[3563] – 180

T.E. (Chemical) (Semester – II) Examination, 2009
INDUSTRIAL ORGANISATION AND MANAGEMENT
(Common to Biotechnology)
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answer **three** questions from Section **I** and **three** questions from Section **II.***
*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, slide rule, Mollier charts, electronic pocket calculator and steam tables is **allowed.***
*6) Assume suitable data, if **necessary.***

SECTION – I

1. Define Management. Explain in detail various functions of management. State the role of managers in a changing global business environment. **16**

OR

2. Distinguish between partnership and Joint stock company. State and explain the formation and functions of joint stock company with its advantages and disadvantages. **16**

3. a) Explain the following concepts :
   i) Management by objectives.
   ii) Principles of organisation. **10**
   b) Explain Henry Fayol's theory of management. **6**

OR

4. a) What is Organisational structure ? Differentiate between project organisation and Matrix organisation. **8**
   b) State and explain Maslow's theory of Motivation. **8**

P.T.O.

5. Distinguish between Job Evaluation and Merit rating. Explain the objectives and methods of Job Evaluation. **18**

OR

6. Explain the following :

   i) Inspection and quality control

   ii) Economic order quantity

   iii) Functions of Material Manager

   iv) LIFO, FIFO. **18**

SECTION – II

7. Define Market research. What are the different methods of market research ? Give your comment how to market chemical product in a competitive market ? **16**

OR

8. Explain the following :

   a) Penetration prices and skimming prices.

   b) Distribution channels.

   c) Role of advertisement. **16**

9. a) Critically evaluate the role of export promotion council to boost foreign trade of India. **10**

   b) State and explain the concept of antidumping duties and how it affect import ? **6**

OR

10. a) Explain the following :

    i) Patent right and Copy right

    ii) Contract Act. **8**

    b) State and explain the concept of total Quality Management. **8**

11. a) Define work study. Explain the objectives and procedures of work study. **10**

    b) State and explain principles of Motion economy. **8**

OR

12. a) State and explain the importance of FERA and MRTP. **6**

    b) Explain the following :

    i) Flow process chart

    ii) Therblige

    iii) Flow diagram. **12**

———————

[3563] – 179

T.E. (Chemical) (Semester – II) Examination, 2009
MASS TRANSFER – II
(2003 Course) (Common to Biotechnology)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Anwer **3** questions from Section **I** and **3** questions from Section **II**.*
*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, slide rule, Mollier charts, electronic pocket calculator and steam tables is **allowed**.*
*6) Assume suitable data, if **necessary**.*

SECTION – I

1. a) Explain with neat sketch "Azeotropic distillation". **6**

   b) A liquid mixture containing 50 mole% of n-heptane (A) and 50 mole% n-octane (B) at 20°C is to be differentially distilled at atmospheric pressure with 60 mole% of the liquid to be distilled. Compute the composition of the composite distillate and residue. **10**

Mole fraction of A in liquid	0	0.157	0.312	0.487	0.655
Mole fraction of A in vapour	0	0.279	0.492	0.674	0.810

OR

2. a) A feed containing 45 mole% of component A and rest water is to be continuosly distilled to get a overhead product as 95% A and bottom product as 98 mole% water. Feed contains 30 mole% vapour. The relative volatility of the system is constant and is equal to 2.6 calculate :

   i) minimum reflux ratio

   ii) number of theoretical stages if reflux ratio of 2.5 times the minimum is used. **14**

   b) What is relative volatility ? **2**

P.T.O.

3. a) 500 kg/hr of Nicotine water solution containing 1.2% nicotine is to be extracted countercurrently with kerosene at 25°C to reduce the nicotine content to 0.15% Determine : **14**

   i) Minimum kerosene rate

   ii) Number of theoretical stages required if 1500 kg/hr

   Equilibrium data :

$\frac{\text{kg of nicotine}}{\text{kg of water}}$	0.001	0.00246	0.00502	0.00751	0.00998	0.0204
$\frac{\text{kg of nicotine}}{\text{kg of kerosene}}$	0.00081	0.00196	0.00456	0.00686	0.00913	0.0187

   b) Explain choice of solvent in extraction. **4**

OR

4. 200 kg of aqueous acetic acid solution containing 25% acetic acid is to be extracted with 150 kg of isopropyl ether solvent at 20°C. Two batch extractions are to be done with fresh and pure solvent. Estimate the quantities and compositions of the extract and reffinate products. **18**

Water layer	A	98.1	95.5	84.4	71.1	59.8	37.1
	B	1.2	1.6	2.3	3.4	4.4	16.5
	C	0.69	2.89	13.3	25.5	36.7	46.4
Ether layer	A	0.5	0.8	1.9	3.9	6.9	15.1
	B	99.3	98.4	93.3	84.7	71.5	48.7
	C	0.18	0.79	4.82	11.4	21.6	36.2

A – Water, B – Ether, C – Acetic Acid

5. a) Explain nature of adsorbents. **4**

   b) A solution of washed raw cane sugar is coloured by the presence of impurities. It is to be decolourised by treatment with an adsorptive carbon in a contact filtration plant. The data for an equilibrium isotherm is given below. The original solution has a colour concentration of 9.6 measured on an arbitrary scale and it is desired to reduce colour to 10% of its original value.

Kg carbon/Kg solution	0	0.001	0.004	0.008	0.02	0.04
Equilibrium colour	9.6	8.6	6.3	4.3	1.7	0.7

   Convert the data to a suitable form for plotting the equilibrium isotherm and determine the quantity of fresh carbon required per 1000 kg of solution for a two stage countercurrent operation. **12**

OR

6. a) Write material balance and minimum adsorbent requirement for multistage counter current operation. **12**

   b) Explain types of industrial adsorbents. **4**

SECTION – II

7. a) Explain working of continuous countercurrent decantation system for leaching with neat sketch. **8**

   b) Prepared cotton seed meats containing 35% extractable oil are fed to a continuous countercurrent extractor of the intermittent drainage type using hexane as solvent. The extractor consists of ten sections, the section efficiency being 50%. The entrainment, assumed constant, is 1.0 kg solution/kg solids.

   What will be the oil concentration in the outflowing solvent if the extractable oil content in the meats is to be reduced to 0.5% by weight. **10**

OR

8. a) Write material balance of single-stage leaching system. **8**

   b) 60 tons per day of oil sand (25 mass% oil and 75 mass% sand) is to be extracted with 40 tons per day of naphtha in a continuous countercurrent extraction battery. The final extract from the battery is to contain 40 mass % oil and 60 mass % naphtha, and the underflow from each unit is expected to consist of 35 mass % solution and 65 mass % sand. If the overall efficiency of the battery is 50%, how many stages will be required ? **10**

9. a) Calculate the yield of $MgSO_4 . 7H_2O$ crystals when 1000 kg saturated solution of $MgSO_4$ at 353 K (80°C) is cooled to 303 K (30°C) assuming 10% of the water is lost by evaporation during cooling.

   Data : Solubility of $MgSO_4$ at 353 K (80°C)

   = 64.2 kg/100 kg water

   Solubility of $MgSO_4$ at 303 K (30°C)

   = 40.8 kg/100 kg water

   At.wt Mg = 24; S = 32; H = 1 and O = 16. **10**

   b) Explain mechanism of crystallization and crystal formation. **6**

   OR

10. a) Write principle and working of vacuum crystallizer with neat sketch. **10**

    b) Write material and enthalpy balance of crystallization operation. **6**

11. a) Explain reverse osmosis with neat sketch. **8**

    b) Explain with neat sketch hollow fiber membranes for gas permeation. **8**

    OR

12. a) Write classification of membrane processes. **8**

    b) State industrial application of nanofiltration. **8**

[3563] – 178

T.E. (Chemical) (Semester – II) Examination, 2009
CHEMICAL PROCESS TECHNOLOGY
(2003 Course)

Time: 3 Hours Total Marks: 100

Instructions : *1) Answer Q.**1** or Q.**2**, Q. **3** or Q. **4**, Q. **5** or Q. **6** from Section **I** and Q. **7** or Q. **8**, Q. **9** or Q. **10**, Q. **11** or Q. **12** from Section **II**.*
*2) Answers to the **two** Sections should be written in **separate books**.*
*3) **Neat** diagrams must be drawn **wherever** necessary.*
*4) Figure to the **right** indicate **full** marks.*

1. a) Write the conventions used while drawing a flow diagram. **6**

   b) Draw schematically the following equipments :
   1) Batch and continuous distination
   2) Single and multiple effect evaporator
   3) Crystariser
   4) Drum filter
   5) Cyclone separator
   6) Shale and tube heat exchanger
   7) Rotary drier
   8) Centrifugal pump
   9) Reboiler
   10) Gas holder. **10**

OR

2. a) Define unit operation and unit processes and five industrial applications of each. **6**

   b) Draw flow diagram for the following industrial processes :
   a) Isopropanol vapour is compressed to 3 atm and passed through tubular catalytic reactor at 300°C containing catalyst. The hot product gases pass through a water cooled condenser and then through a water scrubber where find traces of isopropanol and acetone are removed from hydrogen. The product is then fractionated to give acetone as top product and isopropanol as bottom product. The unreacted isopropanol is recycled to the reactor.

b) Ethanol is vaporised and passed over dehydrogenation catalyst in a reactor at 400°C to produce acetaldehyde. Excess methanol (liquid) is mixed with acetaldehyde and sent to another reactor cataining silica catalyst. The product gases are sent to a series of distillation columns to get raw butadiene. **10**

3. Answer **any three** :

a) Describe the importance of sulfur in the Indian chemical industry.

b) Write briefly on "conservation of sulfur".

c) Discuss the merits and demerits of various catalysts used in the production of sulfuric acid.

d) Compare chambers process with that of content process for sulfuric acid manufacture. **18**

OR

4. a) Explain why sodium carbonate (Na_2CO_3) is called as Sodaash, discuss the uses and importance of Sodaash. **5**

b) Describe with a flow diagram the technology for the manufacture of Sodaash by Solvay process. **10**

c) Compare the merits of Solvay process with other process. **3**

5. a) Describe the technology for the manufacture of ammonia with a flow diagram. **9**

b) Enumerate the engineering problems involved in the process. **5**

c) Name three Indian industries manufacturing ammonia with their location. **2**

OR

6. Write short notes on **any three** : **16**

a) Frasch process for mining of sulfur. **6**

b) Engineering problems associated with DCDA process for sulfuric acid. **5**

c) Importance of fertiliser industry in India. **5**

d) Cost analysis and break-even point. **5**

SECTION – II

7. a) Describe the electrolytic process for the co-production of chlorine, sodium hydroxide and hydrogen with a flow diagram. **12**

   b) Discuss the engineering problems associated with the above process. **6**

OR

8. Answer **any three** :

   a) Discuss the overall factors to be considered in a cement industry.

   b) Write briefly on the classification of cleansing agents.

   c) One common method for the manufacture of detergents.

   d) Name five industries each for manufacturing soap and detergents and their location in India. **18**

9. a) Describe the importance of Sugar Industry. **4**

   b) Discuss with the help of a flow diagram, the technology for the manufacture of sugar from sugarcane. **8**

   c) Discuss the various engineering problems associated with the above process. **4**

OR

10. Write short notes on **any four** of the following :

   a) Petroleum industry.

   b) Petroleum refining products.

   c) Definition of Petroleum and reasons for studying petrochemical industry.

   d) Production of ethylene.

   e) Type of refineries in Petroleum. **16**

11. a) Describe the technology for the manufacture of cumene by prophylene alkyllation process with a flow diagram. **10**

    b) List the major engineering problems with the above process. **6**

OR

12. a) Name different processes for the manufacture of Phenol. **3**

    b) Describe the technology for the manufacture of Phenol by cumene process. **10**

    c) Discuss the major engineering problems with the above process. **3**

[3563] – 177

T.E. (Chemical) (Sem. – II) Examination, 2009
TRANSPORT PHENOMENA
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answer **three** questions from Section **I** and **three** questions from Section **II***
*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, electronic pocket calculator and steam tables is **allowed**.*
*6) **Assume** suitable data, **if necessary**.*

SECTION – I

1. a) What is meant by the term 'Non-Newtonian' ? What types of substance exhibit this behaviour ? **4**

   b) Fluid A has a viscosity that is twice that of fluid B; which fluid would you except to flow more rapidly through a horizontal tube of length L under the same pressure drop ? **6**

   c) An oil has a kinematic viscosity of 2×10^{-4} m^2/s and a density of 0.8×10^3 kg/m^3. What should the mass rate of flow of this film down a vertical wall be in order to have a film thickness of 3.5 mm ? **6**

OR

2. a) Derive an expression for average velocity over a cross section of the flow of a falling film on a region of length L in a wetted wall tower. **8**

   b) Derive an expression for Hagen-Poiseuille law. **8**

3. a) Compare laminar and turbulent tube flow in regard to a) velocity profile b) ratio of average to maximum velocity c) dependence of flow rate on pressure drop. **6**

P.T.O.

b) For the turbulent flow in smooth circular tubes the curve fit function

$$\frac{\overline{V}_z}{\overline{V}_{z,\,max}} = \left(1 - \frac{r}{R}\right)^{1/n}$$

near $R_e = 4\times10^3$, $n = 6$; near $R_e = 1.1\times10^5$, $n = 7$ and near $R_e = 3.2\times10^6$, $n = 10$. Show that the ratio of average to maximum velocity is

$$\frac{\langle \overline{V}_z \rangle}{\overline{V}_{z,\,max}} = \frac{2n^2}{(n+1)(2n+1)}$$ **12**

OR

4. a) A fluid of constant density and viscosity is in a cylindrical container of radius R. The container is caused to rotate about its own axis at an angular velocity Ω. The cylinder axis is vertical so that $g_r = g_\theta = 0$ and $g_z = -g$. Find the shape of the free surface when steady state has been established. **12**

b) Define friction factor for

i) Flow in conduits

ii) Flow around submerged objects. **6**

5. a) Consider a long nuclear fuel rod which is surrounded by an annular layer of aluminum cladding. Within the fuel rod heat is produced by fission; this heat source is dependent on position; with a source strength varying approximately as

$$S_n = S_{no}\left[1 + b\left(\frac{r}{R_F}\right)^2\right]$$

where 'S_{no}' is the heat per unit volume per unit time produced at $r = 0$ and 'r' is distance from the axis of the fuel rod. Calculate maximum temperature in the fuel rod; if the outer surface of the cladding is in contact with a liquid coolant at tempertaure T_L, the heat transfer coefficient at the cladding coolant interface being h_L. The thermal conductivities of fuel rod and cladding are k_F and k_C. **12**

b) Compare Fourier's law of heat conduction with Newton's law of viscosity. **4**

OR

6. a) An oil is acting as a lubricant for a pair of cylindrical surfaces. The angular velocity of the outer cylinder is 7908 rpm. The outer cylinder has a radius of 5.06 cm and the clearance between the cylinders is 0.027 cm. What is the maximum temperature in the oil, if both wall temperatures are known to be 158°F ? The physical properties of oil are :
viscosity = 92.3 Cp, density = 1.22 g/cm^3, thermal conductivity = 0.0055 cal/sec.cm°C. **12**

b) Show that the Grashof and Brinkman numbers are dimensionless. **4**

SECTION – II

7. a) Deduce the equation of energy change for a Newtonian fluid with constant K in terms of fluid temperature T. **8**

b) A solid sphere 0.0254 m in diameter is placed in an otherwise undisturbed air stream, which approaches at a velocity of 30.48 m/s, a pressure of 1 atm, and a temperature of 37.7°C. The sphere surface is maintained at 93.33°C by means of an embedded electric heating coil. What must be the rate of electrical heating in W to maintain the stated conditions ?

Given data at 37.7°C : **8**

$\mu_f = 1.9 \times 10^{-5}$ N.s / m^2 $\qquad \hat{C}_p = 1.0048 \times 10^3$ J / kg.K

$k_f = 0.027$ W / m.k $\qquad \rho_f = 1.137$ kg / m^3

OR

8. a) For forced convection in tubes, derive the correlation of heat transfer coefficient in terms of Reynold's numbers, Prandtl number, and L/D. **8**

b) A solid cylinder in which heat generation is occurring uniformly as q in W/m^3 is insulated at the ends. The temperature of the surface of the cylinder is held constant at T_w. The radius of the cylinder is r = R m. Heat flows only in the radial direction. Derive the equation for the temperature profile at steady state if the solid has a constant thermal conductivity. **8**

9. For diffusion with homogeneous chemical reaction, deduce the equations to obtain the average concentration of A in the liquid phase and for the molar flux of A at surface. **16**

OR

10. Predict D_{AB} for the methane-ethane system at 313 K and 101.325 KPa by the following two methods :

    a) The Slatterry equation.

    b) The Chapman-Enskog theoretical equation using critical pressures and temperatures to estimate the Lennard-Jones parameters.
    Given : $\Omega_{DAB} = 1.45$, $a = 2.745 \times 10^{-4}$, $b = 1.823$

    Methane: $T_c = 190.7$ K $P_c = 45.8$ atm

    Ethane : $T_c = 305.4$ K $P_c = 48.2$ atm **16**

11. For the steady isothermal flow of a liquid solution of A and B in the pipe, deduce the equations to predict the functional dependence of jH and jD. **18**

OR

12. a) Explain the physical significance of $F_z^{(m)}$ and of $Q^{(m)}$. What is the analogous quantity of mass transfer of species A in a binary system ? **10**

    b) Explain in detail the Reynold's analogy for Mass, Heat and Momentum transfer. **8**

[3563] – 176

T.E. (Chemical) (Semester – II) Examination, 2009
CHEMICAL REACTION ENGINEERING – I
(Common to Bio-Technology)
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Answer* ***any 3*** *questions from* ***each*** *Section.*
2) ***Neat*** *diagrams must be drawn* ***wherever*** *necessary.*
3) Black figures to the ***right*** *indicate* ***full*** *marks.*
4) Assume ***suitable*** *data, if* ***necessary****.*

SECTION – I

1. a) Decomposition of phosphine follows the following stoichiometry

$$4PH_3 \rightarrow P_4 + 6H_2$$

if at an instant rate of decomposition of phophine is 2×10^{-4} k mol/m^{3}5. Calculate the rate of formation of phosphorous and hydrogen. **4**

b) What are different ways of expressing reaction rate ? **4**

c) A certain reaction has a rate given by

$$-r_A = 0.005\, C_A^2 \text{ mol/cm}^3\text{.min}$$

if concentration is to be expressed in mol/lit and time in hours. What would be the value and units of the rate constant ? **4**

d) Differentiate elementary Vs non-elementary reaction. **4**

OR

2. a) Experiment shows that homogeneous decomposition of ozone proceeds with a rate

$$-r_{03} = k[O_3]^2\,[O_2]^{-1}$$

a) What is the overall order of reaction ?

b) Suggest two step mechanism to explain this rate. **8**

b) Explain the following non-elementary kinetic models and mechanisms :

i) Free Radicals, chain reaction mechanism

ii) Molecular intermediates, nonchain mechanism

iii) Transition complex, nonchain mechanism. **8**

P.T.O.

3. a) What are different ways to determine the "extent of reaction" at various times ? **4**

   b) Compare differential method of analysis with Integral method of analysis of Batch reactor data. **4**

   c) Liquid A decomposes by first order kinetics and in a batch reactor 50% of A is converted in 5 minutes run. How much longer would it take to reach 75% conversion ? **4**

   d) Derive the expression for irreversible unimolecular type first order reaction $A \rightarrow$ Product in terms of conversion x_A and time 't'. **4**

OR

4. a) At room temperature sucrose is hydrolyzed by the catalytic action of the enzyme sucrase as follows

$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Product}$$

Starting with sucrose concentration C_{A0} = 1.0 millimol/liter and an enzyme concentration C_{E0} = 0.01 millimol/liter, the following kinetic data are obtained in batch reactor (concentrations are calculated from optical rotation measurement)

C_A millimol/liter	0.84	0.68	0.53	0.38	0.27	0.16	0.09	0.04	0.018	0.006
t	1	2	3	4	5	6	7	8	9	10

Determine whether these data can be reasonably fitted by kinetic equation of the

Michaelis-Menten type or $-r_A = \dfrac{K_3 C_A . C_{EO}}{C_A + C_M}$ where C_M = Michaelis constant

if the fit is reasonable, evaluate constants K_3 and C_m. Solve by integral method of analysis. **12**

   b) What is meaning of "Autocatalytic reactions" ? Draw and explain X_A V_s t and $-r_A$ V_s C_A/C_{A0} curves for autocatalytic reaction. **4**

5. a) Develop performance equation for plug flow reactor with its graphical representation. **8**

   b) The liquid phase reaction $A + B \rightarrow C + D$ takes place in a CSTR of volume 25 m^3. The feed stream contains 5 k mol/m^3 of A and 100 k mol/m^3 of B. What volumetric flow rate and space time is required to obtain 50% conversion of the limiting reactant ? The reaction rate constant is 0.0001 m^3/k mol.s at the reaction temperature. **10**

OR

6. a) A homogeneous gas reaction $A \rightarrow 3R$ has a reported rate at 215°C $-r_A = 10^{-2}\, C_A^{1/2}$ [mol/liter. sec]. Find the space time needed for 80% conversion of 50% A 50% inerts feed to a plug flow reactor operating at 215°C and 5 atm ($C_{A0} = 0.0625$ mol/lit). **12**

b) Develop performance equation for CSTR with its graphical representation. **6**

SECTION – II

7. a) Liquid reactant A decomposes as per the following reaction scheme :

$$A \begin{cases} \nearrow R & r_R = K_1 C_A^2 \\ \searrow S \end{cases}$$

with rates $r_R = K_1 C_A^2$, $r_s = K_2 C_A$, $K_1 = 0.4\ m^3/mol.min$ $K_2 = 2\ (min)^{-1}$. An aqueous feed containing A with $C_{A0} = 40\ mol/m^3$ enters a reactor, decomposes, and a mixture of A, R and S leaves the ractor. Find the operating condition (X_A, τ and C_R) which maximizes C_R in mixed flow reactor. **10**

b) Develop the concentration Vs time curves for the reaction $A \xrightarrow{K_1} R \xrightarrow{K_2} S$ $C_{R0} = C_{S0} = 0$ occurring in mixed flow reactor. Derive and show that

$$\tau mopt = \frac{1}{\sqrt{K_1 K_2}}$$ **6**

OR

8. a) Reactant A decomposes by three simultaneous reactions to form three products : one that is desired D and two that are undesired Q and U. These gas phase reactions, together with their corresponding rate laws are

Desired product $A \rightarrow D$

$$r_D = \left\{0.0002 \exp\left[36{,}000\left(\frac{1}{300} - \frac{1}{T}\right)\right]\right\} C_A$$

Unwanted product U

$$A \rightarrow U$$

$$r_U = \left\{0.0018 \exp\left[25{,}000\left(\frac{1}{300} - \frac{1}{T}\right)\right]\right\} C_A^{1.5}$$

Unwanted product Q

$$A \rightarrow Q$$

$$r_Q = \left\{0.00452 \exp\left[5{,}000\left(\frac{1}{300} - \frac{1}{T}\right)\right]\right\} C_A^{0.5}$$

How and under what conditions (e.g. reactor type, pressure, temp. etc) should the reaction above be carried out to minimize the concentration of the unwanted product U and Q ? **10**

b) Discuss product distribution in series reactions. **6**

9. a) Determine the equilibrium conversion for the following elementary reaction between 0°C to 100°C A⇌R at 298 K, $\Delta G° = -14130$ J/mol, $\Delta H_R^\circ = -75300$ J/mol, $C_{PA} = C_{PR}$ = Constant

i) Construct a plot of temperature Vs conversion.

ii) What restrictions should be placed on reactor operating isothermally if conversion of 85% or higher is desired ? **12**

b) Discuss and draw general shape of temperature Vs conversion plot of i) Irreversible ii) Reversible exothermic iii) Reversible exothermic reaction. **4**

OR

10. a) Estimate equilibrium constant at 600 k for the reaction

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

$$\Delta G° = -2030 \text{ k cal/ mol}$$

at 298

$\Delta H_f°$ for $H_2O(g) = -57598$ cal/mol

$C_2H_5OH(g) = -56230$ cal/mol

$C_2H_4(g) = 12495$ cal/mol. **10**

b) Draw a graph of X_A V_S T representing energy balance equation line for adiabatic operation, with increase in inerts, exothermic, endothermic reaction etc. **3**

c) Write a note on "Optimum temperature progression". **3**

11. A pulse of tracer of amount 3.7 mg is injected to a stirred vessel through feed stream. The following table shows the measured tracer concentration in outflow stream. Calculate mean residence time and generate E curve. The volumetric flow rate and hydraulic residence time are 0.5 L/S and 50 sec. respectively **18**

Time (Sec)	0	10	20	30	40	50	60	70	80	90	100
Concentration mg/L	0	0.1	0.3	0.6	0.7	0.65	0.6	0.4	0.1	0.08	0.04

OR

12. Write a note on **(any three)** : **18**

a) C and E, F curves

b) Dispersion Model

c) Examples of non ideality in reactors

d) Tank in series model.

———————

[3563] – 175

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

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answer **three** questions from Section – **I** and **three** questions from Section – **II**.*

*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, slide rule, Mollier charts, electronic pocket calculator and steam tables is **allowed.***

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

SECTION – I

1. a) Show that the fugacity of a gas obeying Van Der Waal's equation of state is given by

$$\ln f = \frac{b}{v-b} - \frac{2a}{RTV} + \ln \frac{RT}{v-b}$$

where a and b are Van Der Waal's constants. **8**

b) Calculate the fugacity of isobutane at 154.5°C and 8620 KPa by using Redlich-Kwong-Soave equation. Its molar volume is 0.154 m^3/k mol, T_C = 135°C, P_C = 3648 KPa, acentric factor = 0.1756. **10**

OR

2. a) The molar enthalpy of a binary solution at constant T and P is given by the relation

$h = 500\ x_1 + 1000\ x_2 + (50x_1 + 40\ x_2)\ x_1x_2$ where h is in J/mol. Determine $\bar{h}_1$ and $\bar{h}_2$ as a function of x_1 and the numerical values of the pure component enthalpies h_1 and h_2. Also determine the partial molar enthalpies at infinite dilution. **10**

b) Write a note on chemical potential. **8**

3. a) The system acetone (1) and cyclohexane (2) forms an azeotrope at $x_1 = 0.7390$ at 25°C and 262 Torr. Estimate the Van Laar constants for the system and calculate the activity coefficients at $x_1 = 0.5$. **8**

b) The volume of aqueous NaCl at 298 k was measured for a series of molalities and it was found that the volume varies with molality according to the following expression :

$V = 1.003\times10^{-3} + 0.1662\times10^{-4}m + 0.177\times10^{-5}\ m^{1.5} + 0.12\times10^{-6}m^2$ where m is the molality and V is in m^3. Calculate the partial molar volumes of the components at m = 0.1 mol/kg. **8**

OR

4. Chloroform (1) and methanol (2) forms an azeotrope at 760 Torr and 53.5°C and $x_1 = 0.65$. Using the Van Laar model calculate the VLE data at 53.5°C.

The Antoine constants are given as

Compound	A	B	C
Chloroform	6.95465	1170.966	226.232
Methanol	8.08097	1582.271	239.726

At 53.5°C $P_1^{sat} = 586.98$ Torr, $P_2^{sat} = 484.05$ Torr. **16**

5. Assuming Raoults law to be valid prepare a P-x-y diagram at 373k and T – x – y diagram at 101.3 KPa for benzene (1) and ethyl benzene (2) system. Antoine equations are given as follows :

$$\ln P_1^S = 13.8858 - \frac{2788.51}{T - 52.41}$$

$$\ln P_2^S = 14.0045 - \frac{3279.47}{T - 60.00}$$

P is in KPa and T is in k. **16**

OR

6. The vapour pressures of acetone (1) and acetonitrile (2) can be evaluated by the Antoine equations

$$\ln P_1^S = 14.5463 - \frac{2940.46}{T - 35.93}$$

$$\ln P_2^S = 14.2724 - \frac{2945.47}{T - 49.15}$$

where T is in k and P is in KPa.

Calculate :

i) x_1 and y_1 at 327 k and 65 KPa
ii) T and y_1 at 65 KPa and $x_1 = 0.40$
iii) P and y_1 at 327 k and $x_1 = 0.40$
iv) T and x_1 at 65 KPa and $y_1 = 0.40$. **16**

SECTION – II

7. a) Explain liquid-liquid equilibrium diagram on a triangular coordinates for a system in which two pairs are partially soluble. **6**

b) Derive the following expression for solid-liquid equilibrium:

$\psi_i = \exp \int_{Tm}^{T} \frac{H_i^l - H_i^s}{RT^2} dt$ where $\psi_i = \frac{fi^s}{fi^l}$ and H_i^l and H_i^s are the molar enthalpies for the species i in the liquid and solid phases. Tm_i is the melting temperature (freezing point) of pure species i. **10**

OR

8. a) Derive the Clapeyron equation by using the criteria of phase equilibrium. **8**

   b) Explain the following two methods of consistency tests for VLE data : **8**

      i) Using the coexistence equation

      ii) Using the partial pressure data.

9. a) Estimate the equilibrium constant k_a at 1000 k and 0.1 MPa for the reaction.

   $CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$

   $k_a(298.15) = 8.685 \times 10^{-6}$ and $\Delta H^{\circ}_{298} = 41.449$ KJ

   $C^{\circ}_P = a + bT + cT^2 + dT^3 + eT^{-2}$ J/mol.k

   T is in k. The constants in the heat capacity equation are given as follows : **14**

Compound	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$	$e \times 10^{-5}$
CO	28.068	4.631	–	–	–0.258
H_2O	28.850	12.055	–	–	1.006
CO_2	45.369	8.688	–	–	–9.619
H_2	27.012	3.509	–	–	0.690

   b) Explain reaction coordinates. **4**

OR

10. a) Calculate the standard Gibbs free energy change and the equilibrium constant at 298.15 k for the following reactions :

   a) $N_2(g) + 3H_2(g) \rightarrow 2\,NH_3(g)$

   b) $C_2H_5OH(g) + \frac{1}{2}O_2(g) \rightarrow CH_3CHO(g) + H_2O(g)$.

   Free energies of formation at 298.15 k are given as follows:

   $\Delta G^{\circ}_f(NH_3) = -16.747$ kJ/mol

   $\Delta G^{\circ}_f(CH_3CHO) = -133.978$ kJ/mol

   $\Delta G^{\circ}_f(H_2O) = -228.600$ kJ/mol

   $\Delta G^{\circ}_f(C_2H_5OH) = -174.883$ kJ/mol . **8**

b) A system formed initially of 2 mol CO_2 , 5 mol H_2 and 1 mol CO undergoes the reactions

$CO_2(g) + 3H_2(g) \rightarrow CH_3OH(g) + H_2O\ (g)$

$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O\ (g)$

Develop expressions for mol fractions of the reacting species as functions of the reaction coordinates for the two reactions. **6**

c) Write a note on application of equilibrium criteria to chemical reactions. **4**

11. a) Solid calcium oxalate dissociates at high temps. into solid calcium carbonate and carbon monoxide.

$CaC_2O_4\ (s) \rightarrow CaCO_3\ (s) + CO(g)$

The equilibrium pressure of CO between 670 and 700 K is given by

$P(atm) = 14.4 - \frac{9600}{T}$, where T is in K.

Assuming ideal behavior calculate ΔG°, ΔH° and ΔS° at 675 K. **10**

b) Explain the phase rule for reacting systems. **6**

OR

12. a) Estimate the equilibrium composition if CO (g), H_2(g) and A (g) are fed to a reactor in the mole ratio 1:2:5 for the production of methanol. The reactor is maintained at 500 K and 5 bar. Assume that the gas phase behaves like an ideal gas. Ka = 4.973×10^{-3}. **10**

b) For gas phase reactions explain the relation of equilibrium constants with composition. **6**

———————

[3563] – 174

T.E. (Chemical) (Sem. I) Examination, 2009
PROCESS EQUIPMENT DESIGN – I
(2003 Course)

Time : 3 Hours Max. Marks : 100

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

SECTION – I

1. a) Write a note on general design considerations. **(8)**

   b) A horizontal pressure vessel having outer diameter 1.25 m and length of 4 m is subjected to an internal pressure of 1 MN/m^2. The vessel has elliptical heads (2:1) at both ends. Calculate the thickness of shell and heads if weld joint efficiency is 85% and allowable stress for material is 100 MPa. **(8)**

OR

2. a) Write a note on design of various types of heads for pressure vessel. **(8)**

   b) A vessel is to be closed by a blind flange. Calculate its thickness, if
      i) Design Pressure = 170 Kg/cm^2
      ii) Design Temperature = 121°C
      iii) Allowable bolt stress at gasket seating and operating conditions = 1306 Kg/cm^2
      iv) Allowable flange stress at gasket seating and operating conditions = 1190 Kg/cm^2
      v) ID of gasket = 34.4 cm
      vi) Width of gasket = 2.5 cm

P.T.O.

vii) m = 3, Y_a = 680.3 Kg/cm^2

viii) Bolt circle diameter = 56.2 mm

ix) Bolt diameter = 50 mm

x) Number of bolts = 16. **(8)**

3. a) Explain various types of construction used for high pressure vessels. **(6)**

   b) A vessel is to be designed to withstand internal pressure of 150 MN/m^2. An internal diameter of 300 mm is specified and a steel having a yield point of 450 MN/m^2 has been selected. Calculate the wall thickness required by various theories with a factor of safety 1.5 and μ = 0.3. **(12)**

OR

4. A skirt support is to be designed for tall vertical vessel having diameter 2.5 m and 37 m high. Skirt diameter is equal to the diameter of the vessel while the skirt height is 3.5 m. The weight of the vessel with all its attachment is 2,00,000 Kg. Other data for the design are :

   i) Minimum weight of the vessel = 1,50,000 Kg

   ii) Wind pressure = 130 Kg/m^2

   iii) Seismic coefficient = 0.08

   iv) K for cylindrical vessel = 0.7

   v) Permissible tensile stress of material = 1400 Kg/cm^2

   vi) Yield stress of material = 2000 Kg/cm^2

   vii) Permissible stress for concrete = 45 Kg/cm^2

   viii) Bolt circle diameter = 282 cm

   ix) Number of bolts = 24

   Calculate (a) Skirt plate thickness (b) The thickness of bearing plate (c) Bolt load and (d) Minimum stress between bearing plate and concrete foundation. **(18)**

5. a) Explain in detail the design procedure for saddle support. **(8)**

   b) Write a note on Horton sphere. **(8)**

OR

6. a) Describe various types of roofs for storage vessels. **(8)**

b) A tank is to be designed to store 26000 Kg of a non-corrosive liquid having density of 980 Kg/m^3. The diameter of tank is 2.4 m and its welded joint efficiency is 85%. If allowable design stress of material is 1020 Kg/ cm^2 then calculate various course thickness of the tank. **(8)**

SECTION – II

7. a) 1.2 kg/sec. of an organic liquid is to be cooled from 45°C to 20°C using chilled water at 5°C in a shell and tube heat exchanger having 12 mm ID/14 mm OD steel tubes of 1.6 m length. Outlet temperature of water is 10°C. Design a suitable heat exchanger with following data.

	Organic Liquid	**Water**	**Steel**
Specific heat, J/Kg°K	2150	4180	–
Viscosity, mNs/m^2	0.25	0.80	–
Density, Kg/m^3	720	1000	–
Thermal conductivity, $W/m°k$	0.133	0.61	45
Fouling resistance, m^2 K/W	0.0002	0.0004	–

As a first estimate take an overall heat transfer coefficient as 610 $W/m^2{}°k$ and validate your design. **(18)**

OR

8. a) Describe various types of baffles used for shell and tube heat exchangers. **(6)**

b) Suggest a suitable design of concentric tube heat exchanger for cooling 1800 Kg/hr of ethylene glycol from 100° C to 60° C by water available at 15° C. Water can be heated upto 40° C. Ethylene glycol flows through the tube while water flows through the annulus counter currently.

Inside/Outside diameter of inner tube = 12.5/14.5 mm

Inside diameter of outer tube = 22 mm

The properties of fluids at mean temperature are

	Ethylene Glycol	**Water**
Density, Kg/m^3	1078	995
Viscosity, Ns/m^3	3.2×10^{-3}	0.853×10^{-3}
Specific heat, J/Kg°K	2665	4180
Thermal conductivity, W/mk	0.261	0.614

Fouting resistance and metal wall resistance can be neglected. **(12)**

9. a) Compare plate heat exchanger with shell and tube heat exchanger. **(8)**

   b) Describe the procedure for design of plate heat exchanger. **(8)**

OR

10. a) Describe the various methods of feeding for evaporators. **(6)**

   b) A dilute solution containing 10% solids is to be concentrated to 50% solids in a tripple effect evaporator with forward feeding arrangement at the rate of 10,000 Kg/hr using saturated steam at 2.05 kg/cm^2 absolute pressure (121°C) for first effect. Third effect is to operated under vacuum at 0.133 Kg/cm^2 absolute pressure (52°C). Design evaporators using following data.

   i) Overall heat transfer coefficients :

   $U_1 = 3100$ W/m^2 °k, $U_2 = 2000$ W/m^2°k, $U_3 = 1100$ W/m^2°k.

   ii) Specific heat of solutions can be taken as constant at 4.2 kJ/kg°k.

   iii) Latent heat of vaporisation :

   (a) At 2.05 Kg/cm^2, $\lambda = 2200$ kJ/Kg and (b) at 0.133 Kg /cm^2, $\lambda = 2377$kJ/kg

   iv) Boiling point rise of solution may be neglected. **(10)**

11. a) Explain the working of rotary vacuum filter in detail. **(10)**

   b) A rotary vacuum filter operating at 2 RPM, filters a slurry at the rate of 1000 lit/min. Operating under the same vacuum and neglecting the resistance of filter cloth, at what speed must the filter be operated to give a filtration rate of 2000 lit/min. **(6)**

OR

12. a) Explain the working of a disc centrifuge with neat sketch. **(6)**

   b) A centrifuge with phosphor bronze basket of 375 mm diameter is to be run at 60 Hz with a 75 mm layer of liquid of 1200 Kg/m^3 density in the basket. What thickness of wall is required in the basket if density of phosphor bronze is 8900 Kg/m^3 and its safe working stress is 55 N/mm^2. **(10)**

[3563] – 173

T.E. (Chemical Engg.) (Sem. – I)Examination, 2009
PROCESS INSTRUMENTATION AND INSTRUMENTAL ANALYSIS
(2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Answer **3** questions from Section **I** and **3** questions from Section **II**.*
*2) Answers to the **two** Sections should be written in **separate** books.*
*3) Neat diagrams must be drawn **wherever** necessary.*
*4) Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is **allowed**.*
*5) Assume suitable data, if **necessary**.*

SECTION – I

1. a) Explain static and dynamic characteristics of measuring instruments. **8**

   b) Explain need and scope of instrumentation in chemical process industries. **4**

   c) Give the classification of instruments. **4**

   OR

2. a) Differentiate Analog and Digital instruments. **4**

   b) Explain the term "calibration". Why calibration of instruments is required ? **4**

   c) What do you mean by errors ? What are the various sources of errors in an instrumentation system ? **8**

3. a) Explain the working principle and construction of radiation pyrometer. **8**

   b) Explain working of industrial mercury in glass thermometer, with the help of a neat diagram. **8**

   OR

P.T.O.

4. a) Explain Quartz Crystal thermometer, its advantages, disadvantages and applications. **8**

   b) Explain seeback effect and its application in working of a temperature measuring instruments. Name the instruments with its working diagram. **8**

5. a) Explain any one type of high pressure sensor in detail. **8**

   b) A mercury in steel thermometer employs Buordon pressure guage which has a range of 0 to 6 MPa for the pointer rotation from 0 to 270°C. In the temperature calibration process, the pointer movement was set to 0° rotation at 0°C and the instrument indicated 250° rotation corresponding to 200°C. Determine

      i) Sensitivity of instruments in rad/°C

      ii) Error in the observed temperature values if the bulb is raised by 60 cm from calibration elevation. **10**

OR

6. a) Explain the working, principle and construction of a inclined tube manometer. **6**

   b) Write short note on

      i) Pressure bellows

      ii) Pirani vacuum guage

      iii) Sources of errors in manometers. **12**

SECTION – II

7. a) What is the difference between variable area meter and variable head meter ? Explain variable area meter with a suitable example. **10**

   b) Write a short note on **8**

      i) Electromagnetic flow meter

      ii) Ultrasonic flow meter

OR

8. a) Describe with the help of neat diagram, the construction and operation of venturimeter. **10**

   b) Describe with the help of neat diagram the construction and operation of pitot tube. **8**

9. a) What are the different level measurements instruments ? Explain any one in detail. **8**

   b) Explain with a neat diagram, the air trap system for liquid level measurement. **8**

OR

10. a) What are the objectives to use of sight glass and float glass for level measurement ? **8**

    b) Write a short note on Ultrasonic method for level measurement. **8**

11. a) Explain construction and working of gas chromatography with neat diagram. **8**

    b) Describe various viscosity measuring devices. **8**

OR

12. Write short note on **any two** of following : **16**

    i) HPLC

    ii) I.R. Absorption Spectroscopy

    iii) Conductivity cell

[3563] – 172

T.E. (Chemical) (Sem. – I) Examination, 2009
MASS TRANSFER – I
(Common to Biotechnology) (2003 Course)

Time : 3 Hours Max. Marks : 100

Instructions *: 1) Answer* ***3*** *questions from Section –* ***I*** *and* ***3*** *questions from Section –* ***II****.*
2) ***Neat*** *diagrams must be drawn* ***wherever*** *necessary.*
3) ***Black*** *figures to the* ***right*** *indicate* ***full*** *marks.*
4) ***Assume*** *suitable data, if* ***necessary****.*

SECTION – I

1. a) A small tube was filled with acetone to 2.5 cm from the top and maintained a temperature of 50°C in current of air, after 20 minutes, the liquid level was found 2.615 cms (0.115 cms decrement). Calculate the diffusivity of acetone in air.

   Data : Vapour pressure 170 mm Hg at 50°C

   Barometric pressure 765.5 mm Hg

   Mol. wt of acetone 58

   ρ_L = 0.798 gm/cc. **8**

   b) Derive expression for Maxwell law of diffusion. **4**

   c) Discuss basic principle of diffusion process and its application in chemical process industry. **4**

OR

2. a) A narrow tube is partially filled with a liquid and maintained at constant temperature. A gentle stream of gas is passing across the open end of the tube. As the liquid evaporates, the level drops slowly. At a given time 't', the level is 'Z' from the top. Derive an equation to calculate the value of diffusivity of the liquid vapour in the gas. **10**

P.T.O.

b) The gas hydrogen at 25°C and 0.01 atm partial pressure is diffusing through a membrane 0.1 mm thick. The other side of membrane has no hydrogen. The solubility of hydrogen in the membrane is 0.05 m^3/m^3 at 1 atm and its diffusivity in the membrane is 1.03×10^{-10} m^2/s. Find out diffusional flux. **6**

3. a) Write a note on "Raynolds" and "Chilton Coluburn analogy". **4**

b) Ammonia is absorbed by water in wetted wall column operated at 25°C at 1 atm. The overall mass transfer coefficient is 1 K mole NH_3 / m^2. std atm. At one point in the column the gas contains 10 mole % ammonia and the liquid phase contains 0.155 mole ammonia / m^3. 95% of the total resistance lies in gas phase. (Henrry's law constant at 293 K is 4.25×10^{-3} std atm / mole NH_3 / m^3 solution). Calculate gas phase coefficient k_g and liquid phase coefficient k_1. **8**

c) Write a note on two film theory. **4**

OR

4. a) Derive the relationship between local mass transfer coefficient and overall mass transfer coefficient in both phases. **6**

b) Write a note on Penetration Theory. **4**

c) Write a note on Surface Renewal Theory. **4**

d) Write in brief about i) Cascades ii) Crossflow cascades iii) Counterflow cascades. **2**

5. a) A counter current absorber is used for scrubbing of an air mixture containing 5% Solute A by volume. The scrubber is fed with water containing 0.002 mole of A per mole of water. The scrubbing water flows at a rate of 1 mole water per mole of air. It is required to absorb 85% of Solute A present in air by operating the column at 20°C.
K = 0.80 mole of A / mole of A / mole of H_2O.
Calculate the concentration of 'A' in outgoing liquid and estimate number of stages using Kresmer equation. The equilibrium relationship is $y = 0.80\ x$. **12**

b) Minimum L/G ratio. **6**

OR

6. a) Derive an equation for determination of number of plates using absorption factor 'A' For A ≠1.

$$\frac{Y_{NP+1}-Y_1}{Y_{NP+1}-mX_0}=\frac{A^{NP+1}-{}^{\circ}A}{A^{NP+1}-1}$$

and show that

$$\text{Number of stages } N_P=\log\frac{\left[\dfrac{Y_{NP+1}-mX_{\circ}}{Y_1-mX_{\circ}}\left(1-\dfrac{1}{A}\right)+\dfrac{1}{A}\right]}{\log A}.$$ **12**

b) Write a note on "absorption with chemical reaction. **6**

SECTION – II

7. a) Derive equation for adiabatic saturation curve given by

$$t_{G1}-t_{as}=(Y'_{as}-Y'_1)\frac{\lambda_{AS}}{C_{S1}}$$

Where t_G : dry bulb temperature, Y' absolute humidity, C_S heat capacity of vapour gas mixture, subscripts 'as' adiabatic saturation, 1, 2 means at position 1 and 2. **10**

b) For an air - water vapour mixture of dry bulb temperature 65°C a wet bulb temperature 35°C was determined under conditions such that the radiation coefficient can be considered negligible. The total pressure was 1 std atm. Compute the humidity of the air.

Data $\lambda_W=2419300\,J/kg$, $Y'_W=0.0365\,kg/kg$, hg / ky = 950 J/kg. **6**

OR

8. a) Consider a drop of liquid immersed in rapidly moving stream of unsaturated vapour - gas mixture. Since mass and heat transfer occurring simultaneously, sketch a gradient of temperature, and partial pressure and derive expression for wet bulb temperature.

$$t_G - t_W = \lambda_W \frac{(Y'_W - Y')}{h_G / Ky}.$$

Where t_G - t_W is wet bulb depression

h_G / K_Y is psychrometric ratio. **10**

b) Air at 1 atm is blown past the bulb of mercury thermometer the bulb is covered with a wick. The wick is immersed in an organic liquid (mol.wt. 58). Thermometer reading is 8.6°C, vapour pressure is 5 KPa. Find the air temperature, if ratio of heat transfer coefficient to mass transfer coefficient is 2 kJ / kg.k and latent heat of vapourisation of liquid is 360 kJ/kg. Assume air is free of organic vapour when blown. Assume suitable data if necessary. **6**

9. a) A batch of wet solid is to be dried from 25 to 6% content on wet basis. The initial wt of solid is 160 kg and drying surface is $1m^2$ per 40 kg dry solid. Determine the total time required for drying. Assuming that X_C = 0.2 kg of moisture / kg of dry solid, using following data of falling rate period.

X	0.2	0.18	0.16	0.14	0.12	0.1	0.09
N	0.3×10^{-3}	0.26×10^{-3}	0.239×10^{-3}	0.2×10^{-3}	0.18×10^{-3}	0.15×10^{-3}	0.097×10^{-3}

($kg/m^2.sec$)

X	0.1	0.09	0.08	0.07	0.064
N	0.15×10^{-3}	0.097×10^{-3}	0.07×10^{-3}	0.043×10^{-3}	0.025×10^{-3}

($kg/m^2.sec$) **12**

b) Explain along with figure constant drying and falling drying rate period. **4**

OR

10. a) A wet solid is dried from 36% to 10% moisture content under constant drying conditions in 6 hours. If equilibrium moisture content is 4% and critical moisture content is 15%, how long will it take to dry 6% moisture under same conditions ? **10**

b) Write a note on Freeze drying and Rotory dryer. **6**

11. a) Compare Packed tower and Tray tower with consideration of following points :

a) Gas hold up b) Pressure drop

c) L/G ratio d) Floor loading. **9**

b) Describe operating characteristics of Sieve tray considering following points :

a) Flooding b) Weeping

c) Coning d) Priming

e) Dumping. **9**

OR

12. Write a note on (**any three**) :

i) Sparged vessels

ii) Random packing

iii) Characteristics of packing material

iv) Pressure drop characteristics in packed tower. **18**

———————

[3563] – 171

T.E. (Chemical) (Sem. – I) Examination, 2009
CHEMICAL ENGINEERING MATHEMATICS
(2003 Course)

Time : 3 Hours | Max. 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) Your answers will be valued as a **whole**.*

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

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

SECTION – I

1. a) Use the Gauss - Seidal method to obtain the solution of the system given below :

$3\ x_1 - 0.1\ x_2 - 0.2\ x_3 = 7.85$

$0.1\ x_1 + 7\ x_2 - 0.3\ x_3 = -19.3$

$0.3\ x_1 - 0.2\ x_2 + 10\ x_3 = 71.4$ **10**

b) Explain the convergence criteria for the Gauss - Seidal Method. **8**

OR

2. a) Use the Gauss - Jorden technique to solve the systems of equation

$10\ x_1 + x_2 + x_3 = 12$

$x_1 + 10\ x_2 + x_3 = 12$

$x_1 + x_2 + 10\ x_3 = 12$ **10**

b) Explain Pivoting in solution of linear simultaneous equation. **8**

P.T.O.

3. a) Ethane gas is produced at 7.3 MPa and temperature at 423°K. It follows Bridgeman Equation of State.

$$P=\left[\frac{RT(1-\epsilon)}{V^2}\right](V+B)-\frac{A}{V^2}$$

Where $A=A_0\left(1-\frac{a}{V}\right)$

$$B=B_0\left(1-\frac{b}{V}\right)$$

$$\epsilon=\frac{C}{VTB}.$$

For ethane, A_0 = 0.588 m^3 / K.mol^2

B_0 = 0.094 m^3 / K.mol

a = 0.05801 m^3 / K.mol

b = 0.019 m^3 / K.mol

c = 90×10^{-4} m^3 $(Kg)^2$/ K.mol

Find the density of ethane gas at the given condition. **8**

b) The data listed in the table gives measurements of heat flux q at the surface of a solar collector. Estimate the total heat absorbed by a 2×10^5 cm^2 collector panel during 14 hr period. The panel has an absorption efficiency ϵ=42%. The total heat absorbed is given by

$$H=\epsilon\int_0^t q.A\,dt$$

Where A is Area, q is heat flux and t is time.

t (hr)	0	1	2	3	4	6	11	14
q Cal/cm^2.hr	0.05	1.72	5.23	6.38	7.86	8.03	5.82	0.24

Use Simpsons $\frac{1}{3}$ rd Rule. **8**

OR

4. In the study of chemical kinetics to calculate the concentration ratio C as $\frac{dc}{dt} = -KC^n$ for time t where k is a reaction rate and n is order of reaction. If K = 0.089 and n = 1.5. Find the concentration ratio at t = 2. If initial condition C (0) = 11.23 for the accuracy of 0.1 using modified Eulers method. **16**

5. a) Using the finite difference method solve the boundry value problem

$$x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} = 1$$

With y (1) = 0, y (1.4) = 0.05666.
Find y (1.1), y (1.2) and y (1.3). **10**

b) What are different types of boundry conditions applied to partial differential equation ? **6**

OR

6. a) Solve $\frac{d^2y}{dx^2} + y = 0$ with boundary conditions.

y = 0 When x = 0
y = 0 when x = 1
Find y at x = 0.5 **10**

b) What are different types of partial differential equations. Give a example of each type. **6**

SECTION – II

7. a) It is known that tensile strength of plastic increases as a function of the time when it is heat treated. The following data is collected.

Time (min)	10	20	30	40	50	60
Tensile strength (N/m^2)	4.2	17.8	49.6	48.2	64.4	104.8

Use least square method to fit a straight line to determine the tensile strength at time of 70 min. **10**

b) What are quantification of error of linear regression ? **6**

OR

8. a) The table below gives the temperature T (°C) and length l (mm) of a heated rod. If $l = a_0T + a_1$. Find the best value of a_0 and a_1. **10**

T	20	30	40	50	60	70
l	800.3	800.4	800.6	800.7	800.9	801.0

b) State various methods of curve fitting. **6**

9. Derive expressions for $(\nabla \cdot V)$ and ∇V in cylindrical coordinates. **16**

OR

10. a) Prove that for symmetrical τ $(\tau : \nabla V) = (\nabla \cdot [\tau \cdot V]) - (V \cdot [\nabla \cdot \tau])$. **10**

b) Explain the term Unit tensor. **6**

11. A small scale unit produces two products A and B. Product A is sold with a profit of 100 Rs. per piece while product B with a profit of Rs. 120 per piece. Each product passes through 3 departments. The table below presents the time requirement for each product and the total time available for various departments per month. Determine the quantity of products to be produced so as to maximize the profit. State whether any spare capacity is available in department. **18**

Departments	Hours required		Available hours / month
	A	B	
1	2	3	1500
2	3	2	1500
3	1	1	700

OR

12. a) Maximize (Z) = 14x + 20 y

Subjected to condition

$20x + 6y \leq 1000$

and $40x + 8y \leq 500$

$x, y \geq 0$ **12**

b) Explain the basic principle of optimization. **6**

———————