

Chemical Processes - I

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Introduction

Historical Development of Chemical Industry In India; Material Resources and Shortcomings; Challenges Faced by Chemical Industry in India, Future Trends; Unit Operations and Processes concepts Used in Chemical Industries; General principles applied in studying and industry.

2. Nitrogen Industries : Manufacture of Ammonia, Ammonium Sulphate, Urea and Nitric Acid.

Chlor–Alkali Industries: Manufacture of Caustic Soda, Chlorine, Hydrochloric Acid and Hydrogen, Manufacture of Soda Ash (Solvay and Dual Process).

3. Manufacture of Sulphur by Frasch Process, by Iron Pyrites Burning, manufacture of Sulphuric Acid by DeDa Process (Different Configurations of Catalyst and Absorber Units).

4. Phosphorous Industries Including the Manufacture of Phosphorous (Electric Furnace Method), Phosphoric Acid (Wet and Electrolytic) and Manufacture of Single and Triple Super Phosphates.

5. Electrolytic Industries : Manufacture of Aluminium, Manufacture of Sodium Metal, Manufacture of Sodium Chlorate.

6. Industrial Gases :

Air Liquefaction and Fractionation to Manufacture Oxygen, Nitrogen. Manufacture of Acetylene. Manufacture of Synthesis Gases, Carbon Dioxide, hydrogen, Carbon Monoxide by Steam Reforming, By Partial Combustion of Hydrocarbons.

Reference:

1. Shreve's Chemical Process Industries (*Austin, G.T.*) McGraw Hill International Edition (5th Edition) .
2. A text book of Chemical Technology – Vol. 1 & 2 (*Pandey, G.N.*) Vikas Publications, 1984.
3. Dryden's Outlines of Chemical Technology for 21st Century (*Rao, G.N. and Sittling, M.*) East West Press, (3rd edition).
4. An Introduction to Industrial Chemistry (*Heaton, C.A.*) Leonard Hill, 1984.
5. The Chemical Industry (*Ibid*) *ibid*, 1986.
6. Morden Inorganic Chemicals Industries (*Thomson R.*) Royal Society of chemistry, 1994 (2nd Edition).
7. Encyclopedia of Chemical Technology (*Kirk-Othmer's*) John Wiley and sons Inc., 1990 (4th Edition).
8. Encyclopedia of Industrial Chemistry (*Ullmann's*) VCH, 1985.
9. Encyclopedia of Chemical Processing and Design (*McKetta's*) Marcel Dekker, 1999.
10. Industrial Electrochemistry (*Pletcher, D. and Walsh*) Chapman and Hall, 1990.



Chemical Engineering Thermodynamics - II

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam.	–	–
Term Work	–	25

SYLLABUS

1. Fundamental property relation for open and closed systems. Criteria of equilibrium in terms of intensive and extensive properties. Chemical potential as criteria for phase equilibria.
2. Properties of ideal mixtures and solutions. Review of Raoult's law, Henry's law, non-idealities of solutions and mixtures. Electrolytes and non-electrolytes. Molar and partial molar properties. Gibbs– Duhem equation.
3. Fugacity and fugacity coefficients. Estimation and determination of activity coefficients for prediction of thermodynamic equilibria. Empirical and semi-empirical methods. Group contribution methods.
4. Phase equilibria at low and moderate pressures. High pressure gas liquid and vapour liquid equilibria. Liquid–liquid and solid–liquid equilibria. Application of these methods to simple cases. Computer methods of prediction of equilibria.
5. Homogenous and heterogenous reaction systems. Equilibrium constant and compositions in simple reactions. Multiphase and multireactions equilibria.
6. Refrigeration cycles (P–V, T–S, H–S, H–X diagrams) for vapour compression and Absortion refrigeration systems. Evaluation of COP, duty and load of such cycles.

Reference:

1. Introduction to Chemical Engineering Thermodynamics (*Smith J.M. and Van Ness H.C.*) McGraw Hill, 1994 (4th Edition).
2. Chemical Engineering Thermodynamics (*Rao Y.V.C.*) University Press, 1997.
3. Chemical Engineering Thermodynamics (*Sandler S.L.*) John Wiley, 1989 (2nd Edition).
4. Chemical Engineering Thermodynamics (*Daubert T.E.*) McGraw Hill, International edition, 1994.
5. Thermodynamics for Chemists (*Glasstone*) Van Nostrand East-West Press, 1964.
6. Phase Equilibria, (Walas J W) Prentice Hall N J.



Mass Transfer Operations - II

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical with Oral Exam	–	25
Term Work	–	25

SYLLABUS

1. Review of Mass Transfer Operations-I

Mass Transfer coefficients, equilibrium stage operations etc.

Distillation : Vapor–liquid equilibria, ideal and non–ideal solutions, effect of temperature / pressure on P–x, y/ T–x, y plots, Azeotropes, immiscible liquids etc. Flash distillation, binary and multi–component, Numerical examples. Differential distillation, Rayleigh equation, Numerical examples. Multistage distillation–Concept of stage by stage calculations for multicomponent systems. (Quantitative procedure only) Multistage distillation–Binary distillation, Ponchon–Savarit method, Numerical examples, McCabe–Thiele Method, Numerical Examples. Packed bed distillation – Concepts of NTU, HTU, and HETP. Distillation with immiscible liquids – Steam distillation, Numerical examples. Concepts of Azeotropic, Extractive, Reactive distillation and Molecular distillation.

2. Liquid–Liquid Extraction

Definition and comparison with other separation operations. Mutual solubilities of liquids, liquid–liquid equilibria, Effect of temperature and pressure on equilibria. Other forms of representation of liquid–liquid equilibria (solvent free coordinates). Choice of solvent. Similarities between extraction and distillation operations. Single stage operations. Numerical examples using various types of coordinates, Multistage extraction - co-current, cross current and counter current(with and without reflux). Numerical examples using all types of coordinates, Extraction in packed columns, Multistage extraction with reflux, Method of calculations, Extraction equipment – description, design principles, Numerical examples.

3. Solid–Liquid Extraction (Leaching)

Representation of equilibria. Construction of simple equilibrium curves. Numerical examples. Similarities in calculations for liquid–liquid and solid–liquid extractions. Numerical examples for single stage, multistage–co–current, cross current and counter current operations. Equipments for leaching–description.

4. Adsorption and Ion Exchange

Types of adsorption, adsorption equilibria, Isotherms–Friendlich and Langmuir. Effect of temperature and pressure etc. Stage wise (single / multi) cross current and counter current adsorption operations – graphical procedures. Application of Friendlich isotherm. Numerical examples. Fixed bed adsorber design. Numerical examples using breakthrough curve data. Pressure swing and Temperature swing adsorption operations. Adsorption equipment – description and operation. Ion–exchange–equilibria, equipments and calculations. Application to chromatography, molecular sieves.

5. Crystallization

Solubility curves, Theories of crystallization, Progress of crystallization. ΔL Law of crystal growth. MSMPR model of crystallization, Population balance method. Material and energy balances for crystallizers, Numerical examples. Melt crystallizers. Crystallization equipment–description.

6. Membrane Separation Operations

Types of membranes—supported and unsupported. Modules for supported membranes. Transport through membranes—fluxes and polarization. Types of operations. Ultrafiltration, Reverse Osmosis, Electrodialysis, Pervaporation, Liquid membranes etc. Flux calculations and design operations for supported membranes, Numerical examples. Equipment and operations. Introduction to combination separation processes. Comparison between all separation processes covered in MTO–I and MTO–II. Principles of selection of separation processes.

Reference:

1. Mass Transfer Operations (*Treybal, R.E.*) McGraw Hill Newyork, 1980 (3rd Edition) .
2. Unit Operations in Chemical Engineering (*McCabe, W.L. and Smith, J.C.*,) McGraw Hill, New York, 1993 (5th Edition).
3. Transport Processes and Unit Operations, (*Geankoplis, C.J.*) Prentice Hall, New Delhi, 1997.
4. Chemical Engineering – Vol. 1 (*Coulson, J.M., Richardson, J.F., Backhurst, J.R. and Harker, J.H. Coulson & Richardsons*) Butterworth Heinman, New Delhi, 2000.
5. Chemical Engineering – Vol. 2 (*Coulson, J.M. Richardson, J.F. Backhurst, J.R. and Harker, J.H. Coulson and Richardsons*) Asian Books Private Ltd., NewDelhi, 1998.
6. Coulson and Richardsons Chemical Engineering – Vol. 6 (*R.K. Sinnott, (Ed)*) Butterworth Heinman, New Delhi, 2000.
7. Perry's Chemical Engineering Handbook, (*Perry J.H. and Chilton, Perry's*) McGraw Hill, 1984(6th Edition) (or a later edition when available)
8. Mass Transfer (*Sherwood T.K., Pigford, R.I. and Wilke.C.R*) McGraw Hill, 1975.
9. Phase Equillibria in Chemical Engineering (*Walas, S.M.*) Butterworth, Boston 1985.
10. Azeotropic and Extractive distillation (*Hoffman, E.J.*) Interscience Publishers Inc, New York, 1964.
11. Fundamentals of multicomponent distillation, (*Holland, C.D.*) McGraw Hill, New York, 1981.
12. Handbook of separation techniques for Chemical Engineers, (*Schweitzer, P.A.*, (Ed)) McGraw Hill, New York, 1988.
13. Chemical Process Equipment Selection and Design, (*Walas, S.M.*) Butterworth, London, 1989.



Process Equipment Design & Drawing - II

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	4 Hrs.	100
Practical & Oral Exam	–	–
Oral Exam	–	25
Term Work	–	25

SYLLABUS

1. Heat Exchangers

Introduction :

Types of Heat Exchangers. Codes and Standards for Heat Exchangers Material of construction. Baffles and tie rods. Tube joining methods. Design of shell and tube heat exchanger (U-tube and fixed tube) as per IS: 4503 & TEMA standards i.e. shell, tube sheets, channel and channel cover, flanged joints Complete fabrication drawing for designed Heat Exchanger to a recommended scale.

2. Evaporators and Crystallizers

Introduction : Types of Evaporators. Material of construction. Entrainment separators and vapor release chambers. Complete design of Evaporators with design of calendria and tube, flange, evaporator drum & heads Types and design considerations for Crystallizers (No numerical problems on crystallizers). Complete fabrication drawing for designed Evaporators to a recommended scale.

3. Distillation and Absorption Columns

Basic features of columns. Stresses in column shell. Shell thickness determination at various heights. Elastic stability under compression stresses. Allowable deflection. Column internals. Design of supports for trays. Complete fabrication drawing for designed column to a recommended scale.

4. High Pressure Vessels

Materials of construction. Review of design of thick cylinder. Prestressing. Design of high pressure vessels–Monoblock and Compound (Multi-layered) Design of shell and head along with stress distribution. Complete fabrication drawing for designed high–pressure vessels to a recommended scale.

Filters

Study of various types of filters such as (a) Vacuum filters, (b) Pressure filters, (c) Centrifuges, (d) Rotary drum filters. Design of rotary drum filters which includes design of drum, shaft, bearing and drive system. Complete fabrication drawing for designed rotary drum filter to a recommended scale.

Auxiliary Process Vessels

Study of various auxiliary process vessels such as (a) Reflux drum, (b) Compressor knock out drum, (c) Liquid–liquid & gas–liquid separators, (d) Entrainment separators.

5. Process Flow Diagrams and Symbols

Symbols of process equipments and their concept. Engineering line diagram (Flow diagram). Utility block diagram. Process flow diagram. P and ID preparations relevant to chemical engineering processes.

6. Piping Design and Layout

Pipe sizing for gases and liquids. Piping for high temperature. Piping layout and its factors under consideration. Design of buried and overhead pipeline.

Design Office Management

Generation of equipment data sheet/Specification sheet. Evolution of drawings. Importance of conclusion of projects. “As built drawings”.

Reference:

1. Process Equipment Design – Vessel Design (*E. Brownell and Edwin, H. Young, John Wiley*) New York 1963.
2. Chemical Engineering Vol 6-Design (*J.M. Coulson, J.F. Richardson and P.K. Sinnott*) Pergamon press, International edition 1989.
3. Introduction to Chemical Equipment Design – Mechanical Aspects (*B.C. Bhattacharya*) CBS Publications.
4. Process Equipment Design (*M.V. Joshi*) Macmillan India.
5. Pressure Vessel Hand Book (*Eugene F. Megyesy*) Pressure Vessel Company USA.
6. Design of Machine Elements (*V.B. Bhandari*) McGraw Hill.
7. Appropriate ISI Specifications and codes for unfired pressure vessels, viz. IS:4503, IS:5403, IS:4049, IS:4864, IS:4870, IS:3138, IS:1239, IS:6392, IS:6418, IS:2062, IS:1730.
8. ASME codes Division VIII, Section 1 & 2.
9. Equipment Design Handbook for refineries and chemical plant Vol 1 & 2 by Evans F.L. Gulf Publishing 1980.
10. Structural Analysis and Design of Equipment (*Jawad M.H., Fav., J.R.*) John Wiley 1984.



Transport Phenomena

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical & Oral Exam	–	–
Oral Exam	–	–
Term Work	–	25

SYLLABUS

1. Viscosity and mechanism of Momentum Transport, Thermal Conductivity and mechanism of energy transport, diffusivity and mechanism of mass transport.
2. Shell Balance : Velocity distribution in laminar flow, temperature distribution in solids and laminar flow, concentration distributions in solids and in laminar flow (restricted to rectangular and cylindrical coordinates only)
3. Equations of Change: Isothermal systems, non–isothermal system, multi–component systems (restricted to rectangular coordinate system).
4. More than one independent variable systems: velocity distribution, temperature distribution concentration distribution (restricted to rectangular and cylindrical coordinates only).
5. Turbulent Flow: Velocity distribution, temperature distribution, concentration distribution.
6. Interphase Transport: Isothermal systems, non–isothermal system, multi–component systems.

Reference:

1. Transport Phenomena (*Dr. G.D. Nageshwar*)
2. Transport Phenomenon (*R.B. Bird, W.E. Stewart, E.N. Lightfoot*) John Wiley, 1960 (1st Edition).
3. Momentum, Heat and Mass Transfer (*C.O. Bannet and J.E. Myers*) (3rd Edition) McGraw Hill, 1982.
4. Principles of Unit Operations (*S. Foust, L.A. Wenzel, C.W. Clums, L.Maus and L.A. Anderson*) Wiley, New York, 1980 (2nd Edition).



Piping Engineering

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical & Oral Exam	–	–
Oral Exam	–	–
Term Work	–	25

SYLLABUS

1. Introduction

Role of piping, Scope of piping engineering, Responsibilities of piping engineer, Inputs received by piping engineers and output given by them, Interactions of piping engineers with other disciplines such as process engineering, instrumentation engineering etc., Introduction to engineering line diagram, Process flow diagram and piping and instrumentation diagram for process plant utilities including various symbols.

2. Material of Construction and Fabrication

Selection of various piping materials such as Ferrous, non-ferrous and non-metallic, Piping fabrication, Precautions, Preparations of pipe edges. Designation of coated electrodes, Requirements of weld tests, Hot bending and cold bending operations, Fabrication specifications.

3. Codes/Standards/Statutory Regulations

Statutory rules and regulations such as C.O.E, S.M.P.V. rules, Petroleum rules, Gas cylinder rules, Factories act, I.B.R. and N.F.P.A. rules, Codes and standards such as A.N.S.I. codes for pressure piping 31.1 and 31.3 standards, D.I.N. and A.P.I.

4. Pipe and Pipe Fittings

Introduction to various standard pipe fittings, pipe flanges and gaskets and their selection and specification, Design calculations for : (a) Schedule number and pipe thickness.
(b) I.D. sizing for liquids and gases.

Reference:

1. Design of Piping system (*Kellogg, M.W.*) M.W. Kellogg Co. 1976 (2nd Edition).
2. Process Piping Design – Vol. 1 and 2 (*Weaver R.*) Gulf publication, 1981.
3. Valve Selection Handbook, (*Zappe, R.W.*) Gulf Publication, 1981.
4. Pipe Stress Analysis (*Sam Kannapan, P.E.*) Willey-Interscience Publications.
5. Handbook of Piping Design (*G.K. Shau*) New Age International Publisher.
6. F. L Equipment Design Handbook of Refineries and Chemical Plants – Vol. 1 and 2. (*Evans*) Gulf Publications.
7. Piping Design Handbook (*Mcketta, J.J.*) Gulf Publications, 1992.
8. Pipeline Rules of Thumb Handbook (*McAllister, E.W.*) Gulf Publication, 1979.
9. Analysis and Control of Unsteady Flow in Pipelines (*Watters G.Z.*) Butterworth, 1986 (2nd Edition).
10. Solid liquid flow slurry pipe line transportation (*Wasp, E.J.*) Gulf publication, Houston, 1979.



Numerical Methods in Chemical Engineering

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical & Oral Exam	–	–
Oral Exam	–	–
Term Work	–	25

SYLLABUS

1. Solution of Linear Algebraic Equations : Gauss elimination and LU decomposition, Gauss Jordan elimination, Gauss Seidel and relaxation methods.
2. Eigen Values and Eigen Vectors of Matrices, Faddeev-Leverrier method, Power method, Householder's and Given method.
3. Non-linear Algebraic Equations : Fixed point method, Multivariable successive substitutions, Single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique.
4. Function Evaluation : Least-square curve fit, Newton's Interpolation formulae, Newton's Divided difference Interpolation polynomial, Lagrangian Interpolation, Pade approximations, Cubic spline approximations.
5. Ordinary Differential Equations (Initial value problem) : Runge Kutta Methods, Semi-implicit Runge Kutta Techniques, step size control and estimates of error.
6. Ordinary Differential equations (Boundary value problems) Finite difference technique, orthogonal collocation technique, orthogonal collocation on finite elements. Partial differential equations : Introduction to Finite Difference Technique.

Reference:

1. Numerical Methods and Modelling for Chemical Engineers (*M.E. Davis*) Wiley, 1984.
2. Numerical Methods for Engineers (*S.K. Gupta*) Wiley Eastern, 1995.
3. MATLAB Programming for Engineers (*Stephan J Chapman*) Cengage Learning, (3rd Edition), 2008.



Optimization and Operation Research

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical & Oral Exam	–	–
Oral Exam	–	–
Term Work	–	25

SYLLABUS

1. Introduction and concept of optimization, Optimization problems in chemical engineering : Heat exchanger, reactor, fluid flow, separation chain, inventory control, analytical methods for unconstrained single variable optimization.
2. **Numerical Method** : Newton, Quasi-Newton, Secant, *Region elimination method* : (i) Golden section, (ii) Fibonacci, (iii) Dichotomous.
Numerical method for unconstrained multivariable optimization : *Direct method* : Univariate search, Conjugate directions search; *Indirect method* : Gradient, Conjugate gradient, Newton.
3. **Linear Programming** : Graphical solution, Simplex Method, Duality and dual simplex, Integer programming (Branch and Bound only), Transportation problem, Assignment problem.
4. **Dynamic Programming** : Calculus method of solution, Tabulation method of solution.
5. **Inventory Control** : EQQ single item static model, Static model with price breaks, Static model with shortage permitted.
Quenching Theory : Cost model, Aspiration Level Model.
Game Theory.
6. **Introduction to CPM-PERT** :
Network representation, Critical path calculation, Resource planning.

Reference :

1. Optimization of Chemical Process (*T. Edger*) M Himmelblau
2. Engineering Optimization (*S.S. Rao*)
3. Operation Research (*Hannidy A. Tabba*)
4. Theory and Problems Of Peration Research (*Richard Bronsan*) Schaums Outline series
5. Problems in Optimization Research (*P.K. Gupta and D.S. Hira*)
6. Problems in Operation Research (*P.K. Gupta and Manmohan*)
7. Problems and Solutions Is Operation Research (*V.K. Kapoor*)
8. Operation Research-Theory and Application (*J.K. Sharma*)
9. Principals of Operation Research (*Narvey M. Wanger*)
10. Dynamic Programming (*Roberts*).



Computer Aided Design

T.E. Sem. VI [CHEM]

EVALUATION SYSTEM

	Time	Marks
Theory Exam	3 Hrs.	100
Practical & Oral Exam	–	–
Oral Exam	–	–
Term Work	–	25

SYLLABUS

1. Structure and Scope of Computer Aided Design System, Introduction to properties databases and their application for Thermo-Physical, Thermodynamic and Transport Properties Computation.
2. Calculation of pressure drop in a pipe including pipe fittings such as valves and elbows, using Chen's method to determine friction factor.
3. Calculation of the dew point and bubble point of gas mixture. Tower sizing of valve trays, Nutter method for calculating tower diameter where valve trays are used. Design of packed tower using pressure drop correlation by Sherwood, Shipley and Holloway.
4. LMTD calculation in shell and tube heat exchanger. Rating of shell and tube heat exchanger with no phase change, using friction factor given by Hedrick correlation. Estimation of heat transfer coefficients for tubes in transition region. Design of double pipe heat exchanger using bare or longitudinal finned tubes calculation of heat load, LMTD for counter current flow, correlated heat transfer coefficient, the heat transfer surface and pressure drop on tube and shell sides.
5. Process Design of Horizontal and Vertical Storage Vessel.
6. Computer Flow Sheeting.

Reference:

1. Fortran Programs for Chemical Process Design, Analysis and Simulation, (*A Kayode Coker*) Gulf Publishing Co. 1995.
2. Product and Process Design Principles (*Warren D Seider, J.D. Seader and Daniel R. Lewin*) Wiley Student Edition, 2004.
3. Mastering Autocad (*Rice and Baker*) BPB Publication, 1991.
4. Fundamentals and Modelling of Separation Processes (*Holland C D*) Prentice Hall, New Jersey, 1975.

