chemical processes.

Unit III Numerical Integration: Trapezoidal Rule and Simpson's 1/3 rule and 3/8 rule. (Rayleigh's equation, Average heat capacity estimation. **Interpolation:** Newton-Gregory Forward and Backward Interpolation, Lagrange's Interpolation formula, (Estimation of thermo-physical properties.

Unit IV Ordinary differential equations: Euler and Modified Euler method, Runge-Kutta method of Fourth order, (Rate equations, Solution of Boundary Value problems. **Curve fitting** by the method of Least Squares linear.

Unit V P – X,Y and T – X, Y evaluation for binary mixtures: Calculation of Bubble Pressure and Bubble Point. Dew Pressure and Dew point for Ideal Binary and multi-component system. Flash Vaporization for multi-component system.

Reference Books:

1. Rajaraman, V., Computer Oriented Numerical Methods, Prentice Hall of India.
2. Mickley, Sherwood, and Reed, Applied Mathematics in Chemical Engineering, Tata McGraw Hill.
3. Grewal, S., Numerical Methods of Engineering and Science, Khanna Publishers.
4. Glyn James, Advanced Modern Engineering Mathematics, PearsonEducation,-3rd Edition.
5. Jenson & Jeffrey's; Mathematical Methods In Chemical Engineering; Mc Graw Hill
6. Luyben WL; Process modeling, simulation and control for chemical engg; Mc Graw Hill

List of Experiment (Pl. expand it):

1. Data representation and treatment by Graphical methods, Pressure- Volume-Temperature and concentration relationships for gases and their mixtures.
2. Integrated methods of data processing. Integral functions and their graphical representation.
3. Estimation of properties from empirical correlations
4. Estimation of critical properties from group contribution method.
5. Redlich-Kwong equation of state and other Virial equations to estimate thermodynamic properties like compressibility factor, molar volume and P-V-T relationships.
6. To study the effect of liquid viscosity and dissolved gases on pump efficiency, reciprocating

pump performance.

7. Measurement errors their propagation and minimization of random errors. Selection of confidence limits.
8. Mass balance problems using continuity equation applied to a dynamic system. Formation of differential equations (component balance) and their solution & examples – CSTR and flow through pipes.
9. Numerical Solutions of batch reactor problems. Euler Algorithm
10. Runge-Kutta algorithm and its application in chemical Engineering. Implicit and explicit calculations. Problems related to effect design, optimum liquid concentration.
11. Transient flow of fluid unsteady temperature and varying concentration problems and use of partial differential equation to solve them.

CM-504 MASS TRANSFER-I

Unit I Fundamentals of Mass Transfer: Individual and film coefficients, overall mass transfer coefficient and their inter relationships; Analogies in transfer processes, determination of mass transfer co-efficient; two phase flow in packed beds, co-current and counter current processes flooding loading, column internals: types of trays/ plates and packing, point and plate efficiency.

Unit II Diffusion phenomenon: Introduction, Types of diffusion in fluids. Types of diffusion in solid. Measurement and calculations of diffusivities. **Eddy diffusion:** Mass transfer coefficients and their correlations. Theories of mass Transfer. Interphase mass transfer, Mass transfer theories: film theory Penetration theory and surface renewal theory.

Unit III Humidification and Dehumidification: Principles, vapour-liquid equilibria, enthalpy of pure substances, basic definition of all humidification terms, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, equipment like cooling towers, tray towers, spray chambers, spray ponds, cooling tower design – HTU, NTU concept, calculation of height of cooling tower..

Unit IV Drying: Drying Equilibria. Drying rate curves. Mechanism of drying. Calculation of batch and continuous drying. Drum dryers, spray and tunnel dryers. **Crystallization:** Factors governing nucleation and crystal growth rates. Controlled growth of crystals. Yield calculations and energy balance. Different types of crystallizer equipments. Fractional crystallization.

Unit V Adsorption: Theories of adsorption, types of adsorbent; activated carbon, silica and molecular sieves, Isotherms, Industrial adsorbents. adsorption; Break through curves, Stagewise operations, Adsorptions calculations and equipments.

Reference Books:

1. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981.
2. Ananthraman, K.M. Begum, M.S., Mass Transfer Theory and Practice, PHI New Delhi, 2011.
3. Coulson JM, Richardson JF and Sinnott RK, Chemical Engineering Vol I, II, IV and V, 4th Edition, Pergmen Press, 1998.
4. Badger & Banchero, Introduction to Chemical Engineering, TMH, 6th Reprint, 1998.
5. Geankoplis, C. J., Transport Processes and Unit Operation, Prentice Hall(I, 2000.
6. Mc-Cabe W.L, Smith J.M.; Unit Operation In Chemical Engineering; Tat Mc-GrawHill.
7. Sherwood, T.K. Pigford R.L. and Wilke, C.R.; Mass Transfer; Mc. Graw Hill.

List of Experiment (Pl. expand it):

1. Determination of relative volatility of a given system of acetic acid water.
2. To prepare the drying rate curve for fluidized bed dryer.
3. To study the characteristics of spray dryer.
6. To study the characteristics of drum and Tunnel dryer.
4. To study the drying characteristics of a wet granular material using natural and forced circulation in tray dryer.
5. Tray Dryer – To calculate rate of Drying
6. Rotary Dryer – To study the Characteristics of Rotary Dryer
7. Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system

8. To study Solid in air Diffusion
9. To study the characteristics of cooling tower
10. Humidifier and Dehumidifier – To study the Characteristics
11. Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient.

CM-505 HEAT TRANSFER

Unit I Introduction: Fundamentals of heat transfer, basic modes of heat transfer. Concept of driving force and heat transfer coefficients, rate expressions for three modes i. e. conduction, convection, radiation. calculation of overall heat transfer coefficients.

Unit II Heat transfer by conduction: Fourier's Law, thermal conductivity, conduction through a at slab, composite slab, conduction through a cylinder, composite cylinder, conduction through sphere, composite sphere. Critical radius of insulation. Concept of thermal resistance, Theory of insulation, fouling factors.

Unit III Heat transfer by convection:
Fundamental considerations in convective heat transfer, significant parameters in convective heat transfer such as momentum diffusivity, thermal diffusivity, Prandtl number, Nusselt number, dimensional analysis of convective heat transfer-Natural and Forced convection equivalent diameter for heat transfer, estimation of wall temperature, correlations for heat transfer by natural convection from hot surfaces
of different geometries and inclination.

Unit IV Heat transfer by radiation: Emissivity, absorptivity, black body, grey body, opaque body, concept of shape factor, stefan boltzmann, kirchhoff law. Equations for rate of heat transfer by radiation for various cases. Basic unsteady state radiation heat transfer.

Unit V Heat Exchangers: Classification and types of heat exchangers, Double pipe heat exchanger, calculation of LMTD, effectiveness NTU method. Introduction to Shell and Tube Heat Exchanger. heat transfer in agitated vessel, heat flux temperature diagram for boiling and condensation under vertical and horizontal surfaces, nucleate & pool boiling, effect of surface condition on condensation, correlation for heat transfer under condensation. **Evaporation**- Type of evaporators and their applications single and multiple effect evaporators, **Reboiler:** Design { Kettle type reboiler, horizontal thermosyphon reboiler, vertical thermosyphon reboiler. Engineering problems and trouble shooting.

References:
1. Donald Q. Kern; Process Heat Transfer; Tata McGraw Hill.
2. Alan J. Chapman; Heat Transfer; Collier McMillan.
3. Rao Y.V.C; Heat Transfer; PHI

List of Experiment (Pl. expand it):
1. To determine the thermal conductivity of metal rod.
2. To determine the equivalent thermal conductivity of composite wall.
3. To determine heat transfer coefficient in force convection.
4. To determine heat transfer coefficient in Natural convection.
5. To determine heat transfer coefficient with the help of Stefan Boltzmann Apparatus.
6. To calculate emissivity of the test plate by emissivity measurement apparatus.
7. To determine heat transfer coefficient in double pipe heat exchanger.
8. To study the heat transfer characteristics of a shell and tube heat exchanger (heating/cooling) of water.

9. To determine heat transfer coefficient in parallel and counter flow heat exchanger.
10. To measure the rate of evaporation using an open pan evaporator.
11. To measure the rate of condensation of pure water vapour and to determine the heat transfer coefficient.
12. Demonstrate the film-wise drop-wise condensation and determination of he heat transfer coefficient.
13. To study the single effect evaporator and find out the heat transfer coefficient