2013 – 2014
B. TECH. (WINTER SEMESTER) EXAMINATION
(Chemical / Petro-Chemical Engineering)
HIGHER MATHEMATICS
(AM – 241)
Credits: 04

Maximum Marks: 60
Duration: Three Hours

Note: Answer all questions.

1. (a) A particle moves along the curve $x = t^2$, $y = 2 \cos 3t$, $z = 2 \sin 3t$, where $t$ is the time variable. Determine its velocity and acceleration at $t = 0$.

   OR

   (a') Find the angle between the surfaces $x^2 + y^2 + z^2 = 9$ and $z = x^2 + y^2 - 3$ at the point $(2, -1, 2)$.

   (b) Find the directional derivative of $\psi = 2xy + 5yz + zx$ at the point $(1, 2, 3)$ in the direction of $5\hat{i} - 5\hat{j} + 4\hat{k}$.

   (c) A fluid motion is given by $\vec{v} = (y + z)\hat{i} + (z + x)\hat{j} + (x + y)\hat{k}$

      (i) Is this motion irrotational? If so, find the velocity potential.

      (ii) Is the motion possible for an incompressible fluid?

2. (a) Verify Green's theorem in the plane for $\oint_C [x^2 - y^2] \, dx + 2xy \, dy$, where $C$ is the closed curve of the region bounded by $y = x^2$ and $y = x$.

   OR

   (a') Show that $\vec{F} = (2xy + z^2)\hat{i} + x^2\hat{j} + 3x^2\hat{k}$ is a conservative field. Find its scalar potential and also the work done in moving a particle from $(1, 2, 1)$ to $(3, 1, 4)$.

   (b) Verify Stokes theorem for $\vec{F} = x^2\hat{i} + xy\hat{j}$ in the square region in the XOY plane bounded by the lines $x = 0, y = 0, x = a, y = a$.

   (c) Verify the divergence theorem for $\vec{F} = 4xz\hat{i} - y^2\hat{j} + yz\hat{k}$ over the cube bounded by $x = 0, x = 1, y = 0, y = 1, z = 0, z = 1$.

3. (a) Evaluate the following:

   (i) $L\left(\frac{1 - \cos t}{t}\right)$

   (ii) $\frac{L\left(\cot^{-1}\frac{y}{k}\right)}{t}$

   where $L$ denotes Laplace transform.

Contd.....2
(a') Using convolution theorem find \( f(t) \) if \( L[f(t)] = \frac{s^2}{(s^2 + a^2)(s^2 + b^2)} \)

(b) Using Laplace transform method, solve the differential equation

\[ y''(t) + 9y(t) = 18t \]

given that \( y(0) = 0, y\left(\frac{\pi}{2}\right) \).

(c) An alternating e.m.f. \( E \sin \omega t \) is applied to an inductance \( L \) and a capacitance \( C \) in series. Show that the current in the circuit is

\[ i(t) = \frac{E}{\sqrt{R^2 - \alpha^2}} \left[ \cos \omega t - \cos \frac{\pi}{2} \right], \]

where \( \alpha = \frac{1}{\sqrt{LC}} \).

(c') (i) Obtain the Laplace transform of the periodic saw tooth wave represented in the figure below:

(ii) Define Heaviside's unit step function and find its Laplace transform.

4. (a) An infinitely long plane uniform plate is bounded by two parallel edges at an angle at right angles to them. The breadth is \( K \); this end is maintained at a temperature \( u \); at all points and the other edges are at zero temperature. Show that in the steady-state, the temperature is given by

\[ u = \frac{4u_0}{\pi} \left[ e^{-\gamma x} \sin x + \frac{1}{2} e^{-3\gamma x} \sin 3x + \cdots \right]. \]

(b) A tightly stretched string with fixed end points \( x = 0 \) and \( x = L \) is initially displaced in a sinusoidal arch of height \( y_0 \) and then released from rest. Find the displacement \( y \) at any distance \( x \) from one end at time \( t \). Show that each point of the string has simple harmonic motion. Find the period.

(c) Solve the partial differential equation \( \frac{\partial u}{\partial t} = \alpha^2 \frac{\partial^2 u}{\partial x^2} \) by the method of separation of variables.
Maximum Marks: 60

Note: Answer all questions. Programmable calculator is not allowed. Do all the calculations up to four decimal places.

1. (a) Find an initial approximate root of the equation \( \cos x = 3x - 1 \), and then apply general iteration method to obtain the root correct to four decimal places.

(b) The equation \( e^x - x - b = 0 \) occurs in heat transfer. When \( a = 0.4 \), \( b = 9.0 \), the equation has a root near \( t = 6.0 \). Find this root by using three iterations of Newton-Raphson method.

(c) Solve the following system of equations by Gauss-Seidal method.

\[
\begin{bmatrix}
2 & -3 & 5 \\
5 & 1 & -2 \\
3 & 4 & -1
\end{bmatrix}
\begin{bmatrix}
x \\
y \\
z
\end{bmatrix}
=
\begin{bmatrix}
10 \\
2 \\
-2
\end{bmatrix}
\]

Perform only three iterations.

OR

(c') Determine \( p, q \) and \( r \) so that the order of iterative method:

\[
x_{n+1} = px_n + \frac{qa}{x_n} + \frac{rb}{x_n^2}
\]

for \( x^k \) becomes as high as possible.

2. (a) (i) Prove the following identities with usual notations

(a) \( \log (1 + \Delta) = \log (1 + \Delta) \).

(b) \( (1 - \Delta) (1 - \Delta) = 1 \).

(ii) Employ Newton's backward formula to find the cubic polynomial which takes the following values

\( y(0) = 1, y(1) = 0, y(2) = 1 \) and \( y(3) = 10 \). Hence obtain \( y(4) \).

OR

(a') Using a polynomial of third degree, complete the record given below of the export of a certain commodity during five years:

<table>
<thead>
<tr>
<th>Year</th>
<th>1917</th>
<th>1918</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export (in tons)</td>
<td>443</td>
<td>384</td>
<td>---</td>
<td>397</td>
<td>467</td>
</tr>
</tbody>
</table>

Contd....2
(b) If the tabulated function is a polynomial of \( n \)th degree, then prove that the \( n \)th divided difference is constant. Show that the third divided difference of the function \( f(x) = \frac{1}{x} \) with arguments \( p, q, r, s \) is \( -\frac{1}{pqrs} \).

(c) Using Lagrange's interpolation formula, find the value of \( y \) corresponding to \( x = 10 \), from the following table.

<table>
<thead>
<tr>
<th>( x )</th>
<th>5</th>
<th>6</th>
<th>9</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

3. (a) The following table of values of \( x \) and \( y \) is given

<table>
<thead>
<tr>
<th>( x )</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>6.9897</td>
<td>7.4036</td>
<td>7.7815</td>
<td>8.1291</td>
<td>8.4510</td>
<td>8.7506</td>
<td>9.0309</td>
</tr>
</tbody>
</table>

Find (i) \( \frac{dy}{dx} \) at \( x = 1.5 \) \hspace{1cm} (ii) \( \frac{d^2y}{dx^2} \) at \( x = 6 \)

(b) Using the following table, find \( \frac{dy}{dx} \) and \( \frac{d^2y}{dx^2} \) at \( x = 2, x = 8 \) and \( x = 15 \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>4</th>
<th>5</th>
<th>7</th>
<th>10</th>
<th>11</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>48</td>
<td>100</td>
<td>294</td>
<td>909</td>
<td>1210</td>
<td>2028</td>
</tr>
</tbody>
</table>

(c) Derive Simpson's \( \frac{3}{8} \) rule:

\[
\int \frac{1}{1+x} dx = \frac{3h}{8} (y_0 + 3y_1 + 3y_2 + y_3) \]

and evaluate \( \int_1^h \frac{dx}{1+x} \), with \( h = \frac{1}{6} \) using Simpson's \( \frac{1}{3} \) rule.

OR

(c') Find the quadrature formula.

\[
\int_0^a x f(x) dx = \lambda_0 f(x_0) + \lambda_1 f(x_1)
\]

which is exact for polynomial of highest possible degree. Use the formula to evaluate

\[
\int_0^a \frac{dx}{(x^2 + 2x + 2)}
\]

Contd...3
4. (a) Using Taylor's Series method, prove that the solution of the differential equation
\[ \frac{d^2y}{dx^2} + xy = 0 \]
is
\[ y = d \left[ 1 - \frac{x^3}{3!} + \frac{1 \times 4}{6!} x^6 - \frac{1 \times 4 \times 7}{9!} x^9 + \ldots \right] \]
when the conditions are \( x = 0, y = d \) and \( \frac{dy}{dx} = 0 \).

(b) Given that \( \frac{dy}{dx} = x^2 + y, y(0) = 1 \), determine \( y(0.02) \) using modified Euler's method. Take \( h = 0.02 \) and perform three iterations.

(c) Use Runge-Kutta fourth order method to find the value of \( y \) when \( x = 0.2 \) for initial value problem
\[ \frac{dy}{dx} = \frac{y - x}{y + x}, \quad y(0) = 1. \]
Take \( a = 0.2 \).

OR

(c') Solve by finite difference method the boundary value problem
\[ y'' + y' - 0, \quad y(0) = 0, \quad y(1) = 1 \text{ with } h = \frac{1}{3}. \]
2013-14
B.TECH. (WINTER SEMESTER) EXAMINATION
ELECTRONICS AND INSTRUMENTATION
EL-202

Maximum Marks: 60
Credits: 03
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.

1(a) Perform the following conversions:
(i) \((2496)_{10} = (?)_{2}\)
(ii) \((CF3D)_{16} = (?)_{10}\)
(iii) \((11011.0111)_{2} = (?)_{10}\)

OR

1(a)' Simplify the expression \(z = \overline{ABC} + \overline{AB}C + ABC\).

[08]

1(b) With the help of clocked JK flip flops and waveforms, explain the working of a three-bit binary ripple counter.

[07]

1(c) What is meant by multiplexer? List out its various applications.

[05]

2(a) Define a transducer. List five physical quantities that transducer measures.

[05]

2(b) Explain the operating principle of a Ramp type DVM.

[07]

2(c) What is an LVDT? Explain the operating principle of an LVDT.

[08]

OR

2(c)' Define a strain gauge. Distinguish between bonded and unbounded strain gauges.

[08]

3(a) Explain microprocessor based system and their impact on modern society.

[08]

3(b) Explain the architecture of 8085 microprocessor with a neat diagram

[12]

OR

3(b)' What are the different types of flags available in 8085 microprocessor? Explain each in brief.

[12]
Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Use of Graph Paper is allowed.

Q.No. Question
1(a) Differentiate any two of the following
   i) Venturi meter and Orifice meter
   ii) NPSH available and NPSH required.
   iii) Energy losses due to sudden enlargement and sudden contraction of pipe.

1(b) A U-Tube manometer is used to measure the pressure of water in a pipe line, which is in excess of atmospheric pressure. The right limb of the manometer contains mercury and is open to atmosphere. The contact between water and mercury is in the left limb. Determine the pressure of water in the main line, if the difference in level of mercury in the limbs of U-tube is 10 cm and the free surface of mercury is in level with the centre of the pipe. If the pressure of water in pipe line is reduced to 9810 N/cm². Calculate the new difference in the level of mercury. Sketch the arrangements in both cases.

OR

1(b') The maximum flow through a 300mm diameter horizontal main pipe line is 18200 litre/min. A venturimeter is introduced at a point of pipeline where the pressure head is 4.6m of water. Find the smallest diameter of throat so that the pressure at the throat is never negative. Assume coefficient of meter as unity.

Contd......2
2(a) Differentiate between Recovery & Rejection. Derive the relation for screen effectiveness.

OR

2(a') Derive the expression for Specific surface of mixture & total no. of particles per unit mass for a mixture having total mass M.

2(b) The following data were collected when a crushed ore was screened using 3.00mm screen to separate the under crushed material so that it can be returned to the crusher for further processing. Compute the effectiveness of screen.

<table>
<thead>
<tr>
<th>ISM mesh (mm)</th>
<th>Aperture size</th>
<th>Mass fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30</td>
<td>-0.296</td>
<td></td>
</tr>
<tr>
<td>-60+30</td>
<td>-0.592 - 0.296</td>
<td>0.118</td>
</tr>
<tr>
<td>-120+60</td>
<td>-1.201 - 0.592</td>
<td>0.045</td>
</tr>
<tr>
<td>-240+120</td>
<td>-3.353 - 1.201</td>
<td>0.109</td>
</tr>
<tr>
<td>-480+340</td>
<td>-4.760 - 3.353</td>
<td>0.146</td>
</tr>
<tr>
<td>-940</td>
<td>+4.760</td>
<td>0.548</td>
</tr>
</tbody>
</table>

3(a) State & derive the expressions for the three basic laws of size reduction. What is the size range of feed for their applicability?

OR

3(a') Explain the working and construction of a Gyratory Crusher.

3(b) A large welded steel silo 4 m & 20 m high is to be built. The silo has a central discharge on a flat bottom. Estimate the pressure on the wall & at the bottom of the silo if the silo is filled with (i) Plastic pellets, (ii) Water.

The plastic pellets have the following characteristics:

Density = 560 kg/m³
μ' (coefficient of friction) = 0.364

Contd…….3
4(a) Discuss any two of the following:
   (i) Nutsche filter
   (ii) Cyclone separator
   (iii) Batch settling process
   (iv) Hindered settling

4(b) Calculate the settling velocity of glass spheres having a diameter of $1.554 \times 10^{-4}$ m in water at 20°C. The slurry containing 60 wt% solids. The density of the glass spheres is $2.467 \text{ kg/m}^3$, density of water $= 998 \text{ kg/m}^3$, viscosity of water $= 1.005 \times 10^{-3} \text{ Pa.s}$.

5(a) Describe the working and construction of rotary drum filter with the help of a neat sketch.

5(b) Solid particles having a size of 0.12 mm, shape factor $\Psi$ of 0.88 & a density of 1000 Kg/m$^3$ are to be fluidized using air at 2.0 atm abs. & 25°C. Physical properties of air are:
   - Viscosity $= 1.845 \times 10^{-5} \text{ Pa.s}$
   - Density $= 2.374 \text{ kg/m}^3$
   - Void at minimum fluidization condition is 0.42.
   - If the cross section of empty bed is 0.30m$^2$ and the bed contains 300 kg of solid,
     calculate the minimum height of the bed at minimum fluidization condition.
   - Calculate the pressure drop at minimum fluidization condition.
   - Calculate the minimum fluidization velocity.
1. (a) Explain the temperature dependency of a reaction rate from transition state theory and show that the rate is proportional to $T \cdot e^{-\Delta H^R/T}$ for a bimolecular reaction and show that Arrhenius law is a good approximation to the temperature depending of both collision and transition state theory. [08]

(b) The rate of bimolecular reaction, $A + B \rightarrow$ products, at $500^\circ$C is 10 times the rate at $400^\circ$C. Calculate the activation energy of the bimolecular reaction by Arrhenius law. [04]

(c) Explain the following terms used in the reaction kinetics:
- (i) elementary reaction
- (ii) Multiple reactions
- (iii) molecularity of non-elementary reactions. [03]

2. (a) Define integral and differential method of analysis of batch reactor data with reference to merits and demerits. [04]

(b) Define the reaction rate for a variable volume system and calculate the fractional change in volume for a reaction $2A \rightarrow R$ if the feed contains 50% A and 50% inert. [03]

(c) Enzyme $E$ catalyzes the transformation of reactant A to the product R as follows:

$$A \xrightarrow{\text{enzyme}} R, \quad -r_A = \frac{200 C_A C_{AO}}{2 + C_A}, \text{mol/lit/min}.$$ [08]

If we introduce enzyme ($C_{BO} = 0.0015 \text{ mol/liter}$) and reactant ($C_{AO} = 10 \text{ mol/liter}$) into a batch reactor and let the reaction proceed, find the time needed for the concentration of reactant drops to 0.02 mol/liter. Note that the concentration enzyme remains unchanged during the reaction.

OR

Contd.....2
(c') A small reaction bomb fitted with a sensitive pressure measuring device is flushed out and filled with pure dimethyl-ether at 840°C and 1.0 atm, a temperature low enough that the reaction does not proceed to any appreciable extent. The temperature is raised rapidly to 504°C and the reaction is carried out isothermally at 504°C in a constant volume reactor. The stoichiometry of the reaction is as follows

$$(\text{CH}_3)_2\text{O} \rightarrow \text{CH}_4 + \text{H}_2 + \text{CO}$$

Determine the rate equation in units of moles, liters and minutes which will satisfactorily fit the data given in the Table 1 for the thermal decomposition of dimethyl ether in the gas phase.

Table 1

<table>
<thead>
<tr>
<th>Time, sec</th>
<th>390</th>
<th>1195</th>
<th>3135</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure increase (mm of Hg)</td>
<td>96</td>
<td>250</td>
<td>476</td>
</tr>
</tbody>
</table>

Given: 1 atom = 760 mm of Hg

3. (a) Explain the various types of reactors employed for carrying out the homogeneous reactions with the help of schematic diagrams with reference to merits and demerits.

(b) A company has one plug flow and one mixed flow reactor in its store. Both reactors are of the same size, 1.0 liter capacity. It has been decided to use them to carry out a homogeneous irreversible reaction, $A \xrightarrow{k \frac{k}{n}} R$, ($k = 1.0$/hr and $n = 1.0$). The volumetric flow rate is constant and is equal to 1.0 liter/hr. The feed is pure $A$ ($C_{A_0} = 1.0$ gmol/liter entering). Calculate the concentration of $A$ leaving the reactor.

![Diagram]

OR

(b') For an elementary reaction, $A \rightarrow R$, the rate is approximated as $(-\gamma_A) = 0.1C_A^2$. Determine the ratio of mixed flow reactor to plug flow reactor if the conversion level required is 60%. The feed entering in both the reactor is pure $A$ and is equal to $C_{A_0} = 1.0$ mol/liter.
(c) For an autocatalytic reaction \( A + R \xrightarrow{k} R + R \), the graph between \( y_A \) and \( X_A \) is given below:

![Graph](image)

For \( x_A = x_{AS} \) discuss the best reactor system(s).

(d) The reactor set-up shown in the figure consists of three plug flow reactors in two parallel branches. If the conversion is to be same in each branch, what fraction of the feed should go to branch D?

![Diagram of reactor system](image)

4. (a) For a multiple reaction, the graphs of instantaneous fractional yield (\( \psi \)) vs \( C_A \) is shown as below:

![Graphs](image)

Discuss the reactor system(s) for the graph shown above.

Contd...
(b) For the parallel decomposition of A,

\[
\begin{align*}
\text{A} & \xrightarrow{k_1} \text{R} \\
& \xrightarrow{k_2} \text{S}
\end{align*}
\]

\[k_1 = 10 \cdot e^{3800T}\]
\[k_2 = 10^8 \cdot e^{5000T}\]

Occurring in a mixed flow reactor with space time of 1.0/hr. Find the temperature which maximises the production of R. Feed is pure A (\(C_{i0} = 1.0 \text{ gmol/liter}\)). Find concentration of R at the outlet of the reactor. Derive the equation(s) used.

OR

(b') For the competitive liquid phase reactions:

\[
\begin{align*}
\text{A} + \text{B} & \xrightarrow{k_1} \text{R}_\text{reacted} \\
\frac{dC_R}{dt} & = 1.0 \quad C_A^{1.5} \quad C_B^{0.5} \text{ mol/liter min}
\end{align*}
\]

and

\[
\begin{align*}
\text{A} + \text{B} & \xrightarrow{k_2} \text{S}_\text{unreacted} \\
\frac{dC_S}{dt} & = 1.0 \quad C_A^{0.5} \quad C_B^{1.4} \text{ mol/liter min}
\end{align*}
\]

Find the fraction of impurity in the product stream for 90% conversion of pure A and B, each has a density of 20 mol/liter, for mixed flow and plug flow reactor. Derive the equation used.
Q1(a) What is a Carnot Engine? Why thermal efficiency of 100% is not possible for heat engines? [02]

Q1(b) A Carnot heat engine operates between two thermal reservoirs at temperatures $T_1$ & $T_2$ ($T_1 < T_2$). If the working medium of the engine is an ideal gas prove that energy conversion efficiency of the engine is always equal to or less than one. [04]

Q1(c) A rigid and insulated tank of volume 2 m$^3$ is divided into two equal compartments by a partition. One compartment contains an ideal gas at 400 K and 3 MPa, while the second compartment contains the same gas at 600 K and 1 MPa. The partition is punctured and the gases are allowed to mix. Determine the entropy change of the gas. The isobaric molar heat capacity of the gas equal to $(5/2) R$. [06]

Q1(d) Explain with a Schematic diagram the working of an absorption refrigeration system. [03]

OR

Q1'(a) Derive the work required in the case of isothermal and Adiabatic process. [02]

Q1'(b) A reversible Heat Engine A absorbs energy from a reservoir at $T_1$ and rejects energy to a reservoir at $T_2$. A second reversible engine B absorbs the same amount of energy as rejected by the engine A, from the reservoir at $T_2$ and rejects energy to a reservoir at $T_3$.

Determine the expression of $T_2$ in terms of $T_1$ and $T_3$ if
(i) The efficiency of engines A and B are the same.
(ii) The work delivered by the engines is the same. [04]

Q1'(c) The Ideal gas undergoes the following sequence of mechanically reversible processes in a closed system.

(i) For an initial state of 343.15K and 1 bar, it is adiabatically compressed to 423.15K.
(ii) It is then cooled from 423.15 to 343.15K at constant pressure.
(iii) Finally it is expanded isothermally to its original state.

Calculate $W$, $Q$, $\Delta U$ and $\Delta H$ for each of the three processes and for the entire cycle. Take $C_v=3/2 R$ and $C_p=5/2 R$. [06]
Q1. Differentiate between Claude and Linde liquefaction process with the help of their line diagram.

Q2(a) Show that for a pure species coexisting liquid and vapour phases are in equilibrium when they have the same temperature, pressure, chemical potential and fugacity.

Q2(b) The excess Gibbs energy of a binary liquid mixture at T and P is given by:

\[ G_x^{ex} = (-2.6x_1x_2 + 1.8x_1) N \]

(i) Find expressions for \( \ln \lambda_1 \) and \( \ln \lambda_2 \) at T and P.
(ii) Show that when these expressions are combined in accord with summability equation the given expression for \( G_x^{ex} \) is recovered.
(iii) Show that \( \frac{d \ln \lambda_x}{dx_1} \mid _{x_1} = \frac{d \ln \lambda_x}{dx_2} \mid _{x_2} = 0 \).

OR

Q2(a) The enthalpy of a binary liquid system of species 1 and 2 at fixed temperature and pressure is represented by the equation:

\[ H = 400x_1 + 600x_2 + x_1 \cdot x_2 \cdot (40x_1 + 20x_2) \]

Where H is in J mol\(^{-1}\). Determine expressions for \( W_1 \) and \( W_2 \) as function of \( x_1 \).

Q3(a) Define Volute Point, Dew Point and Tie Line. Draw a typical T-x-y and P-x-y diagram and show sub cooled liquid, superheated vapor and Liquid-Vapor mixture regions, dew point curve, bubble point curve, boiling points of pure components, and vapors pressure of pure substances on them.

Q3(b) Plot P-x-y data for a binary system at a temperature at which \( P_1 \) \( \text{sat} = 84.562 \) kPa, and \( P_2 \) \( \text{sat} = 19.935 \) kPa. Assume system to follow Raoult's Law. (Determine P and y\(_1\) values for \( x_1 = 0.2, 0.4, 0.6 \) and 0.8).

Q4(a) Drive the relation of equilibrium constant to composition for liquid phase reaction. Modify this relation for the equilibrium mixture behaving as an ideal solution.

Q4(b) The reaction \( N_2 + O_2 \rightarrow 2NO \) takes place in the gas phase at 2700\(^\circ\)C and 2025 kPa. The reaction mixture initially comprises 15 mole% oxygen, 77 mole% nitrogen and rest inert. The standard Gibbs's free energy change for reaction is 113.83 kJ mol\(^{-1}\) at this temperature. Assuming ideal gas behaviour, calculate partial pressures of all species at equilibrium.

OR

Q4(b) For the ammonia synthesis reaction written:

\[ \frac{1}{2} N_2(g) + \frac{3}{2} H_2(g) \rightleftharpoons NH_3(g) \]

With 0.5 mol \( N_2 \) and 1.5 mol \( H_2 \) as the initial amounts of reactants, and with the assumption that the equilibrium mixture is an ideal gas show that \( \gamma = 1 - (1 + 1.295K g/K_B)^{1/2} \)
Q.No. | Question                                                                                                                                                                                                 | M.M. |
------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
1(a)  | Why the year 1859 is generally taken as the starting point of modern petroleum industry. Write an explanatory note on the development of Indian Petroleum Industry.                                                   | [7]  |
1(b)  | Give brief accounts of: i) Sweet and sour crude oils ii) Resins and asphaltenes iii) Heavy and extra heavy crude oils iv) Specific gravity and API gravity OR Descri... | [8]  |
1(b)  | Describe briefly various methods which are usually employed for determining the base of the crude oil. Which method do you feel convenient and superior?                                                      | [8]  |
2(a)  | What are the non-hydrocarbon constituents of crude oils? Give detailed classification of nitrogen and oxygen compounds present in the crude oil along with their adverse effects.      | [9]  |
2(b)  | What do you mean by TBP distillation? What are the different steps in creating a TBP curve taking Arabian heavy crude as your choice? OR What are the problems associated with pipeline transport of waxy crude oil? Discuss the role of pour point depressants for treating such oils. | [9]  |
3(a) Explain the method of operation of a multistage atmospheric distillation column. How does it differ from conventional distillation? Give the different products of crude oil distillation along with their boiling ranges and uses.

3(b) i. How pour point, cloud point and CFPP differ from each other?

3(b) OR

i. Give a comparative account of the compositions and uses of LPG, Aviation gasoline and High-speed diesel.

ii. What do you mean by Octane number and AKI? How do the Motor and Research methods differ from each other?

OR

ii*. Why is an upper limit for aromatic content prescribed for aviation turbine fuels?

4. Write short notes on any three of the following:

   i. Euro and Bharat Standards
   ii. Cibotol process
   iii. Claus process
   iv. Hydrofining process
   v. Adulteration of petro-products
Maximum Marks: 60
Duration: Three Hours

Note: Answer all questions.

1. Explain the various processes available for the manufacture of methyl methacrylate and describe the manufacture of commercial process of methyl methacrylate with the help of a process flow sheet. [15]

OR

1'. (a) Describe the reaction system (reactors), operating conditions employed for the manufacture of acrylic acid with reference to the reactions involved. [05]
(b) Describe the manufacture of DMT with the help of a process flow sheet with reference to the reactions involved and purification system. [10]

2. (a) Explain with the help of schematic diagramme various routes for the manufacture of caprolactam. [05]
(b) Describe the manufacture of phenol with the help of a process flow sheet from camene with reference to the reactions involved and the consumption pattern. What are the demerits of Dow Process for phenol synthesis by the chlorination of benzene? [8+2-10]

OR

(b') Describe the manufacture of linear alkyl benzene (LAB) with the help of a process flow sheet with reference to chemical reactions involved, operating parameters and catalyst. [10]

3. (a) Explain the various commercial methods employed for the manufacture of vinyl chloride monomer (VCM) with reference to chemical reactions and feed stocks available and their merits and demerits. [06]
(b) Explain the manufacture of VCM from the balanced scheme (feed stock available is equimolar amount of ethylene and acetylene) with the help of schematic diagramme. [05]
(c) Explain the merits and demerits of the various feed stocks employed in the manufacture of maleic or phthalic anhydride with reactions involved.

4. (a) Explain the base scheme employed in the manufacture of methanol using partial oxidation or steam reforming techniques/method.

(b) List the side reactions involved in the manufacture of methanol and the steps taken to reduce/avoid them.

(c) Advantages of two reactors over the single reactor in the manufacture of ethylene oxide and use of pure oxygen over the air in general.

(d) Describe the manufacture of ethylene glycol from ethylene oxide.
2013-14
B.TECH. WINTER SEMESTER EXAMINATION
(PETROCHEMICAL ENGINEERING)
SEPARATION PROCESSES IN H.C. INDUSTRIES
PK-241
Credits: 04

Maximum Marks: 60
Duration: Three Hours.

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q No 1
(a) At what point enriching, stripping and feed equations intersect the y=x line in x-y equilibrium diagram.
(b) Define the light, heavy & key components in multicomponent system. Which component is taken as base component for calculation of relative volatility?
(c) Find out the degree of freedom for liquid-liquid extraction process. Also mention the independent variables.
(d) Define leaching process, along with its commercial application with examples.
(e) What do you understand by membrane process. Explain the terms used in membrane process.

Q No 2
(a) What is the assumption of McCabe Thiele method? Explain with the help of neat sketch.

OR

(a') How to find out the optimum reflux ratio? Explain with the help of neat sketch.
(b) Describe the adsorbent used in adsorption process with their commercial application.
(c) Write the step to obtain the minimum solvent rate in liquid-liquid extraction with the help of neat sketch.
(d) How the solid (animal and vegetable materials) feed can be prepared in leaching process.

(c) Write the mechanics of separation in the membrane process.

Q No 3

(a) List the principles on which separation processes are based with one example from each category. Also explain why distillation is the most commonly used separation process in the chemical/petrochemical industries?

(b) Mixture of A & B having 100 molcs with 60 mol% A is vaporized at 101.32 kPa abs pressure until 40 mol of vapor and 60 mol of liquid in equilibrium with each other are produced. This occurs in a single-stage system and the vapor and liquid are kept in contact with each other until the vaporization is complete. The equilibrium chart is given as figure no 1. Calculate the composition of the vapor and the liquid.

OR

(b') A mixture of A & B with 65 molcs % of A at temperature of 60 °C is entering in distillation column. If the bubble point temperature of feed is 95 °C, then find the value of "q".

The required data for the A & B is given below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Boiling Pt °C</th>
<th>Heat Capacity KJ/Kg mol °C</th>
<th>Latent Heat KJ/Kg mol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Liquid</td>
<td>Vapor</td>
</tr>
<tr>
<td>A</td>
<td>80</td>
<td>138</td>
<td>96</td>
</tr>
<tr>
<td>B</td>
<td>110</td>
<td>167</td>
<td>128</td>
</tr>
</tbody>
</table>

(c) 100 kmol/h mixture of A, B, C, & D are fed in to the distillation column at its bubble point temperature. The top temperature of the column is 70°C & bottoms temperature is 130°C. If the number of theoretical stages is 5.0, then calculate minimum reflux ratio using the Underwood method.

The relation between K values and temperature (°C) are given below:

\[ K_A = 0.0002 T^3 - 0.0066 T + 0.3180 \]
\[ K_B = 0.0901 T^2 - 0.0014 T + 0.1250 \]
\[ K_C = 0.0001 T^3 - 0.0102 T + 0.3167 \]
\[ K_D = 0.00009 T^2 - 0.0098 T + 0.3381 \]
Where T is in °C

The composition of feed, distillate & bottom is given below:

<table>
<thead>
<tr>
<th>Components</th>
<th>X_lw</th>
<th>X_d</th>
<th>X_w</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.40</td>
<td>0.6197</td>
<td>0.0011</td>
</tr>
<tr>
<td>B</td>
<td>0.25</td>
<td>0.3489</td>
<td>0.0704</td>
</tr>
<tr>
<td>C</td>
<td>0.20</td>
<td>0.0310</td>
<td>0.5068</td>
</tr>
<tr>
<td>D</td>
<td>0.15</td>
<td>0.0004</td>
<td>0.4217</td>
</tr>
</tbody>
</table>

OR

A waste water solution having 1.0 m³ containing 0.25 kg phenol/m³ of solution. A total of 1.40 kg of fresh granular activated carbon is added to the solution, which is then mixed thoroughly to reach equilibrium. What will be the final equilibrium values and what percent of phenol is extracted? The isotherm equilibrium equation is given below.

\[ q = 0.3x + 0.05 \] (symbol have their usual meaning)

(d) 40 kg of Pure water is to be used to extract acetic acid from 400 kg of a feed solution containing 25 wt% acetic acid in isopropyl ether. Find out the percent recovery in water solution in a single stage process.

(e) Discuss at least two equipment used in leaching process with the help of neat sketch.

(f) Discuss in brief the merits and demerits of membrane separation process over the other separation process.

OR

(f') Discuss at least two equipment used in gas permeation membrane process with the help of neat sketch.

(g) A liquid containing dilute solute A at a concentration \( c_1 = 3 \times 10^{-2} \) kg mol/m³ is flowing rapidly by a membrane of thickness \( L = 3.0 \times 10^{-5} \) m. The distribution coefficient \( K' = 1.5 \) and \( D_A = 7.0 \times 10^{-11} \) m²/s in the membrane. The solute diffuses through the membrane and its concentration on the other side is \( c_2 = 0.5 \times 10^{-3} \) kg
The mass transfer coefficient $K_{a1}$ is large and can be considered as infinite and $K_2 = 2.023 \times 10^{-5}$ m/s. Calculate the flux and the concentrations at the membrane interfaces.

OR

Calculate the flux and rate of removal of urea at steady state in g/h from blood in a cellophane membrane dialyzer at 37 °C. The membrane is 0.025 mm thick and has an area of 2.0 m². The mass transfer coefficient on the blood side is estimated as $K_{o1} = 1.25 \times 10^{-5}$ m/s and that on aqueous side is $3.33 \times 10^{-5}$ m/s. The permeability of membrane is $8.7 \times 10^{-6}$ m/s. The concentration of urea in the blood is 0.02 g urea/100ml and that in the dialyzing fluid will be assumed as 0.

Case 1

...
Answer all the questions.
Assume suitable data if missing.
All questions, and parts thereof, be started on a fresh page of the answer book(s).

Q.No. | Question | M.M.
--- | --- | ---
1. | Mention the steps involved in the synthesis of a chemical process. Elaborate each step in detail giving suitable examples wherever required. | [15]
2. (a) | Explain the structure of a generic process flow diagram. Also give the sequence for the process design of the pieces of equipment, preferably using onion model for it. | [07]
2. (b) | Write short notes on any two of the following:  
(i) Block Flow Diagram  
(ii) Process Flow Diagram  
(iii) Piping and Instrumentation Diagram | [08]
3. | What do you understand by the terms "Primary chemicals" and "primary chemical pathways"? With the help of a suitable example, describe the primary chemical pathway on a process flowsheet. Also identify and discuss other pathways, if present. | [15]

OR

3'. | Discuss the factors that are required to be considered to finalise the operating conditions of a process. Discuss, in detail, the conditions of special concern for the operation of reactor and separator systems. | [15]

4. | Determine the economical shell thickness of a fixed conical roof cylindrical water storage tank, for the data given below:  
Tank height: 12 m  
Tank diameter: 20 m  
Permissible stress for Material of Construction: 142 N/mm²  
Dimension of sheets: 6300 mm X 1800 mm  
Vertical joints: Butt welded  
Horizontal joints: Fillet welded | [15]

OR

4'. (a) | Explain the significance of design codes. Mention some national and international | [03]
codes employed for equipment design.

4'. (b) Describe the storage of non-volatile liquids, volatile liquids and gases. [08]

4'. (c) With the help of a neat sketch, briefly discuss the supports for a horizontal vessel. [04]
2013-14
B.TECH. (WINTER SEMESTER) EXAMINATION
PETROCHEMICAL ENGINEERING
ALTERNAT _E Fuels AND ENERGY RESOURCES
PK 243A (DE-I)

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) The total reserves of fossil fuel of a country is 8375 MTOE. The energy consumption of that country in current year is 258 MTOE. Estimate the number of years the fossil fuel reserves can last, assuming an annual increase of 2% in consumption and neglecting other than fossil fuel power potentials.

1(b) What is an alternate fuel? List down the various fuels which are designed as alternative according to EPA 1992. Why the use of alternate fuel is growing?

1(c) What is a Fuel Cell? How is it different from Leclanche cell? Write down the electrode reactions for Direct Ethanol Fuel Cell.

OR

1(c') What is Trans-esterification Reaction? What are the various factors affecting the reaction?

2(a) Describe the various factors affecting GTL economies.

2(b) Compare low temperature and high temperature Fisher-Tropsch synthesis.

2(c) What is GTL Diesel? How its characteristics differ from conventional refinery diesel?

OR

2(c') Outline the overall GTL process using block diagram.

contd ... 2
3(a) What do you mean by Coal to Liquid(CTL) process? What happens to C/H ratio in a typical CTL process? How is it beneficial?

3(b) How MTG( Methanol to Gasoline) products differ from those of PT( Fisher-Tropsch) synthesis? Explain the equilibrium curve for methanation process.

3(c) Describe (via chemical reactions and block diagram) Exxon Mobil Process of Methanol to Gasoline conversion. Also mention advantages and various constraints of the process.

OR

3(c') What do you mean by polygeneration? Explain the process of a polygeneration plant with a suitable block diagram.

4(a) What are updraft and downdraft fixed bed gasifiers? Show schematically the different reacting zones and mention their relative advantages and limitations of updraft and downdraft gasifiers.

4(b) Describe the working principle of a KT (Koppers-Tolzol) gasifier with a neat sketch, also mention its features.

OR

4(b') Explain the working principle of Lurgi circulating fluidized-bed gasifier with a neat sketch.