CM-601 PROCESS EQUIPMENT DESIGN-I

Unit I Bolted Flanges: Types of Flanges, and selection, Gaskets, Design of non- standard flanges, specifications of standard flanges.
Mechanics of materials: Stress- Strain relationships of elastic materials subjected to tensile, compressive and shear forces, Elastic and plastic deformation.

Unit II Shell and tube heat exchanger- General design considerations- LMTD correction factor, fluid allocation, fluid velocities, stream temperatures, pressure drop, shell side and tube side heat transfer coefficients, **Design of double pipe heat exchanger**. Plate heat exchanger: advantages, disadvantages, design procedure, temperature correction factor, heat transfer coefficients, pressure drop.

Unit III Evaporators: classification, criteria for selection, design of evaporator. **Condensers:** heat transfer fundamentals, condensation outside horizontal tubes, condensation inside and outside vertical tubes, condensation inside horizontal tubes, condensation of mixtures.
Reboilers: types, selection, boiling heat transfer fundamentals,

Unit IV Design Mass Transfer Equipments such as Distillation Columns, Dryers and Absorption column.

Unit V Design of Tall Vessels
Stresses in the shell of a tall vertical vessel, and period of vibration, vessel supports- introduction and classification of supports, design of skirt supports considering stresses due to dead weight, wind load, seismic load, design of base plate, skirt bearing plate, anchor bolts, bolting chairs and skirt shell plates, Design of saddle supports, ring stiffeners.

References
1. L.E. Brownell and E. Young, John Wiley, New York, 1963, "Process equipment design".
2. B.C. Bhattacharya C.B.S. Publications, "Introduction to Chemical Equipment Design" .
3. M.V. Joshi, Mcmillan India, "Process Equipment Design".
4. J.M. Coulson, J.F. Richardson and R.K., Chemical Engineering Vol. 6".
5. Ludwig E.E., Gulf Publishing Company, "Applied Process Design for Chemical and Petrochemical Plants" vol 1 and 2.
6. Walas S.M. Butterworth Heinamen, McGraw Hill book company, New York
7. Brownell, N.E and Young, H.E; Process Equipment Design; John Wiley
8. Perry RH; Hand book of Chemical Engrs; Mc Graw Hill Pub

CM-602 INORGANIC CHEMICAL PROCESS INDUSTRY

Unit I Chlor-Alkali Industries: Solvay process of manufacturing soda ash, caustic soda and chlorine manufacture by electrolytic process: mercury, diaphragm and membrane cells, Bleaching powder, Sodium chloride.

Unit II Sulfur: Elemental Sulfur mining, Sulfur from ores, Oxides of Sulfur (SO2, SO3). **Acids:** Sulfuric acid, Nitric acid, Hydrochloric acid, Phosphoric acid and phosphates.

Unit III Fertilizers: Ammonia, Urea, Ammonium chloride, Ammonium nitrate, Ammonium phosphate, Ammonium sulfate, DAP, Biofertilizers, N-P-K Fertilizers and micronutrients

Unit IV Cement: Various kinds of cements and their major constituents, cement manufacture by cement rock (limestone) beneficiation and *Portland* process. **Glass:** Nature, types, composition and uses of glass, its manufacture: melting, shaping, annealing and finishing operations.

Unit V Coal gasification technologies: various types of fuel gases: producer, water, coke oven, synthesis, LPG & natural gases, **various industrial gases:** carbon dioxide, hydrogen, oxygen, nitrogen, helium, acetylene, carbon monoxide, sulphur dioxide, their sources and applications.

References:

1. Austine G.T.and Shreeves; Chemicasl Process Industries; Mc GrawHill
2. Dryden C.E., M. Gopala Rao; Outlines Of Chemical Technology. Affiliated East-West Press
3. Pandey G.N.; Chemical Technology Volume- I; Lion Press, Kanpur.
4. Bose, P.K., Chemical Engineering Technology, Vol. 1,2, Books and Allied (Pvt Ltd, 2011.
5. Desikan and Sivakumar , Unit Processes in Organic Chemical Industries (Eds., CEDC, IITM, 1982.
6. G.T. Austin, Shreve's Chemical Process Industries, Mc Graw Hill.
7. Shreve's, Chemical Process Industries, McGraw Hill, 4th Edition

CM-603 MASS TRANSFER-II

Unit I Absorption: Absorption. Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption columns. Design of Plate columns. Absorption and Extraction in continuous contact columns, co-current, counter current and cross current contacting fluids, calculations of NTU and HTU, concept of HETP, Absorption and desorption factors

Unit II Distillation: Introduction. Vapour liquid equilibria, Boiling point diagram, Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component systems. Non-ideal systems. Azeotropes. Steam distillation. Flash and simple distillation extractive distillation.

Unit III Multistage distillation.
Multi-stage rectification column, McCabe Thiele, and Ponchon-Savarit methods for multistage operations, tray efficiencies, concept of reflux, minimum reflux ratio, optimum reflux, total reflux,
Murphree plate efficiencies. Multicomponent distillation. Vacuum, molecular, extractive and azeotropic distillations. Fensky and undeinrood equation for minimum numbers of plate calculation.

Unit IV Liquid-liquid extraction: Ternary equilibrium. Solvent selection. Single stage. Multistage-cross-current, counter-current extraction. Equipment for liquid-liquid extraction, continuous contact extraction in packed towers.

Unit V Solid-Liquid Extraction (Leaching): Equipment for leaching. Preparation of solids for leaching. Equilibrium diagrams. , ideal stage equilibrium, stage efficiencies, Calculation of single stage and multi-stage leaching operation.

References

1. Treybal, R.E., Mass Transfer Operations, 3rd Edition, McGraw Hill, 1981
2. Richardson J. F. and Coulson J.M. "Chemical Engineering", Vol. I , II
3. McCabe and Smith, 'Unit Operations in Chemical Engineering"
4. Henley E. J. and Seader H.K. "Stage wise Process Design" , McGraw Hill
5. A.L. Lyderson, "Mass Transfer in Engineering Practices", John Wiley
6. Coulson, J.M., Richardson, J.F. and Sinnott, R.K. , Chemical Engineering Vol I, II, IV and V, 4th Edition, Pergmen Press, 1998.
7. Wankat P.C., Rate Controlled Separations, Elsevier, 1990.
8. Foust, A., Principals of Unit Operation, 2nd Edition, John Wiley, 1994.
9. Geankoplis, C. J, Transport Processes and Unit Operation, Prentice Hall(I, 2000.

List of Experiment (Pl. expand it):
1. To study steam distillation
2. Vapour liquid equilibrium
3. Liquid-liquid equilibrium for ternary system
4. Liquid – Liquid Extraction (single stage and multistage)

5. Characterization of Spray Extraction Column
6. Batch/ Continuous Leaching
7. To verify Rayleigh equation for differential distillation of binary system.
8. To study batch distillation.
9. To study continuous distillation.
10. Studies on packed tower distillation unit.
11. Studies on the sieve plate distillation unit.
12. Studies on bubble cap distillation column.
13. To study the absorption of a gas in a packed column and calculation of NTU and HTU.

CM-604 CHEMICAL PROCESS CONTROL

Unit I Construction and characteristics of final control elements such as Proportional, Integral, PD, PID controllers, pneumatic control valve, principles and construction of pneumatic and electronic controllers.

Unit II Process instrumentation diagrams and symbols, process instrumentation for process equipments such as Distillation column Absorption column, Heat Exchanger, Reactors, Evaporators, fluid storage vessels.

Unit III Laplace Transform, Linear open loop system, first order system and their transient response. Dynamic response of a pure capacitive process, Transportation lag, Dynamic response of a first order lag system.

Unit IV Second order system and their transient response. Interacting and non-interacting system. Linear closed loop system, block diagram of closed loop transfer function, controllers, transient response of closed loop system.

Unit V Stability concept, Routh stability criterion, relative stability, Hurwitz stability criterion, Nyquist's stability criterion. Root locus technique, introduction to frequency response, Bode diagram, Bode stability criterion, gain and phase margins, Ziegler Nichols controller setting.

References:

1. Coughnower & Koppel – Process System Analysis And Control- McGraw Hill, New York.
2. D. P. Eckman – Automatics Process Control – McGraw Hill, New York.
3. Peter Harriot – Process Control – McGraw Hill, New York.
4. J. J. Nagrath & M. Gopal; Control System Engineering.

List of Experiment (Pl. expand it):

1. To study the characteristics of control valves (linear, quick opening, etc)
2. To study the dynamics of liquid level systems of non-interacting and interacting types.
3. To study the response of mercury in glass thermometer with and without a thermowell.
4. To study the characteristics of an electronic PID controller.
5. To study the characteristics of a current to pneumatic converter.
6. To study the effectiveness of computer control of a distillation column.
7. To study the effectiveness of a computer control of a heat exchanger.
8. To study to effectiveness of a computer control of a chemical reactor
9. To study to dynamics of a pressure tanks.
10. To calibrate an air purged liquid level indicator.

CM-605 CHEMICAL REACTION ENGINEERING-I

Unit I Introduction: Scope of Chemical Reaction Engineering, Classification of reactions, Rate equation and rate of reaction, Factors affecting rate of reaction. Chemical kinetics and Thermodynamics/Equilibrium, Temperature dependency of rate constant from Arrhenius, Collision and Transition state theories, activated complex theory, Mechanism of reaction series, Parallel and consecutive reaction, autocatalytic reactions, chain reaction, polymerization reaction.

Unit II Kinetics of Homogeneous Reactions
Defining a rate equation and its representation, single and multiple reactions, Autocatalytic reactions, molecularity and order of reactions, Integral method of Analysis of data, Irreversible, zero, first, second, and nth order reactions (Uni-molecular and bimolecular type), Overall orders from half-life method.
Non-elementary reactions: Difference between elementary and non-elementary reactions. Kinetic models and mechanisms for non-elementary reactions, kinetic models for non-elementary reactions,.

Unit III Design of ideal reactors: Concept of ideality. Development of design expressions for batch, tubular, and stirred tank reactors for both constant and variable-volume reactions, Design of Isothermal and non-isothermal batch, CSTR, PFR, reactors.
Comparison of ideal reactors: General graphical comparison. Multiple Reactor Systems: Plug flow and/or Mixed flow reactors in Series, parallel and series parallel. Reactors of different types and sizes in series.

Unit IV Design of reactors for multiple reactions: Design of Batch reactor, Plug and Mixed flow reactors for Parallel, Series and Series-Parallel reactions, **Thermal characteristics of reactors:** Review of Calculations of heats of reactions and equilibrium constant with temperature dependency. General graphical design procedure for non-isothermal reactors. Optimum temperature Progression.

Unit V Basics of Non Ideal flow: Importance & interpretation of RTD, C, E & F curves & Statistical interpretation. RTD Dispersion model, evaluation of RTD characteristics, Tanks in series model, Conversion in non- ideal flow reactors for simple systems.

References:
1. Levenspeil, O., Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.
2. Fogler, H. S., Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall, 2001.
3. Smith J.M; Chemical Engineering Kinetics; Mc Graw Hill.
4. Denbigh & Turner K.G; Chemical Reaction Theory An Introduction; United Press.
5. Copper & Jeffery's GVJ; Chemical Kinetics And Reactor Engineering; Prentice Hall
6. Levenspiel O; Chemical Reaction Engg; Willey Eastern, Singapore.
7. Houghen Watson & Ragatz; Chemical Process Principles Part Iii; Asian Pub-House Mumbai
8. Laidler, K.J., Chemical Kinetics, Tata McGraw Hill, 1997.
9. Sharma M.M & L.K Doraiswamy, Heterogeneous Reactions, Vol 1
10. Fogler, H.S., Elements of Chemical Reaction Engineering, 4 ed.,PHI, 2008.

List of Experiment:

1. To determine velocity rate constant of the hydrolysis of ethyl acetate by sodium hydroxide.
2. To study the rate constant of hydrolysis of an ester-catalyzed by acid.
3. Determine the rate constant and order of reaction between Potassium per sulphate and Potassium iodide.
4. To study temperature dependency of rate constant, evaluation of activation energy and verification of Arrhenius law.
5. To study a consecutive reaction system(hydraulic model)
6. To study a parallel reaction system (hydraulic model)
7. To study a homogeneous reaction in a semi-batch reactor under isothermal conditions.
8. Study of non catalytic homogeneous saponification reaction in CSTR.
9. To study a non-catalytic homogeneous reaction in a plug flow reactor.
10. To study the residence time distribution behavior of a back mix reactor.
11. To study the RTD behavior of a tubular reactor.
12. To study the RTD behavior of a packed bed reactor.
13. To study the behavior of a continuous flow reactor system-three reactor in series.
14. To study the kinetics of thermal decomposition of calcium carbonate.
15. To study a homogeneous catalytic reaction in a batch reactor under adiabatic conditions.
16. Study of non catalytic saponification reaction in a tubular flow reactor.