[3563] – 250

T.E. (Petrochemical Engg.) (Sem. – II) Examination, 2009
PROCESS EQUIPMENT DESIGN
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answer **any 3** questions from **each** Section.*
*2) Answers to **two** Sections should be written in **separate** answer books.*
*3) **Neat** diagrams must be drawn **wherever** necessary.*
*4) Figures to the **right** indicate **full** marks.*
*5) **Use** of Logarithmic table, slide rule, Mollier charts, Electronic Pocket Calculator and steam table is **allowed.***
*6) **Assume** suitable data, **if necessary.***

SECTION – I

1. a) How will you differentiate process design and process equipment design ? **4**

   b) Describe various fabrication techniques with neat sketches used in process equipment design. **6**

   c) Discuss importance of Codes and Standards in process equipment design along with its advantages. **6**

OR

2. a) Define Factor of safety. Discuss the factors on which Magnitude of Factor of safety depends. **4**

   b) Write a short note on following : **8**
      i) Creative design
      ii) Stress concentration
      iii) Steps in design activity.

   c) Give applications of each of the following codes : **4**
      i) IS 2825 ii) IS 1730
      iii) IS 4503 iv) IS 6392

P.T.O.

3. a) A flat belt is required to transmit 30 kW from a pulley of 1.5 M effective diameter running at 300 rpm. The angle of contact is spread over 11/24 of the circumference. The coefficient of friction between belt and pulley surface is 0.3. Determine taking centrifugal tension in account, width of the belt required. If it is given that belt thickness is 9.5 mm, density of its material is 1100 kg/m^3 and related permissible working stress is 2.5 MPa. **10**

b) The load on a member consists of an axial pull of 30 KN, with shear force of 15 KN, find the diameter of member according to :

a) Maximum Normal Shear Stress Theory

b) Maximum Principal Strain Theory

c) Maximum Strain Energy Theory

Assume permissible tensile stress of 100 N/mm^2 and Poison's ratio 0.3. **7**

OR

4. a) Design a cast iron protective type flange coupling to transmit 15 kW at 900 rpm from an electric motor to a compressor. The service factor may be assumed as 1.35. The following permissible stresses may be used : **12**

Shear stress for shaft, bolt and key material = 40 MPa

Crushing stress for bolt and key = 80 MPa

Shear stress for cast iron = 8 MPa

Width of key = 12 mm and Number of bolts = 3.

b) What are the types of belt drives ? Discuss the criteria of selection of belt drive. **5**

5. a) Discuss in detail with neat sketch about the Area for Area Method of Nozzle compensation used in design of Pressure vessel. **7**

b) Design a Shell of Pressure vessel with following details : **10**

Internal Diameter (Approx.) = 1400 mm

Permissible stress at 150° C = 140 N/mm^2

Internal pressure = 0.35 N/mm^2

Weight = 38000 N

Joint Efficiency = 0.85

Torque offset piping = 500 N-m

Material used is stainless steel.

SECTION – II

6. a) Calculate the shell diameter and Nozzle thickness of shell and tube heat exchanger :

Data :

Permissible stress = 95 N/mm^2

No. of Passes = 2

No. of Tubes = 54 (With 2 pass U-Bundle)

Spacing between tubes = 2.5 cm (Square pitch)

B = 0.7

Joint Efficiency = 85%

Pressure = 0.5 N/mm^2

Nozzle inlet and outlet diameter = 75 mm. **12**

b) Discuss Fouling in Heat exchanger in detail. What are the consequences of fouling ? **5**

7. a) Shell and bottom plate of Circular Cylindrical Tank for storage of crude oil with conical roof.

Tank diameter = 20 m (Approx.)

Tank height = 12 m (Approx.)

Material carbon steel with permissible stress = 142 N/mm^2

Joint efficiency = 85%

Superimposed load = 1250 N/m^2

Density = 7.7

Plate size available are

(6300 mm × 1800 mm, 5000 mm × 2500 mm, 5600 mm × 1100 mm). **14**

b) Name the various types of losses in Storage Tanks. **2**

OR

8. a) Discuss the design of flat bottom cylindrical storage tanks. What are the formulae used to get the shell thickness at different height ? Also mention the plate thickness for bottom plates of this cylindrical tank. Also give design of conical roof with considering slope 1 in 5. **12**

   b) Discuss various types of floating roofs in Storage Tanks. **4**

9. a) Explain design of an agitator on the basis of critical speed of shaft with help of neat diagram. **8**

   b) Calculate the power required for given turbine agitator in a vessel with diameter 1500 mm. **9**

   Diameter of agitator = 500 mm, Speed (Max) = 200 rpm

   For liquid in vessel :

   i) Specific gravity = 1.2

   ii) Viscosity = 600 cp

   Overhead of agitator shaft between bearing and agitator = 1300 mm

   Internal pressure = 0.5 N/mm^2

   Agitator (Blades) flat No. = 06

   Width of blade = 75 mm

   Np (Power curve (Log-Log) value) for this system is found to be 4.5.

   Thickness of blade is 8 mm and number of baffles are 4.

OR

10. Write short notes on : **17**

   a) ASME and TEMA CODES

   b) Pipeline Design considerations

   c) Types of Agitator used in industry (With Neat Sketch)

   d) Different Drives for agitators

   e) Baffles and its need for mixing.

———————

[3563] – 249

T.E. (Petrochemical) (Semester – II) Examination, 2009
TRANSPORT PHENOMENA
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Attempt* ***any 3*** *questions from* ***each*** *Section.*
2) Figures to the ***right*** *indicate* ***full*** *marks.*
3) ***Use*** *of electronic calculator is* ***allowed****.*
4) Draw ***neat*** *sketch* ***wherever*** *necessary.*

SECTION – I

1. a) Explain Momentum transfer in a fluid. Ethyl alcohol with viscosity 0.0177 g/cm.s, is flowing through two parallel flat plates separated by a distance of 0.5 cm, at 273 K. The velocity of lower plate is 10 cm/s while upper plate velocity is stationary. Calculate the shear stress and velocity gradient. **8**

   b) Explain different time derivatives giving example and corresponding expressions. **8**

2. a) What is a control volume ? Derive continuity equation with Eulerian approach and define each of the constituent terms in the equation. **10**

   b) Explain the physical interpretation of Navier Stokes equation for conservation of momentum and conservation of energy respectively. **8**

3. a) Carbon Tetrachloride with density and viscosity of 1.54 gm/cc and 0.87 c.p respectively is to flow through a smooth horizontal circular tube of diameter 3 cm at a volumetric flow rate of 2 liter per second at 25° C. Estimate the pressure drop per unit length of the tube. Give the check for units consistency in the solution. **8**

   b) What do you mean by Reynolds stresses ? Explain with significance Prandtl's Mixing Length theory. **8**

P.T.O.

4. a) Explain various types of impellers with respect to their design, operational features and applications. **8**

   b) A flat-blade tubrine agitator with disk having flat six blades is installed in a tank. The tank diameter is 1.83 m, the turbine diameter is 0.61 m, the width is 0.122 m and the depth of the liquid in the tank is equal to its diameter. The tank contains four baffles, each having a width of 0.15 m. The turbine is operated at 90 rpm and the liquid has a viscosity of 10 cp and a density of 929 kg/m^3. It is desired to scale up the system where equal rate of mass transfer is desired for a vessel whose volume is three times large. **8**

SECTION – II

5. a) Discuss Heat Transfer in Agitated Vessels. **8**

   b) A tank containing 22,679.5 kg material with a specific heat of 2.1 kJ/kg• K is to be heated from 293 K to 398 K. The tank contains a heating coil with a heat transfer surface of 9.29 m^2, and the overall heat transfer coefficient from the coil to the tank contents of 850 W/m^2• K. Derive the expression and solve for the time required to heat the tank contents with steam condensing at 433 K. **8**

6. a) Explain qualitatively the basis of analogies in transport phenomena. **4**

   b) Discuss in detail Reynold's, Prandtl's and Chilton-Colburn's analogies with their relative merits and demerits. **12**

7. a) What is Computational flow modeling ? Discuss the utility of Computational flow modeling in reactor design and optimization. **10**

   b) Discuss with reference to CFD (a) Replacing differential equations with difference equations (b) Formation of Grid. **8**

8. a) Discuss the behavior of two phase gas-liquid vertical flow in a pipe with respect to variation of unit pressure drop and hold up ratio on variation of volumetric flow rate ratio. **8**

   b) Explain with neat diagrams various flow regimes in a horizontal gas-liquid flow through pipe. **8**

———————————

[3563] – 248

T.E. (Petrochemical) (Semester – II) Examination, 2009
REACTION ENGINEERING – I
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Attempt* ***any 3*** *questions from* ***each*** *Section.*
2) Figures to the ***right*** *indicate* ***full*** *marks.*
3) Use of electronic calculators is ***allowed****.*
4) Draw ***neat*** *sketch* ***wherever*** *necessary.*

SECTION – ONE

1. a) Explain the classification of reactions with suitable examples. **6**

   b) A reaction $2A(g) \rightarrow B(g) + C(g)$ is studied over a range of temperatures. The results are obtained are as follows : **10**

Temperature (°K)	633	666	697	715	781
Rate constant k (Lit/mol.s)	$1.7*10^{-5}$	$1.07 * 10^{-1}$	$5.01 * 10^{-4}$	$1.05 * 10^{-3}$	$1.51 * 10^{-3}$

   a) Find the value of activation energy graphically.

   b) Determine by what factor the rate increases when temperature rises from 300 K to 310 K.

2. a) Differentiate between integral and differential method of analysis of the kinetic data. **6**

   b) The thermal decomposition of dimethyl ether is carried out in a constant volume batch reactor. The reactor is initially filled with pure ether and the reactor pressure is 312 mmHg. From the following data find the rate equation representing the decomposition. **10**

Time. sec	390	777	1195	3355
Total pressure. mmHg	96	176	250	476

P.T.O.

3. a) Derive the performance equation of steady state plug flow reactor and give its graphical representation. **7**

   b) Define holding time and space time for flow reactors. **3**

   c) A homogeneous gas reaction $A \rightarrow 3R$ has a reported rate at 200°C as $-r_A = 0.1\ C_A$, (mol/1.s). Find the space time required for 80% conversion of a 50% A and 50% inerts feed to a plug flow reactor operating at 200°C and 5 atm. pressure. Initial concentration of A is 0.0625 mol/lit. **8**

4. a) Draw some conclusions about kinetics of the reaction from each of the following statements. **9**

      a) conversion is independent of mixing pattern (CSTR or PFR)

      b) Reaction goes to completion in a batch reactor in finite time

      c) Rate goes on increasing as conversion increases.

   b) Define various forms of rate of reaction as a function of the state of the system. **7**

SECTION – TWO

5. a) Liquid phase reaction second order reaction A ----- 2R with rate constant 0.05 is carried out in a series of two equal volume CSTRs. Calculate the volume of each tank if feed flow to the first reactor is 2 m^3 with initial concentration of A as 5 mol/lit. overall conversion in the effluent of the second reactor is to be 65%. **10**

   b) Write a note on Best arrangement of a set of ideal reactors. **8**

6. Derive the expression for a maximum obtainable concentration of R in a CSTR for an elementary reactions in series given by $A \rightarrow R \rightarrow S$, with rate constants k_1 and k_2 respectively. **16**

7. a) Determine the equilibrium conversion for the elementary reaction $A \rightleftarrows R$, at 70°C. Data given at 298 K is $\Delta G° = -14130$ J/mol, $\Delta H_R^\circ = -75300$ J/mol and $Cp_A = Cp_R$. **12**

   b) Discuss the effect of temperature and pressure on reaction rate. **6**

8. Write short notes on the following : **16**

   a) Multiple steady states of a reactor

   b) Optimum Temperature Progression

   c) Autocatalytic reactions

   d) Nonadiabatic reactor operations.

———————

[3563] – 247

T.E. (Petrochemical Engg.) (Sem. – II) Examination, 2009
MASS TRANSFER OPERATIONS

Time: 3 Hours | Total Marks: 100

Instructions : *1) Answer **any 3** questions from **each** Section.*

*2) Answers to the **two** Sections should be written in **separate books**.*

*3) **Neat** diagrams must be drawn **wherever** necessary.*

*4) **Black** figures to the **right** indicate **full** marks.*

*5) **Use** of logarithmic tables, Mollier charts, electronic pocket calculator and steam tables is **allowed**.*

*6) **Assume** suitable data, **if necessary**.*

SECTION – I

1. Attempt **any three** from the following : **18**

   i) Write down Kremser-Brown-Souders equations for absorption and stripping operations.

   ii) Write a brief note on : Choice of Solvent for Gas absorption.

   iii) Write a brief note on : HETP, HTU and NTU.

   iv) Compare tray towers versus packed towers.

OR

2. a) A mixture of acetone vapour and air containing 5% by volume of acetone is to be freed of its acetone content by scrubbing it with water in a packed bed absorber. The flow rate of the gas mixture is 700 m^3/hr of acetone-free air measured at NTP and that of water is 1500 kg/hr. The absorber operates at an average temperature of 20° C and a pressure of 101 kPa. The scrubber absorbs 98% acetone. The equilibrium relation for the acetone vapour-water system is given by : $y^* = 1.68\ x$

where, Y = k mole acetone /k mole dry air

X = k mole acetone/k mole water.

Calculate : a) Mean driving force for absorption, b) Mass transfer area if the overall mass transfer coefficient is given by :

k_G = 0.4 k mole of acetone/m^2.hr(kmole acetone/per kmole dry air) **10**

b) A soluble gas is absorbed from a dilute gas air mixture by counter-current scrubbing with solvent in a packed tower. If the liquor led to the top of the tower contains no solute, show that number of transfer units required is given by :

$$N = \left[\frac{1}{\left(1-\frac{mG_m}{L_m}\right)}\right] ln\left[\left(1-\frac{mG_m}{L_m}\right)\frac{y_1}{y_2}+\frac{mG_m}{L_m}\right]$$

where, G_m and L_m = flow rates of the gas and liquid in k mole/s.m^2 of tower area y_1, y_2 = mole fraction of the gas at the inlet and outlet of the column. The equilibrium relation is given as, $y_e = mx$. **8**

3. a) Derive Rayleigh's equation for simple distillation. State the assumption made, if any. **6**

b) Methanol and ethanol form an ideal solution. Compute vapour-liquid equilibrium data and prepare plots of x-y and T-x-y at 1 atm pressure. The following pure component vapour pressure data is given in Table.

Vapour pressure, mm Hg	200	400	760	1520
Temperature °C for ethanol	48.4	62.5	78.4	97.5
Temperature °C for methanol	34.8	49.9	64.7	84

What value of relative volatility will you recommend for this system ? **10**

OR

4. a) Define q line (feed line). How is q related to the feed condition ? Discss in brief the five possible feed conditions with neat graph. **6**

   b) Write a brief note on : Optimum Reflux Ratio. **6**

   c) A still has a liquor composition of o-Xylene 10%, m-Xylene 65%, p-Xylene 17%, benzene 4%, and ethyl benzene 4%. How many plates at total reflux are required to give a product of 80% m-Xylene and 14% p – Xylene ? The data are given as mole percent. Use Fenske's equation. **4**

5. It is desired to separate by distillation at 760 mm Hg mixture containing 42% m heptane and 58% m ethyl benzene to produce a distillate containing 97% m heptane and residue containing 99% m ethyl benzene.

   a) Using a reflux ratio of 2.5 determine the numer of equilibrium stages needed for a saturated liquid feed and bubble reflux by the McCabe-Thiele Method.

   b) Determine the minimum reflux ratio.

   c) Determine the number of equilibrium stages at total reflux.

   Equilibrium data : Vapour liquid equilibria for heptane-ethyl benzene system at 760 mm Hg.

Y	0	0.23	0.42	0.51	0.60	0.72	0.81	0.90	0.96	1.0
X	0	0.08	0.18	0.25	0.33	0.48	0.65	0.78	0.91	1.0

   where, Y and X are mole fractions heptane in vapour and liquid respectively. **16**

OR

6. a) A continuous rectification column is used to separate a binary mixture of P and Q. Distillate is produced at 100 kmol/hr containing 98 mole % P. The mole fractions of P in the liquid and in the vapor, x and y respectively, from two adjacent ideal plates in the enriching section are as follows :

x	y
0.65	0.82
0.56	0.76

If the latent heat of vaporization is the same for all mixtures and if the feed is saturated liquid, calculate :

i) The reflux ratio

ii) Vapor rate in the stripping section in kmol/hr. **6**

b) A liquor of four components A, B, C and D with 0.3 mol fraction each of A, B and C is to be continuously fractionated to give a topproduct of 0.9 mol fraction A and 0.1 mol fraction B. The bottoms are to contain not more than 0.05 mol fraction A. Estimate the minimum reflux ratio required for this separation if the relative volatility of A to B is 2.0. **6**

c) Explain the principles of following distillation methods : **4**

i) Vacuum and Steam Distillation

ii) Azeotropic and Extractive distillation.

SECTION – II

7. a) A solute is recovered from an aqueous solution containing 20% of the solute by weight using kerosene as the solvent. The distribution of the solute in water and kerosene may be described by x' = 6.45 y' where x' is the kg of solute per kg of water and y' is the kg of solute per kg kerosene. Calculate the following :

i) The final concentration in the final raffinate if the extraction is done in 3 simple equilibrium contacts using 5 kg solvent per kg of initial solution in each stage.

ii) The number of equivalent theoretical contracts necessary to obtain the concentration of solute in the final raffinate as 3.5% by weight with the extraction done by counter current stage contacting using 6 kg of kerosene per kg of aqueous solution. **8**

b) One thousand kilograms of a 30-wt% dioxane in water solution is to be treated with benzene at 25°C to remove 95% of the dioxane. The benzene is dioxane free, and the equilibrium distribution coefficient $K_{D,B}$ is 1.2. Calculate the solvent requirements for the following cascade configurations :

a) A single batch extraction.

b) Three crosscurrent stages using equal amounts of benzene.

c) Two countercurrent stages.

d) An infinite number of crosscurrent stages. **8**

OR

8. a) It is required to extract picric acid from a dilute aqueous solution containing 0.1 mole picric acid per litre of solution using benezene as solvent with a recovery of 80% of the picric acid originally present. Determine the quantity of benzene required per litre of aqueous solution by employing (a) single-stage extraction and (b) three-stage extraction (crosscurrent) using equal amounts of fresh solvent in each stage. The equilibrium data for benzene-picric acid-water system at 25°C is given by :

$C_B \times 10^2$	0.0932	0.225	1	2	5	10	18
$m = \frac{C_B}{C_A}$	2.23	1.45	1.705	0.505	0.32	0.24	0.187

Where, C_B and C_A are the equilibrium concentrations of picric acid in benzene and aqueous phases respectively in mole/litre. **12**

b) Discuss the factors, which govern the selection of solvents to be used for liquid-liquid extractions. **4**

9. a) State the applications of leaching operation in industry. **4**

   b) Classify the commercial extraction equipments. State working principles of Pulse columns. **6**

   c) Discuss the ternary diagram for liquid-liquid extraction by taking suitable example. **6**

OR

10. a) Give the classifications of crystallizer. Explain the working principles and construction of any one type of crystallizer with neat sketch. **9**

    b) State Mier's theory of Supersaturation for Crystallization. **7**

11. a) The adsorption of ethane as Linde molecular sieve 5 A, was studied by Glessner and Myers (1969) at 35°C. Using the data given below,

    a) Determine if the Langmuir equation can be used to model the data.

    b) Calculate the total surface solid, if Density of Ethane = 0.3549 gm/cc.

    Data :

P, [mm Hg]	Uptake, V [cm^3 (STP/gm)]
0.17	0.059
0.95	0.318
5.57	1.638
12.09	3.613
111.32	24.236
220.87	34.278
300.05	38.340
401.25	41.779
500.18	44.037
602.74	45.693

10

b) In an experiment, an activated alumina adsorbent was used on a queous glucose solution. The equilibrium data at a single temperature is shown in the table given below :

Data :

C (g/cm^3)	0.0042	0.0091	0.0150	0.0262	0.0560	0.1918
q (g glucose/g alumina)	0.0271	0.0472	0.0672	0.0805	0.1078	0.1312

Which of the three models best suits this data and what are the parameters ? **8**

OR

12. Write short notes on (**any three**) : **18**

a) Reverse osmosis: Principles and applications

b) Classification of membrane separation processes

c) Types of Adsorption Isotherms

d) Membrane modules for membrane processes

e) Types of adsorbents.

[3563] – 246

T.E. (Petrochemical Engineering) Semester – II Examination, 2009
UNIT PROCESSES IN ORGANIC SYNTHESIS
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answer **any three** questions from **each** Section.*
*2) Answers to the **two** Sections should be written in **separate** books.*
*3) Figures to the **right** indicate **full** marks.*
*4) Neat diagrams must be drawn **wherever** necessary.*

SECTION – I

1. a) Describe with flowsheet the liquid phase oxidation process for conversion of acetaldehyde to acetic acid. **10**

   b) Explain the processes used for working up of sulfonation. **5**

   c) Write a note on DVS. **3**

2. a) Describe with flowsheet the process for conversion of ethyl benzene to styrene. **10**

   b) Describe the process of photochlorination of cyclohexane. **6**

3. a) Describe with flowsheet the thermal process for conversion of 1, 2-Dichloroethane to VCM. **10**

   b) Write a note on Schmidt nitrator. **6**

4. a) Describe with flowsheet the process for conversion of benzene to dodecyl benzene. **10**

   b) Mention desulfonation reaction along with significance. **3**

   c) Write a note on oxynitration. **3**

P.T.O.

SECTION – II

5. a) Describe the continuous process for manufacture of aniline from chlorobenzene. **10**

   b) Explain orientation of aromatic nitration for toluene, anisole, benzaldehyde and benzoic acid. **8**

6. a) Describe with flowsheet the process for conversion of benzene to ethyl benzene. **10**

   b) Write a note on Bechamp reduction. **6**

7. a) Mention with examples the methods used for chlorination. **6**

   b) Write a note on catalysts used in hydrogenation. **5**

   c) Mention with examples the types of oxidative reactions. **5**

8. a) Compare sulfuric acid and sulfur trioxide as sulfonating agents. **5**

   b) Write a note on agents used for alkylation. **5**

   c) Differentiate between : **6**

      i) Sulfonation and sulfation

      ii) FC alkylation and acylation

      iii) Amination by reduction and by ammonolysis.

[3563] – 245

T.E. (Petrochemical Engineering) (Semester – I) Examination, 2009
PROCESS AND ANALYSIS INSTRUMENTATION
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Attempt Q.* ***1*** *or* ***2****, Q.* ***3*** *or* ***4****, Q.* ***5*** *or* ***6****, Q.* ***7*** *or* ***8****, Q.* ***9*** *or* ***10****, Q.* ***11*** *or* ***12****.*

2) Figures to the ***right*** *indicate* ***full*** *marks.*

3) ***Use*** *of electronic calculators, steam table is* ***allowed****.*

4) Draw neat sketch ***wherever*** *necessary.*

SECTION – I

1. a) Write a note on codes and symbols used in instrumentation. **8**

   b) Differentiate between Accuracy and Precision; Repeatability and Reproducibility; Static and Dynamic characteristics. **8**

OR

2. Write short notes on : **16**

   a) Calibration of an instrument

   b) Characteristics of an instrument

   c) Classification of instruments.

3. a) Write a short note on Nickel RTD and Copper RTD. **8**

   b) Describe the sources of static errors in case of radiation pyrometers with respect to reference junction temperature; and with reference to distance between hot target and receiving element. **8**

OR

4. a) Write a short note on LVDT. **8**

   b) Describe liquid expansion thermometer. **8**

5. a) A gas of density 0.52 Kg/m^3 flows through a pipe of diameter 8 cm. The flow is measured by a ventury tube of 4 cm throat diameter and a U tube manometer containing mercury. What is the flow for a manometer reading of 10 cm ? Take coefficient of Cd=0.95. **6**

   b) Explain the various sealing techniques in pressure gauges. **6**

   c) Draw a Feedback control loop of shell and tube heat exchanger. **6**

OR

6. a) Write a short note on the various factors required for the selection of valves. **6**

   b) Describe the method used for measuring level in closed vessel like boiler drum. **6**

   c) Describe components of a SCADA system. **6**

SECTION – II

7. a) Give the principle and working of HPLC. **8**

   b) Describe types of detectors used in gas chromatography. **8**

OR

8. a) Explain composition analysis using refractive index method. **8**

   b) Describe the various sampling techniques. **8**

9. a) Why is the internal standard procedure seldom used in atomic absorption procedures ? Give the Procedure. **10**

   b) How will you determine lead in petrol using Atomic Absorption Spectroscopy ? **8**

OR

10. a) Write a note on X-ray diffraction method used for composition analysis. **8**

    b) What is the principle and applications of NMR ? Define Chemical Shift ; Spin Spin coupling ; Equivalent hydrogen ; Integral curve. **10**

11. a) Discuss total hydrocarbon analysis. **8**

    b) Explain the method of analysis using thermal conductivity. **8**

OR

12. a) Describe briefly the characteristics of an optically active substance. **8**

    b) Write a note on the mass spectrometer. **8**

[3563] – 244

T.E. (Petrochemical) (Semester – I) Examination, 2009
CHEMICAL ENGINEERING THERMODYNAMICS
(2003 Course)

Time : 3 Hours Max. Marks : 100

N.B. *: 1) Answer any* ***3*** *questions from* ***each*** *Section.*
2) Figures to the ***right*** *indicate marks.*

SECTION – I

1. Differentiate and distinguish. **16**
   a) System and Universe.
   b) Closed and Open Systems.
   c) State and Path Functions.
   d) Extensive and Intensive Properties.
   e) Adiabatic and Isolated System.
   f) Reversible and Irreversible work.

2. Write notes : **18**
   a) Phase rule and its Utility.
   b) First law for open and closed systems.
   c) Statements of Second Law.

3. An inventor has come forward with a device in which an ideal gas of constant heat capacity (Cp = 30 KJ/Kmol. °k) enters at 10 bar and 295°K and is split into hot and cold streams even when the device is mechanically and thermally insulated. One half of the gas leaves at 355°K and 1 bar while the other half leaves at 235°K and 1 bar. Determine if this process violates the laws of thermodynamics. **16**

4. a) Explain the concept of equation of state. **3**
   b) Elaborate upon any two models (or equations of state) of non-ideal gas. **6**
   c) Write a note on Joule Thomson Effect. **4**
   d) What is a 'Critical Point" ? **3**

P.T.O.

SECTION – II

5. a) Write a note on Carnot cycle and explain its Thermodynamic significance. **6**

   b) Distinguish between heat pump and heat engine. **4**

   c) Write a note on Maxwell's Relations. **6**

6. Explain the following terms along with their utility : **16**

   a) Chemical potential.

   b) Hess's Law.

   c) Kirchoff's law.

   d) Criteria of equilibrium.

7. Determine the mean heat of vaporization of carbon tetracloride from the following data :

Pressure mm Hg	113.8	174.4	258.9	373.6
Boiling Point °C	25	35	45	55

16

8. Write notes : **18**

   a) Fugacity and Fugacity coefficient.

   b) Activity and activity coefficient.

   c) Criterion for chemical reaction equilibrium.

   d) Non-ideal solution behaviour.

———————

[3563] – 243

T.E. (Petrochemical) (Sem. – I) Examination, 2009
DIFFUSION AND MASS TRANSFER
(2003 Course)

Time : 3 Hours | Max. Marks : 100

Instructions *: 1) Answer **any three** questions from **each** Section.*
*2) Answers to the **two** Sections should be written in **separate** books.*
*3) **Neat** diagrams must be drawn **wherever** necessary.*
*4) **Black** figures to the **right** indicate **full** marks.*
*5) **Use** of logarithmic tables, Mollier charts, electronic pocket calculator and steam tables is **allowed**.*
*6) Assume **suitable** data, **if necessary**.*

SECTION – I

1. Answer the following questions in brief (**any three**) : **18**

   a) Distinguish between molecular and eddy diffusion.

   b) Give the correlations for estimation of gases and liquids and explain the terms involved in it.

   c) Classify Mass Transfer operations by giving suitable example (s).

   d) Write a note on : Simple Distillation and Raleigh Equation.

OR

2. a) Classify Chemical Engineering Separation Process giving suitable examples. **6**

   b) Explain the methods to conduct the mass transfer operations. **6**

   c) Write a brief note on : Importance of Mass Transfer in (Petro-) Chemical Engineering field. **6**

P.T.O.

3. a) Discuss the Winklemann's method for estimation of diffusivity of vapors. **6**

b) An ethanol-water solution in the form of a stagnant film 2.0 mm thick at 293 K is in contact with an organic solvent in which ethanol is soluble and water is not. Hence, ethanol is diffusing through the solution into the solvent.

At point 1 in the solution the concentration of ethanol is 16.8 wt% and the solution density is 972.8 kg/m^3. At point 2 the concentration of ethanol is 6.8 wt % and 988.1 kg/m^3. The diffusivity of ethanol in water $D_{AB} = 0.740 \times 10^{-9}$ m^2/s at 293 K. Also given MW of ethanol = 46, MW of water = 18.

Determine the steady-state flux N_A (in kg-mole/m^2.s) between point 1 and point 2 using the following equation :

$$N_A = \frac{D_{AB} C_{avg}}{(z_2 - z_1)} ln \left[\frac{1 - X_{A_2}}{1 - X_{A_1}} \right]$$ Where,

C_{ave} is the average total concentration (ethanol and water) in the solution (kg-mole/m^3).

$C_{ave} = (C_1 + C_2)/2$; C_{A_1} is the total concentration in point 1 and C_2 is the total concentration in point 2.

X_{A_1} is the mole fraction of A in point 1.

X_{A_2} is the mole fraction of A in point 2. **10**

OR

4. a) An open tank, 4 m in diameter and containing toluene at 25° C, is exposed to air at 100 kPa in such a manner that the surface of the liquid is covered with a stagnant air film estimated to be 5 mm thick. The concentration of toluene beyond the stagnant film is negligible. The vapour pressure and density of liquid toluene at 25° C are 3.8 kPa and 862 kg/m^3, respectively. The diffusivity of toluene in air at 0° C is 0.071 cm^2/s. Estimate the loss of toluene per day from this tank. **10**

   b) Equimolar counterdiffusion is occurring at steady state in a tube 0.11 m long containing N_2 and CO gases at a total pressure of 1.0 atm abs. The partial pressure of N_2 is 80 mm Hg at one end and 10 mm at the other end. Predict the D_{AB} by the method of Fuller et al. (1966).

   Calculate the flux in kmol/(s.m^2) at 298 K for N_2. **6**

5. Ammonia (NH_3) is selectively removed from an air - NH_3 mixture by absorption into water. In this process, ammonia is transferred by molecular diffusion through a stagnant gas layer 2 cm thick and then through a stagnant water layer 1 cm thick. The concentration of ammonia at the outer boundary of the gas layer is 3.42 mole% and the concentration of ammonia at

   $D_{NH3–air} = 0.215\ cm^2/s$, $D_{NH_3–H_2O} = 1.77\times10^{-5}\ cm^2/s$.

   Equilibrium data for ammonia in air over aqueous solutions :

P_{NH_3} in air (mm H_g)	5	10	15	20	25	30
C_{NH_3} in water (mole/$cm^3\times10^6$)	6.1	11.9	20.0	32.1	53.6	84.8

   Calculate the rate of ammonia absorption into the water from the air. **16**

OR

6. Write short notes on (**any four**) :

   a) Cooling Towers

   b) Analogy between heat, mass and momentum transfer.

   c) Resistence concept in interphase mass transfer.

   d) Packed Towers versus Tray Towers

   e) Wetted Wall Tower. **16**

SECTION – II

7. a) In a typical chemical process, Component A is desorbed from an aqueous solution into an air stream in a mass transfer tower at a certain operating temperature and pressure. At a particular point in the tower, analysis report temperature and pressure. At a particular point in the tower, analysis report shows that :

   $P_{A, G}$ = 12 mm Hg;

   $C_{A, L}$ = 4 k mole/m^3

   The overall mass-transfer coefficient, $K_G = 0.269 \frac{\text{K mole A}}{(m^2 .hr .atm.)}$

   If Henry's law is applicable to this system and if 56% of the total mass transfer resistance is encountered in gas film. Calculate :

   a) Gas film coefficient, $K_{g.}$

   b) Liquid film coefficient, K_l.

   c) Molar flux of component A, N_A. **12**

b) Bromine is being rapidly dissolved in water. Its concentration is about half saturated in 3 minutes. Predict the mass transfer coefficients. **6**

OR

8. a) A stream of air at 100-kPa pressure and 300 K is flowing on the top surface of a thin flat sheet of solid naphthalene of length 0.2 m with a velocity of 20 m/sec. The other data are :

Mass diffusivity of naphthalene vapor in air = 6×10^{-6} m^2/sec

Kinematic viscosity of air = 1.5×10^{-5} m^2 .sc

Concentration of naphthalene at the air-solid naphthalene interface = 1×10^{-5} kmol/m^3

a) The average mass transfer coefficient over the flat plate

b) The rate of loss of naphthalene from the surface per unit width.

Note : For heat transfer over a flat plate, convective heat transfer coefficient for laminar flow can be calculated by the equation.

$$Nu = 0.664 \ Re_L^{1/2} \ Pr^{1/3}$$

You may use analogy between mass and heat transfer. **8**

b) Calculate the value of Mass transfer coefficient and flux of mass transfer from a sphere of naphthalene to air at 45°C and 1 atm flowing at velocity of 0.4 m/s . The diameter of sphere is 25.4 mm. The diffusivity of naphthalene in air at 45°C is 6.92×10^{-6} m^2/s and vapor pressure of solid naphthalene is 0.55 mm of mercury.

Data: $\mu = 1.93\times10^{-5}$ Pa.s, $\rho = 1.113$ kg/m^3

You may use the following correlation :

$Sh = 2 + 0.552\ Re^{0.53} + Sc^{0.33}$ Where, $Sh = K'_c \dfrac{d_p}{D_{AB}}$. **10**

9. a) Explain with neat graph the different moisture content in the solid. **6**

   b) Classify industrial dryers. Discuss the working principles and construction of Rotary drum with neat sketch. **10**

OR

10. In order to test the feasibility of drying a certain foodstuff, drying data were obtained in a tray dryer with airflow over the top of the exposed surface having an area of 0.186 m^2. The bone-dry sample weight was 3.765 kg dry solid. At equilibrium after a long period, the wet sample weight was 3.955 kg H_2O plus solid. Hence 3.955 – 3.765, or 0.190 kg of equilibrium moisture was present. The following sample weights versus time were obtained in the drying test.

Time (hr)	0	0.4	0.8	1.4	2.2	3.0	4.2	5.0	7.0	9.0	12.0
Weight (kg)	4.94	4.88	4.80	4.69	4.55	4.40	4.24	4.15	4.01	3.97	3.95

   a) Calculate the free moisture content X kg H_2O/kg dry solid for each data point and plot W versus time (Hint: for 0 hrs, 4.944 – 0.190 – 3.765 = 0.989 kg free moisture in 3.765 kg dry solid. Hence X = 0.989/3.765)

   b) Measure gradients along the drying curve, calculate the drying rate R, and plot R versus X. **16**

11. a) Discuss in detail the design of a cooling tower based on enthalpy transfer unit concept. State the important assumptions made and the limitations in application. **12**

   b) Define all humidity terms you know. **4**

OR

12. Write short notes on (**any three**) : **16**

i) Mass transfer coefficients in turbulent flow.

ii) Rate of drying curve.

iii) Classification of membrane separation processes.

iv) Material balance equations for counter current mass tranasfer process.

v) Stage Efficiency.

[3563] – 242

T.E. (Petrochemical) (Sem. – I) Examination, 2009
MATHEMATICS FOR PETROCHEMICAL ENGINEERS
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Answers to the **two** Sections should be written in **separate** answer books.*

*2) In Section **I**, attempt Q. No. **1** or Q. No. **2**; Q. No. **3** or Q. No. **4**; Q. No. **5** or Q. No. **6**. In Section **II**, attempt Q. No. **7** or Q. No. **8**; Q. No. **9** or Q. No. **10**; Q. No. **11** or Q. No. **12**.*

*3) **Neat** diagrams must be drawn **wherever** necessary.*

*4) Figures to the **right** indicate **full** marks.*

*5) Use of non-programmable electronic pocket calculator is **allowed**.*

*6) Assume suitable data, if **necessary**.*

SECTION – I

1. a) Obtain all the basic solutions of the following system of equations : **6**

$x_1 + 2x_2 + x_3 = 4$

$2x_1 + x_2 + 5x_3 = 5$

Which of them are basic feasible solutions and which are non-degenerate basic solutions ? Is the non-degenerate solution feasible ?

b) A company manufactures two types of products P_1 and P_2. The profit per unit of the products are Rs. 20 and Rs. 10 respectively. Each product needs three raw materials R_1, R_2 and R_3. The following table gives the quantities of raw material required to produce P_1 and P_2. Using Simplex method, determine what quantity of products P_1 and P_2, the company should manufacture, so as to maximize the profit. **10**

Raw Materials	P_1	P_2	Availability
11	1	6	300
12	2	2	150
13	4	1	240

OR

2. a) Construct the dual of the primal problem : **6**

Maximize $Z = 2x_1 + x_2 + x_3$

Subject to $x_1 + x_2 + x_3 \geq 6$

$3x_1 - 2x_2 + 3x_3 = 3$

$-4x_1 + 3x_2 - 6x_3 = 1$

$x_1, x_2, x_3 \geq 0$

b) Solve the LP problem : **10**

Minimize $Z = \frac{15}{2} x_1 - 3x_2$ subject to

$3x_1 - x_2 - x_3 \geq 3$

$x_1 - x_2 + x_3 \geq 2$

$x_1, x_2, x_3 \geq 0.$

3. a) Find an initial basic feasible solution to the following Transportation Problem, using Vogel's Approximation Method. Is it optimal ? **8**

		Destination				
		1	**2**	**3**	**4**	**Availability**
Origin	**A**	7	2	5	5	30
	B	4	4	6	5	15
	C	5	3	3	2	10
	D	4	–1	4	2	20
	Requirement	20	25	15	15	

b) A city corporation invites tenders from contractors to carry out repair work on four of its main roads, with the condition that one road will be awarded to only one contractor. Five contractors have sent their bids, as follows. (Figures in lakhs). **8**

	R_1	R_2	R_3	R_4
C_1	9	14	19	15
C_2	7	17	20	19
C_3	9	18	21	18
C_4	10	12	18	19
C_5	10	15	21	16

i) Find the best way of assigning the repair work to the contractors, that will minimize the cost. Find also the minimum cost.

ii) Which of the five contractors will be unsuccessful in his bid ?

OR

4. a) A marketing manager has four salesman and four sales districts. Considering the capabilities of the salesmen and the nature of districts, the manager estimates the sales per month (in rupees hundred) for each salesman in each district as follows : **6**

		Districts			
		I	II	III	IV
Salesmen	A	42	35	28	21
	B	30	25	20	15
	C	30	25	20	15
	D	24	20	16	12

Find the assignment of salesmen to districts that will result in maximum sales. Find alternative optimal assignments, if any.

b) Apply Vogel's Approximation Method to obtain an initial basic feasible solution to the transportation problem given below. Test the solution for optimality. If not, modify to obtain optimal solution. Find also the optimum cost. **10**

	D_1	D_2	D_3	D_4	Supply
S_1	19	30	50	10	7
S_2	70	30	40	60	9
S_3	40	8	70	20	18
Demand	5	8	7	14	

5. a) Find the coefficient of correlation between industrial production and export, using the following data, and comment on the result. **7**

Production (in crore tons) :	55	56	58	59	60	60	62
Export (in crore tons) :	35	38	38	39	44	43	45

b) It is given that the mean of a binomial distribution is 2 and variance is 4/3. Find the probability of obtaining i) exactly two successes, ii) less than 2 successes. **5**

c) The distribution of typing mistakes committed by a typist is given below :

Mistakes per page :	0	1	2	3	4	5
No. of pages :	142	156	69	27	5	1

Fit a Poisson distribution to the above data and calculate the expected frequencies. **6**

OR

6. a) The marks of 1000 students in a University are found to be normally distributed with mean 65 and s.d. 10. Estimate the number of students whose marks will be i) between 50 and 70 ii) more than 70, iii) less than 60.

Given : Area under the standard normal curve

z	Area	z	Area
0.5	0.1915	1.5	0.4332

6

b) A manufacturer of electronic goods has 4% of his product defective. He sells the articles in packets of 50 and guarantees that not more than 2 items will be defective. Find the probability that a box will fail to meet the guaranteed quality.

6

c) The table below gives number of books issued from a certain library on the various days of a week.

Days	**No. of books issued**
Mon.	120
Tues.	130
Wed.	110
Thurs.	115
Fri.	135
Sat.	110

Test at 5% level of significance, whether issuing of book is day dependent.

Given : $\chi^2_{5,\,0.05} = 11.07.$

6

SECTION – II

7. a) With usual notations establish the following : **9**

i) $\sin h D = \mu s$.

ii) $\frac{\Delta}{\nabla} - \frac{\nabla}{\Delta} = \Delta + \nabla$.

iii) $D = \frac{1}{h}\left[\Delta - \frac{\Delta^2}{2} + \frac{\Delta^3}{3} - \frac{\Delta^4}{4} + \ldots\ldots\right]$.

b) Evaluate $\int_{0.5}^{0.74} e^{-x}\, x^{1/2}\, dx$ taking h = 0.04 by using

i) Trapezoidal rule.

ii) Simpson's $\frac{1}{3}$rd rule.

iii) Simpson's $\frac{3}{8}$th rule. **8**

OR

8. a) For the following tabulated data : **8**

x	0.0	0.5	1.0	1.5	2.0	2.5	3.0
f(x)	0.000	0.191	0.341	0.433	0.477	0.494	0.499

Find the value of f(1.65) using Stirling's formula.

b) For the following tabulated data : **9**

x	0	1	2	3	4	5
y	1.12	3.45	6.67	10.8	16.12	24.52

find y at x = 0.5, $\frac{dy}{dx}$ at x = 5.5.

9. a) Using Newton-Raphson iterative method find a root of the equation $x \sin x + \cos x = 0$ which is near to $x = \pi$. **8**

b) Solve the following system of equations by Gauss elimination method. **8**

$$5x_1 + x_2 + x_3 + x_4 = 4$$

$$x_1 + 7x_2 + x_3 + x_4 = 12$$

$$x_1 + x_2 + 6x_3 + x_4 = -5$$

$$x_1 + x_2 + x_3 + 4x_4 = -6$$

OR

10. a) Solve the following system of equations Gauss – Seidel iterative method : **8**

$$20x_1 + x_2 - 2x_3 = 17$$

$$3x_1 + 20x_2 - x_3 = -18$$

$$2x_1 - 3x_2 + 20x_3 = 25$$

b) Use method of least squares to fit a second degree parabola of the form $y = a + bx + cx^2$ to satisfy following data : **8**

x	0	1	2	3	4
y	1	1.8	1.3	2.5	6.3

11. a) Solve the Laplace equation $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ at the pivotal points of the grid shown in the Fig. 11a **9**

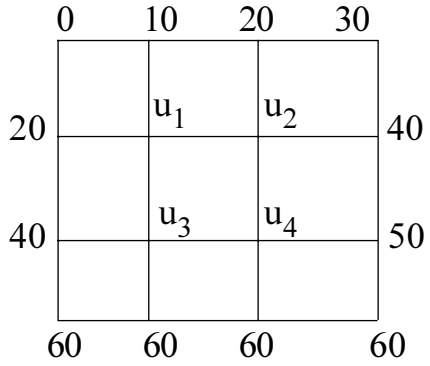

Fig. 11a

b) Using modified Euler's method solve the equation $\frac{dy}{dx} = x + \left|\sqrt{y}\right|$; $y(0) = 1$ find y at x = 0.4 taking h = 0.2, correct to four places of decimals. **8**

OR

12. a) Solve the equation $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = -x^2y^2$ over the square with sides x = 0 = y, x = 3 = y with u = 0 on the boundary and mesh length = 1. **9**

b) Use Runge – Kutta method of fourth order to solve : **8**

$$\frac{dy}{dx} = \frac{y^2 - x^2}{y^2 + x^2}; \; y(0) = 1$$

to find y at x = 0.4 taking h = 0.2.

———————

[3563] – 241

T.E. (Petrochemical Engineering) (Sem. – I) Examination, 2009
CHEMICAL PROCESS INDUSTRIES
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Answer any* ***three*** *questions from* ***each*** *Section.*

2) Answers to the ***two*** *Sections should be written in* ***separate*** *answer books.*

3) ***Neat*** *diagrams must be drawn* ***wherever*** *necessary.*

4) Figures to the ***right*** *indicate* ***full*** *marks.*

SECTION – I

1. a) Describe with flowsheet the Raschig - Olin process for manufacture of hydrazine. **12**

   b) Mention major engineering problems in production of ethanol by fermentation. **6**

2. a) Describe with flowsheet the ammonium carbamate decomposition process for manufacture of urea. **10**

   b) Write a note on dyes and their classification. **6**

3. a) Describe with flowsheet the contact process for manufacture of sulphuric acid. **10**

   b) Write a note on carbohydrates and their applications. **6**

4. a) Describe with flowsheet the Harber process for manufacture of ammonia. **10**

   b) Mention end uses of nitric acid, glycerine and urea. **6**

P.T.O.

SECTION – II

5. a) Describe with flowsheet the ammonia oxidation process for manufacture of nitric acid. **12**

   b) Write a note on by-products of sugar industry. **6**

6. a) Describe with flowsheet the Bergius process for manufacture of aromatic liquids from coal. **10**

   b) Mention major engineering problems in production of lime. **6**

7. a) Describe with flowsheet the extraction process for manufacture of crystal sugar. **10**

   b) Mention end uses of ethanol, sulphuric acid and caustic soda. **6**

8. a) Describe with flowsheet the solvay process for manufacture of soda ash. **10**

   b) Describe the process for production of gur from sugarcane. **6**
