2012 – 2013
B.TECH. AUTUMN (V SEMESTER) EXAMINATION
(Chemical Engineering)
NUMERICAL METHODS & OPTIMIZATION
(CH – 311)
Credits: 04

Maximum Marks : 60
Duration : Three Hours

Note: Answer all questions.

(a) (i) Differentiate between “accuracy” and precision and explain them through
an example.

(ii) Find the round-off error in storing the number 642.5316 using a four digit
mantissa.

(iii) The Stefan-Bolzmann law can be employed to estimate the rate of radiation
of energy ‘H’ from a surface as

\[ H = A \epsilon \sigma T^4 \]

Where ‘I’ is in Watts
A = surface area (m²)
\( \epsilon \) = emissivity (dimensionless)
\( \sigma \) = Stefan Boltzmann constant \[ = 5.67 \times 10^{-8} \frac{W}{m^2 K^4} \]
T = absolute temperature (K)

Determine the error in the estimation of ‘H’ for steel plate with \( A = 0.2m^2 \),
\( \epsilon = 0.90 \) and \( T = 650 \pm 50 \). Compare your results with the exact value.

OR

(a') Use secant method to estimate the root of equation \( x^2 - 4x - 10 = 0 \) with an initial
estimates of \( x_1 = 4 \) and \( x_2 = 2 \). Make 3-iterations correct upto 4-decimal places.

What are the limitations of the secant method?

(b) Derive the Newton-Raphson iterative formula from Taylor Series expansion and
show that the Newton-Raphson method converges to solution quadratically.

2. (a) What is curve fitting? What is the difference between interpolation and regression?

The velocity distribution of a fluid near a flat surface is given below:

<table>
<thead>
<tr>
<th>( x )</th>
<th>0.1</th>
<th>0.3</th>
<th>0.5</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v )</td>
<td>0.72</td>
<td>1.81</td>
<td>2.73</td>
<td>3.47</td>
</tr>
</tbody>
</table>

where ‘\( x \)’ is the distance from the surface (cm) and ‘\( v \)’ is the velocity (cm/s).

Using the third Order Newton interpolation polynomial obtain the velocity at
\( x = 0.6 \). How is Newton’s interpolation better than Lagrange interpolation?

Contd....2
(a') An investigator has reported following data tabulated for an experiment to determine the growth rate of bacteria ‘k’ (per day), as a function of oxygen concentration ‘c’ (mg/l). It is known that such a data can be modelled by the following equation:

\[ k = \frac{K}{C_s + C^2} \]

where \( C_s \) and \( k_{\text{max}} \) are parameters. Use Linear Regression to estimate \( C_s \) and \( k_{\text{max}} \) and predict growth rate at \( C = 2 \) mg/l. Derive the equation used.

<table>
<thead>
<tr>
<th>C (mg/l)</th>
<th>0.5</th>
<th>0.8</th>
<th>1.5</th>
<th>2.4</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>K (per day)</td>
<td>1.1</td>
<td>2.4</td>
<td>5.3</td>
<td>7.6</td>
<td>8.9</td>
</tr>
</tbody>
</table>

(b) Solve the given system of equations using Gauss-Jordan method.

\[
\begin{align*}
 x_1 + x_2 - 2x_3 &= 3 \\
 4x_1 - 2x_2 + x_3 &= 5 \\
 3x_1 - x_2 + 3x_3 &= 8 
\end{align*}
\]

3. (a) Current through a capacitor is given by

\[
I(t) = C \frac{dv}{dt} = Cv(t)
\]

Where, \( v(t) \) is the voltage across the capacitor at time ‘t’ and ‘C’ is the capacitance value of the capacitor. Estimate the current through the capacitor at \( t = 0.5 \) using two point forward difference formula with the step size, \( h = 0.2 \). Assume the following:

\[
v(t) = (t + 0.1)e^t \text{ volts} \\
C = 2F
\]

Derive the formula used with its error term.

(b) Why Heun’s method is classified as one step predictor-corrector method? Solve the pair of simultaneous equations.

\[
\begin{align*}
\frac{dy_1}{dx} &= y_2; y_1(0) = 0 \\
\frac{dy_2}{dx} &= y_1y_2 + x^2 + 1; y_2(0) = 0 
\end{align*}
\]

to estimate \( y_1(0.2) \) and \( y_2(0.2) \) using Heun's method. Take \( h = 0.1 \).
(b') Evaluate the integral using composite Trapezoidal rule using \( n = 2 \)

\[
I = \int_{-1}^{1} e^x \, dx
\]

Derive the equation used, starting from Newton's forward difference formula.

(a) Write down the methods used for unconstrained multivariable optimization. Draw the flow chart for the Steepest Descent method.

(b) Find the maximum of the function,

\[
f(x) = x (1.5 - x)
\]

(i) By using accelerated step size unrestricted search, find the initial interval of uncertainty with \( x_1 \) (initial guess) = 0.0 and \( S(\text{step size}) = 0.1 \).

(ii) Use Region of uncertainty obtained in part (i) and isolate the design variable 'x' to within 10% by Golden Section search.
B.TECH. AUTUMN (V SEMESTER) EXAMINATION
(Chemical/Petrochemical Engineering)
MASS TRANSFER OPERATIONS
(CH-313/PK-313N)
CREDIT: 04

Maximum Marks: 60

Note: (i) Symbols have their usual meanings unless otherwise specified.
        (ii) Use of graph paper is allowed.
        (iii) Start each question and its part thereof from fresh page.
        (iv) Be precise in your answer and underline the final answer of the numerical problems.

1(a) An open beaker, 0.06 m in height, is filled with liquid benzene at 25 °C to within 0.005 m of the top. A gentle breeze of dry air at 25 °C and 1 atm is blown by a fan across the mouth of the beaker so that evaporated benzene is carried away by convection after it transfers through a stagnant air layer in the beaker. The vapor pressure of benzene at 25 °C is 0.131 atm. The mutual diffusion coefficient for benzene in air at 25 °C and 1 atm is 9.05 × 10^{-6} m^2/s. Compute

(i) Initial rate of evaporation of benzene as molar flux in kmol/m^2-s
(ii) The time in hours for the benzene level to drop 0.02 m from the initial level if the specific gravity of liquid benzene is 0.874. Neglect the accumulation of benzene and air in the stagnant layer as it increases in height.

1(b) Sulfur dioxide (A) is absorbed into water in a packed column. At a certain location, the bulk conditions are 50 °C, 2 atm, γ_{AB} = 0.085, and x_{AB} = 0.001. Equilibrium data for SO2 between air and water at 50°C are given as

\[ γ_{SO2} = 29.74x_{SO2} + 6.733x_{SO2}^2 \]

Experimental values of the mass transfer coefficients are as follows.

Liquid phase: \( k_c = 0.18 \text{ m/h} \)

Gas phase: \( k_c = 0.040 \text{ kmol/h-m^2-kPa} \)

(i) Using mole-fraction driving forces, compute the mass-transfer flux by Assuming an average Henry's-law constant and a negligible bulk-flow effect.
(ii) Determine the relative magnitude of the two resistances and the values of the mole fractions at the interface.

\[ OR \]

1'(a) Derive the following form of Fick's first law

\[ \dot{J}_A = - \frac{\rho^2}{cM_A M_B} D_{AB} \nabla w_A \]

1'(b) Water (B) at 25 °C, in contact with pure CO2 (A) at 1 atm, flows as a film down a vertical wall 1 m wide and 3 m high at Reynolds number of 25. Using the following properties, estimate the rate of absorption of CO2 into water in kmol/s
\( D_{AB} = 1.96 \times 10^{-9} \text{m}^2/\text{s} \); \( \rho = 1000 \text{kg/m}^3 \); \( \mu_L = 0.89 \text{cP} \)

Solubility of CO₂ in water at 1 atm and 25 °C = 3.4×10⁻² kmol/m³

2(a) For stripping operation, derive the following expression for the number of overall liquid transfer unit for dilute solution

\[
N_{tol} = \frac{x_1 - x_2}{(x^* - x)_{LM}}
\]

2(b) Ninety five percent of the acetone vapor in an 85 vol% air stream is to be absorbed by a countercurrent contact with pure water in a valve-tray column with an overall tray efficiency of 50%. The column will operate essentially at 20 °C/101 kPa pressure. Equilibrium data for acetone-water at these conditions are:

<table>
<thead>
<tr>
<th>Mole percent acetone in water</th>
<th>3.30</th>
<th>7.20</th>
<th>11.70</th>
<th>17.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone partial pressure in air, mm Hg</td>
<td>30.00</td>
<td>62.80</td>
<td>85.40</td>
<td>103.00</td>
</tr>
</tbody>
</table>

Calculate:

(i) Minimum value of \( L_s / G_s \)

(ii) The number of equilibrium stages required using a water flow rate \( 1.25 \) times the minimum

(iii) The concentration of acetone in the exit water

OR

2(b) Solute A is to be stripped from a liquid stream by contacting with a pure gas. The liquid enters the tower at an A-free rate of 2.5 kmol/s and contains 30 mol% A. The gas enters the column counter currently at a rate equals to 1.5 times the minimum. Determine the number of theoretical stages required to reduce the concentration of A in the exiting liquid to 1.0 mol%. The distribution of A in the gas and liquid is expressed by \( y_A = 0.4x_A \).

3(a) Define the terms relative saturation and percentage saturation related to humidification operation and obtain a relationship between them. Show that the relative saturation is always greater than the percentage saturation except for the extreme conditions of dry gas (0% humidity) and saturated gas (100% humidity).

3(b) It is desired to dehumidify 1.2 m³/s of air, available at 38 °C dry bulb, 30 °C wet bulb temperatures, to a wet bulb temperature of 15 °C in a countercurrent tower using water chilled to 10 °C. The packing will be 50-mm Raschig rings for the overall volumetric mass transfer coefficient \( k_{g*} \) is 3.40 kg/m³·s. To keep entrainment minimum, \( G_s \) will be 1.25 kg air/m²·s, and a liquid flow rate of 1.5 times the minimum will be used. Determine the temperature of the outlet water, cross section and height of the packed section of the tower.

OR
3(b) A horizontal spray chamber with re-circulated water is used for adiabatic humidification and cooling of air. The active part of the chamber is 2 m long and has cross section of 2 m². With an air flow rate 3.5 m³/s at dry bulb temperature 65 °C and humidity 0.017 kg water/kg dry air, the air is cooled and humidified to a dry bulb temperature 42 °C. If a duplicate spray chamber operates in the same manner were to be added in series with the existing chamber, what outlet conditions could be expected for the air?

4(a) What do you mean by constant drying condition? Briefly discuss the effect of the varying drying condition with respect to the gas velocity, gas temperature, gas humidity, and thickness of drying solid on the rate of drying in constant rate period.

4(b) Show that specific interfacial area in a sparged vessel is given by

\[ a = \frac{\varphi_g}{\bar{d}_p} \]

Where \( \varphi_g \) is the fraction gas holdup and \( \bar{d}_p \) is the sautéer mean diameter of gas bubbles.
1. (a) The thermal decomposition of ethane to ethylene and other products is believed to proceed in the following sequences:

**Initiation:**
\[ C_2 H_6 \xrightarrow{k_1} 2 CH_3^* \]

**Propagation:**
\[ CH_3^* + C_2 H_6 \xrightarrow{k_2} CH_4 + C_2 H_5^* \]
\[ C_2 H_5^* \xrightarrow{k_3} C_2 H_4 + H^* \]
\[ H^* + C_2 H_6 \xrightarrow{k_4} C_2 H_5^* + H_2 \]

**Termination:**
\[ 2 C_2 H_5 \xrightarrow{k_5} C_4 H_{10} \]

Use pseudo steady-state hypothesis to derive the rate laws for the disappearance of ethane and formation of ethylene.

OR

(a') To explain the kinetics of enzyme-substrate reactions, Michaelis and Menten (1913) came up with the following mechanism that uses an equilibrium assumption

\[ A + E \xrightleftharpoons{k_2}{k_1} X \]
\[ K = \frac{[X]}{[A][E]} \]

\[ X \xrightarrow{k_3} R + E \]
\[ [E_o] = [E] + [X] \]

Where \([E_o]\) represents total enzyme and \([E]\) represent the free unattached enzyme.

Briggs and Haldane (1925) on the other hand employed a steady-state assumption in place of the equilibrium assumption.

\[ A + E \xrightleftharpoons{k_2}{k_1} X \]
\[ \frac{d[X]}{dt} = 0 \]

\[ X \xrightarrow{k_3} R + E \]
\[ [E_o] = [E] + [X] \]

What final rate form \((-v_o)\) in terms of \([A],[E_o]\), \(k_1, k_2\) and \(k_3\) do the above two mechanism give? Comment on your results.
(b) When concentrated urea solution is stored, it slowly condenses to biuret by the following chemistry reaction:

\[ 2 \text{NH}_2\cdot \text{CO} \cdot \text{NH}_2 \rightarrow \text{NH}_2 \cdot \text{CO} \cdot \text{NH} \cdot \text{CO} \cdot \text{NH}_2 + \text{NH}_3 \]

To study the rate of condensation of the solution, a sample of urea (20 mol/liter) is stored at 100°C. After 7 hr 40 min it was found that 1 mole% has turned into biurete. Find the rate equation for this condensation reaction.

2. (a) A high molecular weight hydrocarbon gas is fed continuously to a heated high temperature mixed flow reactor where it thermally cracks (a homogeneous gas reaction) into lower molecular weight materials (collectively called R) by a stoichiometry approximated by \( A \rightarrow 5R \).

By changing the feed rate, different extents of cracking are obtained as follows:

<table>
<thead>
<tr>
<th>( F_{A_p} ), millimol/hr</th>
<th>300</th>
<th>1000</th>
<th>3000</th>
<th>5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{A_p} ), millimol/liter</td>
<td>16</td>
<td>30</td>
<td>50</td>
<td>60</td>
</tr>
</tbody>
</table>

The internal void volume of the reactor is \( V = 0.1 \) liter, and at the temperature of the reactor the feed concentration is \( C_{A_p} = 100 \) millimol/liter. Find a rate equation to represent the cracking reactions.

(b) Consider the trambouze reactions (parallel decomposition of A of different orders):

\[
\begin{align*}
A & \quad \rightarrow \quad R, \quad r_R = 1 \\
& \quad \rightarrow \quad S, \quad r_S = 2C_A \\
& \quad \rightarrow \quad T, \quad r_T = C_A^2 
\end{align*}
\]

Determine the maximum concentration of the desired product S (for a feed concentration of \( C_{A_p} = 4 \) mol/liter) in (i) PFR (ii) MFR.

OR

(b') At present 90% of reactant A is converted into product (\( A \rightarrow R \)) by a second order reaction in a single mixed flow reactor. It is planned to place a second reactor similar to the one being used in series with it.

(i) For the same treatment rate as that used at present, how will this addition affect the conversion of reactant?

(ii) For the same 90% conversion, by how much can the treatment rate be increased?

(iii) How would the treatment rate be affected if the reactor is hooked up in parallel instead of in series?

You may like to use Figure 1 in your solution to the problem (Te figure must be attached with the Answer Book).
3. (a) Find the elementary aqueous reaction

$$\Delta G_{298}^0 = -14,130 \text{ J/mol}$$
$$\Delta H_{298}^0 = -75,300 \text{ J/mol}$$
$$C_p^a = C_p^w = \text{constant}$$
$$C_p^w = 1000 \text{ cal/kg.K}$$
$$1 \text{ Cal} = 4.1842 \text{ J}, 0.239 \text{ cal/s} = 1 \text{ w}$$

Based on kinetic experiments, in a batch reactor, the conversion temperature chart with reaction rate as parameter has been prepared along with equilibrium conversion. The result, for $C_{A_0} = 1 \text{ mol/liter}$ and $C_{B_0} = 0$ is presented in Figure-2.

Using the locus of maximum rates, determine the volume of the mixed flow reactor needed for 80% conversion of a feed of $F_{A_0} = 1000 \text{ mol/min}$, $C_{A_0} = 1 \text{ mol/liter}$. What is the heat duty if feed enters at $25^\circ \text{C}$ and the product is to be withdrawn at this temperature?

OR

(a') For the parallel first order decomposition of $A$

$$A \rightarrow R_{\text{desired}}$$
$$A \rightarrow S$$

Occurring in a mixed flow reactor, with a specified space time $\tau$, find the temperature level which maximizes the production of $R$.

$$k_1 = k_{10} \exp \left( \frac{-E_1}{RT} \right)$$
$$k_2 = k_{20} \exp \left( \frac{-E_2}{RT} \right)$$
$$E_1 < E_2.$$

(b) The accepted mechanism for the highly exothermic solid catalyzed gas phase oxidation of naphthalene to product phthalic anhydride is

$$R = 8.314 \frac{\text{J}}{\text{mol K}}$$

$$\begin{cases} 
 k_1 - k_2 - 2 \times 10^{17} \exp \left( -159,000 / RT \right) \text{ hr}^{-1} \\
 k_3 - 8.15 \times 10^{17} \exp \left( -209,000 / RT \right) \text{ hr}^{-1} \\
 k_4 = 2.1 \times 10^7 \exp \left( -83,600 / RT \right) \text{ hr}^{-1} 
\end{cases}$$

Contd…..4
A = naphthalene (reactant)
R = naphthaquinone (postulated intermediate)
S = Phthalic anhydride (desired product)
T = CO₂ + H₂O (waste products)

The Arrhenius activation energy is given in units of J/mol. This reaction is to be run somewhere between 900 – 1200 K.

(i) What kind of flow reactor would you suggest.
(ii) If you could keep the whole of your reactors at whatever temperature and τ value desired, what would be the yield of phthalic anhydride per mole of the naphthalene reacted?
(iii) What operating temperature have suggested?

4. (a) The flow through a reactor is 10 liter/min. A pulse tracer test conducted with the vessel gave the following outlet concentration in an arbitrary units:

<table>
<thead>
<tr>
<th>T (min)</th>
<th>C×10⁵</th>
<th>t (min)</th>
<th>C×10⁵</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>15</td>
<td>238</td>
</tr>
<tr>
<td>0.4</td>
<td>329</td>
<td>20</td>
<td>136</td>
</tr>
<tr>
<td>1.0</td>
<td>622</td>
<td>25</td>
<td>77</td>
</tr>
<tr>
<td>2</td>
<td>812</td>
<td>30</td>
<td>44</td>
</tr>
<tr>
<td>3</td>
<td>831</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>785</td>
<td>40</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>720</td>
<td>45</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>650</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>523</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>418</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

(i) Tabulate and plot the exit age distribution E(t) for the vessel.
(ii) Determine the mean residence time (tₘ) and the variance (σ²).
(iii) What is the reactor volume?

(b) Briefly explain the problem relating to the stability of Mixed flow reactors during exothermic reactions.

OR

(b') A pulse of concentrated NaCl solution is introduced as a tracer into the fluid entering a vessel (V = 1m³, v = 1m³/min) and the concentration of tracer is measured in the fluid leaving the vessel. The tracer output data is sketched in Figure 3. Develop a flow model to represent the vessel.

(c) Derive the conversation-time expression for the reaction of a spherical particle with a fluid

\[ A(g) + bB(s) \rightarrow \text{Products} \]

When chemical reaction controls under SCM.

[Figure Attached ]
Contd...5
**Figure 1** Comparison of performance of a series of $N$ equal-size mixed reactors with a plug flow reactor for elementary second-order reactions

\[2A \rightarrow \text{products} \]

\[A + B \rightarrow \text{products}, \quad C_{A0} = C_{B0}\]
Figure 2.

Figure 3: Tracer output data
Enumerate two important bioprocess industries along with their substrate, name of microorganisms, product and their future prospects. [04]

Discuss the important phases of a typical batch growth curve with the help of a neat diagram. [06]

Explain with the help of a diagram the experimental method of measuring the growth of mould. [05]

OR

Discuss the significance of nutrients for growth of microorganisms for bioprocess industries. [04]

Explain Gaden's classification of bioproducts with suitable examples. [06]

Why are bioprocesses run in batch mode on industrial scale? Explain it. [05]

Derive Michaelis–Menten equation, to determine the rate of an enzyme catalyzed reaction. How will you determine the constant to be used in this equation? Show that competitive inhibition reduces the rate of reaction. [10]

Discuss one of the methods of enzyme immobilization with suitable examples. [05]

OR

Explain the effect of two important parameters on enzyme activity in a biochemical reaction. [03]

What are merits and demerits of immobilized enzymes? Explain two methods of enzyme immobilization. [12]

How will you monitor and control the temperature and pH in a bioprocess industry? [05]

Explain the merits and demerits of Bubble column and Loop reactors with the help of their diagrams. [04]
(c) Discuss briefly the following:
   (i) Air Sterilization
   (ii) Medium Sterilization and
   (iii) Control of liquid level.

4. (a) Recommend a general line diagram for separation of micro-organisms, impurities product and waste water from fermented broth.

   (b) Discuss the nature of growth of lactic acid bacteria. Explain industrial production of lactic acid with the help of a neat and schematic process flow sheet. Also mention future scope of acid besides the mechanism of acid production.

   (c) What are industrial applications of Centrifuge? Explain your answer with examples.
Maximum Marks: 60

Duration: Three Hours

Note: Answer all questions.

1. (a) Explain the harmful effects of hazardous wastes containing Asbestos.

   OR

   (a') Discuss the harmful effect of hazardous wastes containing PCBs (poly Chlorinated Biphenyls)

   (b) What is Toxicity? Explain the terms LC50 and LD50.

2. (a) Explain the sampling devices and methods used for hazardous wastes.

   OR

   (a') Explain briefly any two of the analytical methods for hazardous wastes characterization:

   (i) Gas Chromatography (GC) (ii) Salmonella Test

   (iii) SASS (iv) MM5

   (b) Write the characteristics, which according to EPA make hazardous waste reactive.

3. (a) Explain any one of the following chemical treatments for hazardous wastes:

   (i) Adsorption (ii) Neutralization

   (iii) Oxidation / Reduction

   (b) Explain how reverse osmosis is used for treatment of hazardous wastes.

4. (a) Explain any TWO of the following treatment methods:

   (i) Pyrolysis (ii) Gasification (iii) Incineration

   (b) Explain advantages and disadvantages of Incineration of hazardous waste.

   OR

   (b') Explain the TSCA incineration standards for regulation on burning of liquid PCBs.

5. (a) What is the DOT definition of shipper generators of hazardous wastes?

   OR

   (a') What is the DOT definition of carrier / transporters of hazardous wastes?

   (b) Explain landfills as hazardous waste disposal sites. Also draw figure.
1.a. A company is considering the purchase of a new piece of testing equipment that is expected to produce $8000 additional income during the first year of operation, this amount will probably decrease by $500 per year for each subsequent year of ownership. The equipment costs $20000 and will have an estimated salvage value of $3000 after 8 years of use. For an interest rate of 15% compounded quarterly, determine whether the investment is economically justified or not. Use present worth method.

OR

1.a’. A standby electric power generator was purchased 6 years ago for $8000. At that time it was expected that the equipment would be used for 15 years and would have a salvage value of 10 percent of the first cost. The generator is no longer needed and is to be sold for $2500. Using an interest rate of 14% compounded monthly, determine the difference between the anticipated and actual equivalent annual costs.

1.b. A proposed mill in an isolated area can be furnished with power and water by a gravity feed system. A stream high above the mill will be tapped to provide flow for water needs and power requirements by connecting it to the mill with a ditch-and-tunnel system or with a wood-and-concrete flume that winds its way down from the plateau. Either alternative will meet current and future needs, and both will utilize the same power generating equipment. The ditch-and-tunnel system will cost $500000 with an annual maintenance cost of $2000. The flume has an initial cost of $200000 and a yearly maintenance cost of $12000. In addition, the wood portion of the flume will have to be replaced every 10 years at a cost of $100000. Compare the alternatives on the basis of capitalized costs with an interest rate 8% per year.
2.a. Differentiate between:

i. Defender and Challenger

ii. Demand Pull inflation and Cost Push inflation

iii. Declining balance and double declining balance methods of depreciation

2.b. 4 projects are to be compared on the basis of benefit cost criteria. Each project has an expected life of 50 years and is to be evaluated with a tax free interest rate of 10%. Data for the project, in rupees, are as follows:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Cost (Rs.)</strong></td>
<td>150,000</td>
<td>200,000</td>
<td>310,000</td>
<td>450,000</td>
</tr>
<tr>
<td><strong>Annual</strong></td>
<td>8,000</td>
<td>10,000</td>
<td>5,000</td>
<td>20,000</td>
</tr>
<tr>
<td><strong>Maintenance Cost (Rs.)</strong></td>
<td>35,000</td>
<td>30,000</td>
<td>59,000</td>
<td>80,000</td>
</tr>
<tr>
<td><strong>Estimated Annual Benefits (Rs.)</strong></td>
<td>2500</td>
<td>2000</td>
<td>4000</td>
<td>4500</td>
</tr>
</tbody>
</table>

On the basis of an incremental B/C ratio analysis select the appropriate alternative.

OR

2. b'. A machine was purchased 3 years ago for Rs. 40,000. It is proposed to replace it with a new machine which will cost Rs. 34,500 and is expected to reduce the operating costs. Costs and salvage values for the two machines are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Defender D</th>
<th>Challenger C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Operating cost (Rs.)</td>
<td>Salvage Value (Rs.)</td>
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<tr>
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</table>

Should a replacement be made if the required rate of return is 15% and the services of the machine will be needed for only 4 more years?
3.a. How do different managers require different skills and roles in an organization? Explain using practical examples.

3.b. What are the environmental and ethical issues considered important in context of management? Give examples.

4.a. Differentiate between tactical goals and operational goals in the context of an organization.


4.c. Leadership and management are related but they are not same. Do you agree? Giving suitable examples support your answer.

OR

4’a. Explain the leadership grid in the context of behavioral approach to leadership

4’b. List the benefits and limitations of job specialization. Explain any two approaches used to counter the problem associated with job specialization.

4’c. Why is motivation important in organization? State the essential elements of any motivation theory.

5.a. What is first order exponential smoothing method of making forecast? Demand for part number 2710 was 200 in April, 50 in May and 150 in June. The forecast for April was 100 units. With a smoothing constant of 0.2 and using first order exponential smoothing, what is the July forecast?

5.b. A company orders a certain automobile part periodically and delivery is instantaneous. Annual demand estimated to be 2160 units is constant. The cost of the part/unit and procurement cost per order are $8 and $9 respectively while the carrying charge per unit time is estimated to be 15% of the cost of the part. What quantity should be ordered and when?

5.c. What is Pareto's analysis and how it is used in industry? Explain with an example.
2012-2013
B.Tech Autumn (V Semester) Examination
(Chemical/Petrochemical Engineering)
Heat Transfer Operations
PK 312/CII 312
Credit: 04

Maximum Marks: 60
Duration: Three Hours.

Answer All questions

Q No 1
(a) Why does a bird fluff its feathers on a cold day? Explain. 2.0

(b) A furnace wall is made up of 230 mm of fire brick, 75 mm of insulating brick and 89 mm of red brick. The temperature at the inner surface is 800 °C and that of the outer surface is 60 °C. Average thermal conductivity values of the three types of bricks i.e. fire brick, insulating brick, red brick are 1.21, 0.121 and 0.865 W/(m. °C) respectively. Calculate the temperatures at the interface between different kinds of bricks. 5.0

(c) Air at 2 atm and 200 °C, is heated as it flows through a tube with a diameter of 2.54 cm at a velocity of 10 m/s. Calculate the heat transfer per unit length of the tube if a constant heat flux condition is maintained at the wall and the wall temperature is 20 °C above the air temperature all along the length of the tube. How much would the bulk temp increase over a 3 m length of the tube? Data: \( \mu = 2.57 \times 10^{-5} \text{ kg/m.s} \), \( k = 0.0386 \text{ W/m.°C} \), \( \varepsilon_p = 1.025 \text{ kJ/kg.°C} \) 8.0

OR

(c') A 2.0 cm diameter horizontal heater is maintained at a surface temperature 38 °C and submerged in water at 27 °C. Calculate the free convection heat loss per unit length of the heater. Data: \( k = 0.02624 \text{ W/m.°C} \), \( Pr = 0.708 \), \( \varphi = 15.69 \times 10^{-6} \text{ m}^2/\text{s} \)

Q No 2
(a) What are the common causes of fouling in a heat exchanger? How does fouling affect heat transfer and pressure drop? 4.0

(b) Prove that in a counter-current heat exchanger the total heat transferred \( Q \) is given by \( Q = UAD\Delta T_{LM} \)

Where-
- \( U \) is the overall heat transfer coefficient,
- \( A \) is the total heat transfer area
and \( \Delta T_{LM} \) is the logarithmic mean temperature difference between the two fluid streams. 5.0
(c) Water at the rate of 80 kg/min is heated from 24 °C to 70 °C by an oil having a specific heat of 1.9 kJ/kg. °C. The fluids are used in counterflow double pipe heat exchanger, and the oil enters the exchanger at 115 °C and leaves at 80 °C. The overall heat-transfer coefficient is 405 W/m².°C. Calculate the heat exchanger area A. What do you expect about the area if it were co-current (comment only)?

OR

(c') Water is flowing at the rate of 10000 kg/h through the tube of a heat exchanger and is heated from 25 °C to 70 °C. Hot water at 90 °C is available but the minimum discharge temp of this water has to be 76 °C. The overall heat transfer coefficient based on inside diameter of 25 mm tube in a shell and tube heat exchanger is 900 kcal/h.m².°C. If the hot water makes one shell pass and the design water velocity in the tube is 0.45 m/s, calculate the number of tubes and length of the heat exchanger. Assume correction factor for LMTD to be 0.86.

Q No. 3

(a) Which one has higher heat transfer coefficient: filmwise condensation or dropwise condensation? Explain clearly.

(b) Draw the general boiling curve and level various regimes on it.

OR

(b') Show the schematic of forward feed arrangement of a triple effect evaporator.

(c) Define capacity and steam economy of an evaporator.

(d) A single effect, vertical short-tube is used to concentrate a syrup from 10% to 40% solid at the rate of 2000 kg of feed per hour. The feed enters at 30 °C and a reduced pressure of 0.33 kg/cm² is maintained in the vapour space. At this pressure, the liquor boils at 75 °C. Saturated steam at 115 °C is supplied to steam chest. No subcooling of the condensate occurs. Calculate steam requirement and number of tubes (0.0254m, 16 BWG) if the height of caldern is 1.5 m.

Data:

Specific heat of liquor = 0.946 kcal/kg. °C
Latent heat of steam at 0.33 kg/cm² pressure = 556.5 kcal/kg
Latent heat of saturated steam at 115 °C = 529.5 kcal/kg
Boiling point of water at this pressure = 345 K
The overall heat transfer coefficient = 2150 kcal/h.m².°C
Q No 4
(a) Differentiate between specular and diffused radiation.

(b) State and prove Kirchhoff's law for radiation

(c) The inner sphere of a Diwar flask is 30 cm dia and outer sphere is of 36 cm dia. Both spheres are coated for which emissivity is 0.05. Determine the rate at which liquid oxygen (latent heat 21.44 kJ/kg) would evaporate at 90 K when outer atmosphere temperature is 20 °C. Assume the other modes of heat transfer are absent.

OR

(c') A Black body is at temperature of 1000 °C. Calculate

i. The wavelength at which the body has maximum monochromatic emissive power and the corresponding emissive power.

ii. The total emissive power of black body

iii. The fraction of the total radiant energy between the wave length 2.0 and 4.5 micro meter.
Answer ALL the questions. Notations used have their usual meaning.

1(a) Explain the difference between orientational, electronic and ionic polarizations in brief. [05]

(b) Define static dielectric constant and obtain the relation \( P = \varepsilon_0(\varepsilon_r - 1) E \). [05]

(c) What is piezoelectricity? Give two examples of piezoelectric materials. Draw hysteresis curve for ferroelectric material and discuss it briefly. [05]

OR

(c') The electronic polarizability of the Ar atom is \( 1.8 \times 10^{-39} \) F.m\(^2\). What is the static dielectric constant of Ar gas at 1 atmospheric pressure at room temperature (300K)? [Given: \( k_B = 1.38 \times 10^{-23} \) J/K and \( \varepsilon_0 = 8.854 \times 10^{-12} \) F/m] [05]

2(a) What is dipolar relaxation? Obtain the relation for orientational polarization in alternating fields. [07]

(b) Explain the diffusion process in semiconductors and find a relation for diffusion current per unit area for \( n \) and \( p \) type semiconductors. [05]

(c) An intrinsic Si sample is doped with donors from one side such that \( N_d = N_e \exp(-a x) \). [03]

(i) Find an expression for \( E(x) \) at equilibrium over the range for which \( N_d \gg n_i \).

(ii) Evaluate \( E(x) \) when \( a = 4 \) (um\(^{-1}\)).

3(a) How ferromagnetism is explained on the basis of exchange interaction? Give a brief account of Weiss theory of ferromagnetism. [07]

(b) The magnetic field in a diamagnetic material is 1000 Am\(^{-1}\). Calculate the magnetization and flux density of the material if its susceptibility is \(-0.4 \times 10^{-5}\). [04]

(c) Distinguish between hard and soft magnetic materials. Give two examples for each. [04]
4(a) Derive the London's equations and explain the term coherence length.

(b) A d.c. voltage of $1\mu V$ is applied across a Josephson junction. Calculate the frequency of the Josephson current generated. [Given: $h = 6.63 \times 10^{-34} \text{ J.s}$]

(c) Discuss briefly the potential applications of superconductors.

OR

4(a') Explain d.c. Josephson effect. Show that the super current of superconducting pairs across the junction depends on the phase difference.

(b') A superconductor sample has a critical temperature of 3.722 K in zero magnetic field of 0.0305 T at 0 K. Evaluate the critical field at 2 K.

(c') Discuss the thermodynamics of superconducting transition in detail.