Max Marks: 60

Note:  
(i) Answer all the questions as directed.  
(ii) All questions carry equal marks.

1. (a) The equation \( x^2 + ax + b = 0 \) has two real roots \( \alpha \) and \( \beta \). Show that the iteration method \( x_{k+1} = -\frac{ax_k + b}{x_k} \) is convergent near \( x = \alpha \) if \( |\alpha| > |\beta| \) and that \( x_{k+1} = -\frac{b}{x_k + a} \) is convergent near \( x = \alpha \) if \( |\alpha| < |\beta| \). Show also that the iteration method \( x_{k+1} = -\left[ x_k^2 + b \right]/a \) is convergent near \( x = \alpha \) if \( 2|\alpha| < |x + \beta| \)

OR

(a) Find a real root of the equation \( x^3 + x^2 - 100 - 0 \) by general iteration method giving 5 iterations only.

(b) Derive the Newton-Raphson iteration formula for finding the cube root of a positive number \( N \). Hence find the cube root of 12.

(c) Solve, by Gauss Seidel method of iteration the equations \( x + y + 54z = 110, 27x + 6y - z = 85, 6x + 15y + 2z = 72 \). Give only three iterations.

2. (a) (i) Prove the following with usual notations:
   \[ hD = \sin h^3 (\mu 6) \]
   (ii) Find the polynomial which passes through the points \((0,3), (2, -3), (4, -1), (6, 9), (8, 27)\) and \((10, 53)\).

OR

(a') It is known that in the following table, one value of \( y \) is incorrect and that \( y \) is a cubic polynomial in \( x \).

\[
\begin{array}{cccccccc}
 x & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\
 y & 25 & 21 & 18 & 18 & 27 & 45 & 76 & 123 \\
\end{array}
\]

Construct a difference table for \( y \) and use it to locate and correct the wrong value.

(b) (i) In the table below, estimate the missing value:

\[
\begin{array}{cccc}
 x & 0 & 1 & 2 & 3 & 4 \\
 y & 1 & 2 & 4 & - & 16 \\
\end{array}
\]

Explain why it differs from \( 2^3 - 8 \).

(ii) With usual notations prove the following:
   \[ \mu = \sqrt{1 + \frac{1}{4h^2}} \quad \text{and} \quad E = e^{hD} \]

OR

(b') Given \( \log_{10} 654 = 2.8156, \log_{10} 658 = 2.8182, \log_{10} 659 = 2.8189 \) and \( \log_{10} 661 = 2.8202 \), find the value of \( \log_{10} 656 \) using Lagrange's interpolation formula.

Contd....2
(c) Given the data
\[
x: \quad 0 \quad 1 \quad 2 \quad 5 \\
f(x): \quad 2 \quad 3 \quad 12 \quad 147
\]
find the cubic function of \( x \) by Newton's divided difference interpolation formula.

Hence find \( f(3) \), \( f'(4) \) and \( \int_0^2 f(x) \, dx \).

3. (a) From the following table of values of \( x \) and \( y \), obtain the radius of curvature \( \rho \) given by the formula \( \rho = \frac{1 + \left( \frac{dy}{dx} \right)^2}{\frac{d^2y}{dx^2}} \) at \( x = 1, \ x = 0.5 \).

\[
\begin{array}{cccccccccc}
  x & 0 & 2 & 4 & 6 & 8 & 10 \\
  y & 0 & 8 & 64 & 216 & 512 & 1000 \\
\end{array}
\]

(b) Derive general quadrature formula and hence obtain Boole's rule from it. Use Boole's rule to evaluate \( \pi \) from the formula
\[
\frac{\pi}{4} = \int_0^1 \frac{1}{1 + x^2} \, dx \text{ with } h = \frac{1}{8}.
\]

OR

(b') Find the quadrature formula
\[
\int_0^1 \frac{f(x) \, dx}{\sqrt{x(1-x)}} = \alpha_1 f(0) + \alpha_2 f(\frac{1}{2}) + \alpha_3 f(1)
\]
which is exact for polynomials of highest possible degree. Then use the formula on \( \int_0^1 \frac{dx}{\sqrt{x-x^2}} \) to evaluate its value.

4. (a) Apply the fourth order Runge-Kutta method to find an approximate value of \( y \) when \( x = 0.2 \), given that \( \frac{dy}{dx} = x + y \), \( y(0) = 1 \). Take \( h = 0.1 \).

(b) Solve the boundary value problem
\[
\frac{d^2y}{dx^2} - 64y + 10 = 0
\]
with \( y(0) = y(1) = 0 \), by finite difference method. Take \( h = \frac{1}{4} \) and compute the value of \( y(0.5) \).

(c) Given \( \frac{dy}{dx} = x^2 + y \), \( y(0) = 1 \), find the value of \( y \) when \( x = 0.1 \) in steps of 0.5 using Euler's modified method giving two iterations at each step.

OR

(c') Given the differential equation
\[
\frac{dy}{dx} = \frac{1}{x^2 + y}, \text{ with } y(4) = 4, \text{ obtain } y(4.1) \text{ and } y(4.2) \text{ by Taylor's series method correct up to 3 decimal places.}
UNIT I

1. Write a persuasive letter to the prospective buyers of luxurious flats being developed in Greater Noida with all modern facilities. Try to convince the buyer with interesting and attractive offers.

OR

Write a job application and create your CV in response to an advertisement that you recently saw in a national newspaper.

UNIT II

2. Define and draft any two of the following business messages assuming appropriate business situations:
   (a) Tender and Bid
   (b) e-mail
   (c) Press Notice
   (d) Memo

UNIT III

3. Make note or write an abstract of the following passage:

The real estate sector continues to confront liquidity issues owing to subdued demand and restricted debt funding. However, private equity (PE) funds have continued to gain strength as an alternative source of funding. PE fund inflows into the real estate sector in the first quarter of calendar year 2015 grew by 15% to Rs. 5,000 crore, of which the residential sector attracted 32%.

A study by real estate consultancy Cushman & Wakefield attributed the increase to improved market sentiments and higher investments in residential and commercial office assets.

The report said Chennai was the only city to see investment in commercial office in first quarter of 2015. However, it said leased office assets such as IT parks and IT-SEZs are likely to gain significant interest from foreign investors due to low risk, owing to high occupancy levels along with stable rental yields, and significant potential for capital value appreciation. In addition, the introduction of REITs (real estate investment trusts) in India is likely to boost investments as investors now have an exit route.

During the period, residential assets recorded the second highest PE investment since 2008 with total value of investments in residential sector 2.5 times more than the year ago figure at Rs. 1,750 crore. The total investment in commercial office assets was at Rs. 2,416 crore, up 68%.

It was the third highest investment in the commercial office sector since 2008.

“With improving macro-economic conditions, enabling policy environment, recovering demand, attractive valuations and increasing capital requirements of the Indian real estate sector, PE funds are likely to increase their investments in the next few years,” Surjay Dutt, Executive Managing Director, South Asia, Cushman & Wakefield said in a statement.

“However, the PE funds are likely to take only calculated risks and collaborate strictly with renowned developers to protect their investments.”

The report said that although the number of deals during the quarter fell to 16 from 18, average deal size more than doubled to Rs. 320 crore from Rs.150 crore.
UNIT – IV

4. How will you maximize your performance in a job frequently asked questions in job interviews? Attempt to answer two of such questions.

OR

Write the transcript of a telephonic conversation you had with the student advisor of a foreign university discussing your prospect of admission for M.S. and also the different options available for financial support there.

UNIT – V

5. Generate a group discussion choosing ONE of the following topics with at least FOUR participants:

(a) Reservation in jobs is doing more harm than good for the country.

(b) Privatization of health care will improve the quality of health care facility.

(c) Government should give more incentives to the farmers to ensure food security.
Q.1(a) Differentiate any two-
(i) Expression of work and Heat for Isothermal and Reversible Adiabatic process
(ii) First law and second law of Thermodynamics

Q.1(b) Suppose 1 mole of an ideal gas has undergone a change of state from (P₁, V₁, T₁) to (P₂, V₂, T₂). The two different paths connecting the initial and final state are:
(i) Constant volume process followed by isothermal expansion.
(ii) Constant pressure process followed by isothermal compression.
Derive the expression of per mole of entropy change for these two paths, and hence prove that entropy is a state function.

Q.1(c) Heat is transferred to 10 Kg of air which is initially at 100kPa and 300K until its temperature reaches 600K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the following process:
(i) Constant volume process
(ii) Constant pressure process
Assume that air is an ideal gas for which the P-V-T relationship is PV=nRT, where n is the number of moles of the gas and R is the Ideal gas constant. Take Cp=29.099 kJ/mol K,
 Cv=20.785 kJ/mol K and molecular weight of air=29.

Cont... 2
Q1(d) A particular power plant operates with a heat-source reservoir at 623.15 K (350°C) and a heat-sink reservoir at 303.15 K (30°C). It has a thermal efficiency equal to 55% of the Carnot-engine thermal efficiency for the same temperatures. 

(i) What is the thermal efficiency of the plant? 

(ii) To what temperature must the heat-source reservoir be raised to increase the thermal efficiency of the plant to 35%? Again thermal efficiency is 55% of the Carnot-engine value. 

OR 

Q1'(a) What is the perpetual motion machine of second kind? Discuss the limitations of first law of Thermo dynamics. 

Q1'(b) A reversible engine operating between a reservoir at 600 K and ambient atmosphere at 300K drives a refrigerator operating between 240K and the ambient atmosphere. Determine the ratio of energy rejected by both the devices to the energy absorbed by the engine from the reservoir at 600K. 

Q1'(c) An ideal gas, initially at 303.15 K (30°C) and 100 kPa, undergoes the following cyclic processes in a closed system: 

(i) In mechanically reversible processes, it is first compressed adiabatically to 500 kPa, then cooled at a constant pressure of 500 kPa to 303.15 K (30°C), and finally expanded isothermally to its original state. 

(ii) The cycle traverses exactly the same changes of state, but each step is irreversible with an efficiency of 50% compared with the corresponding mechanically reversible process. Calculate Q, W, ΔU, and ΔH for each step of the process and for the cycle. Take Cp = (7/2)R and Cv = (5/2)R. 

Q1'(d) During summer there is an increased demand of ice to cool soft drink bottles in various shops. It is desired to produce ice at 0°C at the rate of 5000 kg/hr from water at 0°C. The ambient temperature is 40°C. To operate the refrigerating machine it is planned to supply power from heat engine. The heat engine operate
between the ambient atmosphere and a source at 100°C which is supported by solar heating panels. Calculate the minimum power required for operating the refrigerating unit, the maximum possible efficiency of the heat engine and the ratio of energy rejected to the ambient atmosphere to the energy absorbed from the water at 0°C. The latent heat of fusion of water at 0°C is 6.002 KJ/mol and the molar mass of water is 18 x 10^-3 Kg/mol.

Q2(a) Show that for an ideal gas entropy change of mixing is always positive and mixing is an irreversible process.

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

\[ G^E/RT = -(2.6x_1 - 1.8x_2) x_1 x_2 \]

(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 equation for \( G^E/RT \) is recovered.
(iii) Show that \( (d \ln \lambda_1/\text{d}x_1)_{x_2} = (d \ln \lambda_2/\text{d}x_2)_{x_1} - \gamma < 0 \).

OR

Q2(b)' At 300K and 1 bar, the volumetric data for a liquid mixture of Benzene and Cyclohexane are represented by:

\[ V = 109.4 \times 10^{-6} - 16.8 \times 10^{-6}X - 2.64 \times 10^{-4}X^2 \]

where \( X \) is the mole fraction of Benzene and \( V \) has the units of m³/mol.
(i) Find expressions for the Partial molar volumes of Benzene and Cyclohexane.
(ii) Show that when these expressions are combined in accord with Summability equation the given equation for \( V \) is recovered.

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

cont'd... 4
Q3(b) Binary System Acetonitrile(1)/Nitromethane(2) conforms closely to Raoult's law. [10]

Vapor Pressures for the Pure species are given by the following Antoine equation:

\[ \ln P_1^{\text{sat}}/\text{kPa} = 4.2724 - (2945.47/T-49.15) \]

\[ \ln P_2^{\text{sat}}/\text{kPa} = 4.2043 - (2972.64/T-64.15) \]

(i) Prepare a graph showing \( P \) vs \( x_1 \) and \( P \) vs \( y_1 \) for a temperature of 348.15 K.

(ii) Prepare a graph showing \( T \) vs \( x_1 \) and \( T \) vs \( y_1 \) for a pressure of 70 kPa.

(iii) What will be the equilibrium liquid and vapor composition of Acetonitrile/Nitromethane at 348.15 K and 60 kPa.

Q4(a) What is standard Gibb's free energy change of a chemical reaction? Prove that [07]

standard Gibb's free energy change is related to the equilibrium constant by the relation.

\[ \ln K = \frac{-\Delta G^\circ}{RT} \]

Q4(b) Derive the relationship between mole fraction of species in multiple reactions and [08]

the extent of reactions, also calculate the equilibrium constant at 298 K of the reaction:

\[ \text{N}_2\text{O}_3(\text{g}) \rightarrow 2\text{NO}_2(\text{g}) \]

Given that standard free energies of formation at 298 K are 97,540 J/mol for \( \text{N}_2\text{O}_3 \) and 51,310 J/mol for \( \text{NO}_2 \).

OR

Q4(h) The reaction \( \text{N}_2 + \text{O}_2 \rightarrow 2\text{NO} \) takes place in the gas phase at 2700°C and [08]

2025 kPa. The reaction mixture initially comprises 19 mole% oxygen, 77 mole% nitrogen and rest inert. The standard Gibb's free energy change for reaction is 113.83 kJ/mol at this temperature. Assuming ideal gas behaviour, calculate partial pressures of all species at equilibrium.
2014-2015
B.TECH. (WINTER SEMESTER) EXAMINATION
BRANCH
COURSE TITLE: Crude Oil and Petroleum Products
COURSE CODE: PK 222 N

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)  Write an explanatory note on the historical development of Indian Petroleum Industry. Mention the name of at least six petroleum refineries of India along with their refining capacity.  [10]

OR
1'(a)  Explain the following:
i) Sweet and sour crude oils ii) Resins and asphaltenes iii) Heavy and extra heavy crude oils iv) Specific gravity and API gravity v) Kerogen  [10]

1(b)  In what way Rotary drill method is more superior to the cable tool drilling method.  [5]

2(a)  What are the non-hydrocarbon constituents of crude oil? Give detailed classification of sulfur, nitrogen and oxygen compounds present in the crude oil along with their adverse effects.  [10]

2(b)  What do you mean by TBP distillation? How does the TBP distillation become an important tool at the hands of the refiner to know a crude oil?  [05]

OR
2'(b)  What are the problems associated with pipeline transport of waxy crude oil?  [05]
Discuss the role of pour point depressants for treating such oils.
3(a) Explain the method of operation of a multidraw atmospheric distillation column with the help of a neat sketch. How does it differ from conventional distillation? Give the different products of crude oil distillation along with their carbon number, boiling ranges and uses.

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

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

4. Write short notes on any three of the following: [5*3]
   i. Merox Process
   ii. Hydrotreating Process
   iii. Bharat Standards
   iv. Adulteration of petro-products
Note: Answer all questions.

1. (a) Explain the dehydrogenation cum partial oxidation and direct oxidation process for the manufacture of formaldehyde with reference to chemicals reactions involved, operating condition, flammability limits and the catalysts employed. Why the dehydoration cum partial oxidation process is called auto thermal process? [08]

(b) Describe the manufacture of methanol with the help of a process flow sheet using the ICI adiabatic process. [07]

OR

1'. (a) Explain the base scheme employed in the manufacture of methanol using partial oxidation OR steam reforming technique. [03]

(b) Describe the manufacture of ethylene glycol for (ethylene and air) direct oxidation process with the help of a process flow sheet. [07]

(c) Explain the role of inhibitor and the use of two reactors in series in the manufacture of ethylene oxide. [03]

2. (a) List the various processes available for the manufacture of acetone OR phenol. [03]

(b) Describe the manufacture of acetone with the help of process flow sheet with reference to operating parameters and catalyst life. [10]

(c) Mention the chemical reactions involved in the manufacture of linear alkyl benzene OR Caprolactam. [02]

3. (a) What are the important industrial processes available for the manufacture of Vinyl chloride monomer? Explain them with the help of reactions involved. [08]

(b) Describe the manufacture of maleic anhydride with the help of flow sheet, reactions involved. [07]

OR

Could.....2
3. (a) Explain the merits and demerits of the various feed stocks employed in the manufacture of maleic and phthalic anhydride with reference to reactions involved.

(b) Describe the manufacture of styrene with the help of reactions involved applications, catalyst and the process flow sheet.

4. (a) List the chemical reactions involved in the manufacture of acrylic acid and toluenesulfonic acid.

(b) Mention the commercial applications of acrylates and methyl methacrylate.

(c) Describe the manufacture of DMT with the help of process flow sheet with reference to reactions involved operation why the Dupont process through simple could not succeed in the market?
2014-15
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) 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) Discuss any one the following with the help of suitable diagram
1. Flash distillation
2. Differential distillation
3. Steam distillation

OR

(b') Discuss the significance of reflux ratio. How optimum reflux ratio can be obtained? Explain with neat sketch.

(c) A rectification column is fed 200 kg mol/h of a mixture of 35 mol % A and 45 mol % B at 101.31 kPa abs pressure. The feed is liquid at the boiling point. The distillate is to contain 98 mol % A and the bottoms 4 mol % A. The reflux ratio is 2.21. Calculate the kg mol/h distillate, kg mol/h bottoms, and the number of theoretical trays needed using the McCabe-Thiele method.

OR

(c') A distillation column is fed 100 kg mol/hr of a equimolar mixture of A and B. The...
distillate composition is 96 mol\% of A and bottom 03 \% mol of A. Calculate the following:

1. Minimum no of stages for total reflux
2. Ratio of minimum reflux for saturated liquid and saturated vapor feed

Q No 2

(a) Derive the Fenske's equation for minimum number of stages in multicomponent system.

(b) Explain the methods for regeneration of fixed bed adsorption processes.

(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\(^\circ\)C & bottoms temperature is 130\(^\circ\)C. If the number of theoretical stages, N_m is 5.0, then calculate:
   1. Minimum reflux ratio using the Underwood method
   2. Number of theoretical stages at an operating reflux ratio R of 1.5 R_m using the Erbar-Maddox correlation

The relation between K values and temperature (\(^\circ\)C) are given below:

\[
K_A = 0.0002 T^3 + 0.0086 T + 0.3180 \\
K_B = 0.00001 T^2 - 0.0014 T + 0.1250 \\
K_C = 0.0001 T^2 - 0.0102 T + 0.3167 \\
K_D = 0.00009 T^2 - 0.0098 T + 0.3381
\]

Where T is in \(^\circ\)C

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

<table>
<thead>
<tr>
<th>Components</th>
<th>X_{F}</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 stream alcohol vapor in air was adsorbed by activated carbon particles in a packed bed having a diameter of 4 cm and length of 14 cm containing 79.2 g of carbon. The inlet gas stream having a concentration, c_o of 600 ppm and density of 0.00115 g/cm\(^3\) entered the bed at flow rate of 754 cm\(^3\)/s. The break point concentration is set at \(c/c_o = 0.01\). For the given equilibrium concentration curve calculate the following:
1. Determine the break point time, the fraction of total capacity used up to break point and the length of unused bed. Also determine the saturation loading capacity of the carbon.

2. If the break point time required for a new column is 6.6 h, what is the new total length of the column required?

Q No 3

(a) Carry out degree of freedom analysis for liquid-liquid extraction process. Also mention the independent variables and draw typical equilibrium graph in triangular coordinate.

(b) Discuss any one equipment used in leaching process with the help of neat sketch.

(c) 100 kg of pure ether is to be used to extract acetic acid from 200 kg of a feed solution containing 25 wt % acetic acid in water. Find out the percent recovery in water solution in a two stage cross current process. Extractive solvent flow rate is same for both stages.

OR

(c') An inlet water solution of 100 kg/h containing 0.010 wt fraction nicotine (A) in water is stripped with a kerosene stream of 200 kg/h containing 0.0005 wt fraction nicotine in a countercurrent stage tower. The water and kerosene are essentially immiscible in each other. It is desired to reduce the concentration of the exit water to 0.0010 wt fraction nicotine. Determine the theoretical number of stages needed. The equilibrium data are given below, with x, the weight fraction of nicotine in the water solution and y in the kerosene.

<table>
<thead>
<tr>
<th>x</th>
<th>0.00101</th>
<th>0.00246</th>
<th>0.00500</th>
<th>0.00746</th>
<th>0.00988</th>
<th>0.0202</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>0.00081</td>
<td>0.00196</td>
<td>0.00454</td>
<td>0.00682</td>
<td>0.00904</td>
<td>0.0185</td>
</tr>
</tbody>
</table>

Q No 4

(a) What do you understand by membrane separation process? Also explain the mechanism of membrane separation.

OR

(a') Discuss the different types of membrane separation processes with one suitable example.
(b) Discuss the two common types of equipment used commercially for gas permeation membrane separation process.

(c) Derive the equation for series resistances in liquid membrane process.
A desired product L is produced via the following reaction path:

\[ \begin{align*}
A & \quad \rightarrow \quad B + C \\
B + D & \quad \rightarrow \quad E \\
E + 2F & \quad \rightarrow \quad 2G + H + 2D \\
G + D & \quad \rightarrow \quad I \\
I + C + J & \quad \rightarrow \quad F + K \\
2K & \quad \rightarrow \quad L + C + D 
\end{align*} \]

Molecular weight and cost of the species are as given below:

<table>
<thead>
<tr>
<th>Species</th>
<th>Molecular Weight</th>
<th>Cost (Rs/Lg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>47</td>
<td>11</td>
</tr>
<tr>
<td>D</td>
<td>61</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>110</td>
<td>7</td>
</tr>
<tr>
<td>F</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>G</td>
<td>86</td>
<td>13</td>
</tr>
<tr>
<td>H</td>
<td>144</td>
<td>17</td>
</tr>
<tr>
<td>I</td>
<td>90</td>
<td>32</td>
</tr>
<tr>
<td>J</td>
<td>58</td>
<td>20</td>
</tr>
<tr>
<td>K</td>
<td>72</td>
<td>36</td>
</tr>
<tr>
<td>L</td>
<td>106</td>
<td>40</td>
</tr>
</tbody>
</table>

Assuming that any species other than L appearing as product has no commercial value, determine whether the process has potential for commercialization.
1(b) Mention the heuristics/thumb rules employed to economize the separation tasks.

OR

1'(a) A stream containing Propane (45.4 kmol/hr), isobutane (136.1 kmol/hr), n-butane (226.8 kmol/hr), i-Pentane (181.4 kmol/hr), and n-Pentane (317.5 kmol/hr) is to be separated into pure components. Suggest an appropriate separation sequence of ordinary distillation units if the approximate relative volatilities for all adjacent pairs are as follows:

<table>
<thead>
<tr>
<th>Component pair</th>
<th>Approximate $\alpha$ at 1 atm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{C}_4 / \text{iC}_4$</td>
<td>3.6</td>
</tr>
<tr>
<td>$\text{iC}_4 / \text{nC}_4$</td>
<td>1.5</td>
</tr>
<tr>
<td>$\text{nC}_4 / \text{iC}_5$</td>
<td>2.8</td>
</tr>
<tr>
<td>$\text{iC}_5 / \text{nC}_5$</td>
<td>1.35</td>
</tr>
</tbody>
</table>

1'(b) Acetone is manufactured from isopropanol by the following reaction:

$$\text{C}_3\text{H}_7\text{OH} \xrightarrow{\text{catalyzer}} \text{C}_3\text{H}_4\text{O} + \text{H}_2$$

The isopropanol is to be preheated to 315 $^\circ$C and injected into a catalyst-filled reactor where the reaction goes to completion. Suggest a suitable equipment flow sheet. Can we use reactor effluents to preheat the cold isopropanol feed? Give reasons.

1'(c) What are the roles and significance of "Species Allocation" and "Task Integration" in Process Synthesis?

2(a) Discuss, in brief, the significance and salient features of Block Flow Diagram (BFD), Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (P&ID).

2(b) Following symbols are used to represent specific information on a Process Flow Diagram.

\[ \begin{align*}
\text{Diamond} & \quad \text{Rectangle} & \quad \text{Triangle} & \quad \text{Halo} & \quad \text{Cylinder} & \quad \text{Arrow}
\end{align*} \]

Mention the information for which each of these symbols are used.
2(c) Prepare the simplest principal type of flowsheet for the following process and indicate the flowrates of the principal chemical components:

A refinery stream containing paraffins and a mixture of aromatics (benzene, toluene, xyylene, and heavier aromatics) is extracted with a liquid solvent to recover the aromatics. The solvent and aromatics are separated by distillation, with the solvent recycled to the extraction column. The aromatics are separated in three columns, recovering benzene, toluene, and mixed xylenes, in that order. The feed stream consists of the following:

- Paraffins: 300,000 kg/h
- Benzene: 100,000 kg/h
- Toluene: 180,000 kg/h
- Xylene: 70,000 kg/h
- Heavy aromatics: 40,000 kg/h

A 3-to-1 weight ratio of solvent to aromatics is used.

3 A Process Flow Diagram (PFD) for the production of Benzene via the hydrodealkylation of toluene is shown in Fig Q3. Identify the primary chemicals and establish the primary reaction pathway. Show the primary pathway on the flowsheet and describe the same. Also, show the material balance of primary chemicals using the information given in Table Q3.

4(a) Describe in detail, the storage of non-volatile liquids, volatile liquids and gases. Also discuss large capacity storage tanks that are beyond the scope of design codes.

4(b) Discuss the stresses acting on tall vertical vessels that need to be given due consideration for proper design and operation of such vessels/towers.

OR

4* A process vessel having the nominal diameter of 1.5 m and tangent to tangent length of 3.0 m is to be operated at the maximum internal pressure of \( Z \) kN/m\(^2\), where

\[
Z = Y, \text{ if } Y \geq 100 \\
Z = 10Y, \text{ if } 10 \leq Y < 100 \\
Z = 100Y, \text{ if } Y < 10
\]

\( Y \) = last three digits of your Faculty number.

The permissible stress value of the material of construction is 120 MN/m\(^2\).

Assuming the corrosion allowance of 3 mm:

(a) Determine the thickness of the shell plate to be used for fabrication.
Determine the maximum pressure a spherical vessel of same diameter, material of construction and thickness will withstand safely.