2014-15
B.TECH. AUTUMN (III SEMESTER) EXAMINATION
CHEMICAL, PETRO-CHEMICAL ENGINEERING
HIGHER MATHEMATICS
AM 241

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all questions.
Programmable calculators are not allowed.
Notations and symbols used have their usual meaning.

Q. No. | Questions | M.M.
---|---|---
1(a) | If the directional derivative of \( \varphi = ax^2y + by^2z + cz^2x \) at the point \((1,1,1)\) has maximum magnitude 15 in the direction parallel to the line \( \frac{x-1}{2} = \frac{y-1}{2} = \frac{z-1}{2} \), then find the values of \( a, b \) and \( c \). | 05 |
1(b) | A fluid motion is given by \( \vec{V} = (y + z)\hat{i} + (z + x)\hat{j} + (y + x)\hat{k} \)
   
   (i) Is this motion irrotational? If so, find the velocity potential.
   
   (ii) Is the motion possible for an incompressible fluid? | 06 |
1(c) | (i) A rigid body is rotating with constant angular velocity \( \omega \) about a fixed axis. If \( \vec{v} \) is the velocity of any point of the body, then prove that \( \text{curl} \, \vec{v} = 2\vec{\omega} \).
   
   (ii) If \( \vec{F} \) is a vector function and \( \alpha \) is a scalar function, then prove that \( \text{div} \left( \alpha \vec{u} \right) = \alpha \text{div} \, \vec{u} + (\text{grad} \, \alpha) \cdot \vec{u} \). | 05 |
2(a)(i) | The acceleration of a particle at time \( t \) is given by \( \vec{a} = 18 \cos 3t \vec{i} - 8 \sin 2t \vec{j} + 6t \vec{k} \). If the velocity \( \vec{v} \) and displacement \( \vec{r} \) to be zero at \( t = 0 \), find \( \vec{v} \), \( \vec{r} \) at any point \( t \). | 04 |
2(a)(ii) | If \( \vec{r}(t) = 5t^2 \vec{i} + tf \vec{j} - \vec{f} \vec{k} \), then find \( \int_1^2 \left( \vec{r} \times \frac{d\vec{r}}{dt} \right) \, dt \). | 04 |
2(b) | Verify Stoke's theorem for \( \vec{F} = (x^2 + y^2)\vec{i} - 2xy\vec{j} \) taken around the rectangle bounded by the lines \( x = \pm a, y = 0, y = b \). | 07 |

OR

2'(b) | Verify Gauss divergence theorem for \( \vec{F} = 4xyz - yz \vec{i} + xy\vec{k} \) over the cube bounded by \( x = 0, x = 1, y = 0, y = 1, z = 0, z = 1 \). | 07 |
3(a)(i) | State convolution theorem and find \( L^{-1} \left( \frac{1}{s(s^2 + w^2)} \right) \). | 04 |
3(a)(ii) | If \( L\{f(t)\} = \log \left( \frac{e^{2t}}{e+2} \right) \), then find \( f(t) \). | 04 |
3(b) Solve the equations:
\[
\begin{align*}
3 \frac{dx}{dt} + \frac{dy}{dx} + 2x &= 1 \\
\frac{dx}{dt} + 4 \frac{dy}{dx} + 3y &= 0
\end{align*}
\]

given that \( x = 0, y = 0 \) when \( t = 0 \), zero, using Laplace transforms.

3*(b) An alternating voltage \( 250 \sin 100t \) is applied at \( t = 0 \) to a circuit with an inductance 50 mH, capacitance 400 \( \mu \)F and resistance 10 \( \Omega \). Find the current \( i \) at time \( t \) seconds if the initial current and charge were zero, using Laplace transforms.

4(a) An infinite long plane uniform plate is bounded by two parallel edges and an end at right angles to them. The breadth is \( x \), this end is maintained at a temperature \( u_0 \) at all points and other edges are at zero temperature. Find the temperature at any point of the plate in the steady state.

OR

4(a') In case of an infinite rod with no radiation at the surface the initial temperature is given by \( u = (-1)^n V \) between \( x = nx \) and \( x = (n+1)x \), where \( n \) is zero, any positive or any negative integer. Show that if \( t > 0 \), then
\[
u = \frac{4V}{\pi} \sum_{p=0}^{\infty} \frac{\sin((2p+1)\pi x/c) e^{-k(2p+1)^2t}}{(2p+1)^2}
\]

4(b) A string is fixed at two points 1 apart and is stretched. The motion takes place by displacing the string in the form \( y = a \sin \left( \frac{\pi x}{L} \right) \) from which it is released at time \( t = 0 \). Show that the displacement of any point at a distance \( x \) from one end at time \( t \) is
\[
y(x, t) = a \sin \left( \frac{\pi x}{L} \right) \cos \left( \frac{\pi ct}{L} \right).
\]
2014-15
B.TECH. (AUTUMN SEMESTER) EXAMINATION
CHEMICAL/PETROCHEMICAL ENGINEERING
BASIC PRINCIPLES OF CHEMICAL ENGINEERING
CH 211/PK 211

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Start each question and its part thereof from a fresh page.
Notations used have their usual meaning unless otherwise specified.

1(a) A mixture contains 10.0 mole% ethanol, 75.0 mole% ethyl acetate, and 15.0 mole% acetic acid. Calculate the mass fraction of each compound in the mixture and average molecular weight of the mixture. The molecular weights of ethanol, ethyl acetate, and acetic acid are 46.07 kg/kmol, 88.10 kg/kmol, and 60.05 kg/kmol respectively.

1(b) Methane and oxygen react in the presence of a catalyst to form formaldehyde. In a parallel reaction, methane is oxidized to carbon dioxide and water:

\[ \text{CH}_4 + \text{O}_2 \rightarrow \text{HCHO} + \text{H}_2\text{O} \]
\[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]

The fractional conversion of methane is 0.900 and the fractional yield of formaldehyde is 0.855. Calculate the molar composition of the reactor output stream and the selectivity of formaldehyde production relative to carbon dioxide production.

OR

1'(a) The Prandtl number, \( Pr \), is a dimensionless group important in heat transfer calculations. It is defined as \( C_p \mu / k \), where \( C_p \) is the heat capacity of a fluid, \( \mu \) is fluid viscosity and \( k \) is the thermal conductivity. For a particular fluid, \( C_p = 0.583 \text{ J/(g \text{°C})} \), \( k = 0.286 \text{ W/(m \text{°C})} \), and \( \mu = 1936 \text{ lbm/(ft h)} \). Estimate the value of the dimensionless Prandtl number, \( Pr \).

1'(b) A certain gas has a molecular weight of 30.0, a critical temperature of 310 K, and a
critical pressure of 4.5 MPa. Calculate the density in kg/m$^3$ of this gas at 465 K and 9.8 MPa. (a) if the gas is ideal and (b) if the gas obeys the law of corresponding state. Obtain the compressibility factor from figure given below.

![Diagram of compressibility factor chart.]

**Generalized compressibility chart at moderate pressure**

2(a) Differentiate between the terms differential balance and integral balance. How the integral balances on semi batch and/or continuous processes can be obtained from the differential balances of these processes.

2(b) A stream containing 5.15 wt% chromium, Cr, is contained in the wastewater from a metal finishing plant. The wastewater stream is fed to a treatment unit that removes 95% of chromium in the feed and recycles it to the plant. The residual liquid stream leaving the treatment unit is sent to a waste lagoon. The treatment unit has maximum capacity of 4500 kg wastewater/h. If wastewater leaves the finishing plant at a rate higher than the capacity of the treatment unit, the excess (anything above 4500 kg/h) bypasses the unit and combines with the residual liquid leaving the unit, and the combined stream goes to the waste lagoon. If the wastewater leaves the finishing plant at a rate of 6000 kg/h, calculate the flow rate of liquid to the waste lagoon and the mass fraction of Cr in this liquid.

OR

2 (b') Ethylene oxide is produced by the catalytic oxidation of ethylene:
\[ 2C_2H_4 + O_2 \rightarrow 2C_2H_2O \]

An undesired competing reaction is the complete combustion of ethylene:

\[ C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O \]

The feed to the reactor contains three moles of ethylene per mole of oxygen. The single pass conversion of ethylene is 20%, and for every 100 moles of ethylene consumed in the reactor, 90 moles of ethylene oxide emerges from the reactor products. A multiple-unit process is used to separate the products; ethylene and oxygen are recycled to the reactor. For 1000 kg per hour of ethylene oxide produced, calculate the molar flow rates of ethylene and oxygen in the fresh feed and the overall conversion of ethylene.

3(a) What is Hess's law? Use Hess’s law to calculate the standard heat of water gas shift reaction

\[ CO (g) + H_2O (g) \rightarrow CO_2 (g) + H_2 (g) \]

from the following heat of reaction data

\[ CO (g) + \frac{1}{2} O_2 (g) \rightarrow CO_2 (g); \quad \Delta H_f = -121.740 \text{ Btu/lb-mole} \]

\[ H_2 (g) + \frac{1}{2} O_2 (g) \rightarrow H_2O (g); \quad \Delta H_f = -104.040 \text{ Btu/lb-mole} \]

OR

3(a') Calculate the heat of vaporization of water (kJ/mol) at 50 °C and low pressure using the following information.

- Heat of vaporization of water at its normal boiling point: 40.656 kJ/mol
- Heat capacity of liquid water: \(75.4 \times 10^{-3} \text{ kJ/mol °C}\)
- Enthalpy of water vapor at 100 °C relative to 25 °C: 2.54 kJ/mol

Show clearly the process path selected for the calculation.

3(b) A stream containing 10% CH₄ and 90% air by volume is to be heated from 20 °C to 300 °C. Assuming ideal gas behavior, calculate the required rate of input in kW if the flow rate of gas is 2000 L (STP)/min. The enthalpy of air at 0 °C and 300 °C relative to 25 °C is \(-0.72 \text{ kJ/mol}\) and \(8.17 \text{ kJ/mol}\) respectively. The heat capacity \([\text{kJ/mol·°C}]\) of CH₄ at a temperature \(T [°C]\) is given by:

\[ C_p = 0.03461 + 5.469 \times 10^{-5} T + 3.661 \times 10^{-7} T^2 - 1.10 \times 10^{-17} T^3 \]
4(a) Methanol is added to a storage tank at a rate of 1200 kg/h and is simultaneously withdrawn at a rate $\dot{m}_w$ that increases linearly with time. At $t = 0$ the tank contains 750 kg of liquid and $\dot{m}_w = 750$ kg/h. Five hours later $\dot{m}_w$ becomes 1000 kg/h. Calculate how long will it take for the mass of methanol in the tank to reach its maximum value and calculate that value. Then, calculate the time it will take to empty the tank.

4(b) Air at 80 °F and 80% relative humidity is cooled to 51 °F at a constant pressure of 1 atm. Use the psychrometric chart to calculate the fraction of water that condenses and the rate at which the heat must be removed to deliver 1000 ft³/min of humid air at the final condition.
Psychrometric Chart, Ref: H\textsubscript{2}O (I, 32 °F, 1 atm); Air (g, 0 °F, 1 atm)
Answer all the questions. Assume suitable data if missing. Notations used have their usual meaning.

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
</tr>
</thead>
</table>
| 1(a) | Perform the following conversions:  
(i) \((11011001)_2 = (_____)_10\)  
(ii) \((268)_{10} = (_____)_8\)  
(iii) \((11011011)_2 = (_____)_8\)  
| OR |  
| 1(a)' | Draw the logic circuit for the given identity \(Y = ABC + ABC + B\). Also simplify the expression. | [08] |
| 1(b) | Why NAND and NOR gates are called universal gates? | [07] |
| 1(c) | What is meant by multiplexer? List out its various applications. | [05] |
| 2(a) | Define a transducer. What are the functions of a transducer? | [05] |
| 2(b) | Explain the principle of a successive approximation type DVM. | [07] |
| 2(c) | What is a load cell? Where is it used? | [08] |
| 2(c)' | Distinguish between bonded and unbounded strain gauges. | [08] |
| 3(a) | Draw the block diagram of a microprocessor based computer system showing the address, data and control bus structure. | [10] |
| 3(b) | Explain the function of registers of 8085 and explain their individual significance. | [10] |
| 3(b)' | Describe 8085 flags. | [10] |
1. a. What is monopoly? Give examples of some situations where it would be beneficial. Also explain how the price of a product may be determined in a monopoly.

   b. Explain the Law of Diminishing returns with suitable examples.

   c. A company 3 years ago borrowed Rs. 40,000 to pay for a new machine tool agreeing to repay the loan in 100 monthly instalments at an annual nominal interest rate of 12% compounded monthly. The company now wants to pay off the loan. How much would this payment be, assuming no penalty cost for early payment?

   OR

1'. a. What is inflation? What are its causes? How does it affect the economy of a nation?

   b. Machines that have the following costs are under consideration for a robotized welding process. Using an interest rate of 10% per year, determine which alternative should be selected:

<table>
<thead>
<tr>
<th></th>
<th>Machine X</th>
<th>Machine Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Cost (Rs)</td>
<td>250,000</td>
<td>430,000</td>
</tr>
<tr>
<td>Annual operating cost (Rs/year)</td>
<td>60,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Salvage Value (Rs)</td>
<td>70,000</td>
<td>95,000</td>
</tr>
<tr>
<td>Life (Years)</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

2. a. What is depreciation? What is the need for calculating it?

   b. Differentiate between defender and challenger.

   It is proposed to replace a 2 year old precision measuring instrument immediately. The expected costs and lives of the two instruments are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original purchase price (Rs.)</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Current market value (Rs.)</td>
<td>17,000</td>
<td></td>
</tr>
<tr>
<td>Remaining life (Years)</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Estimated value in 3 years (Rs.)</td>
<td>9,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Annual operating cost (Rs.)</td>
<td>8,000</td>
<td>3,000</td>
</tr>
</tbody>
</table>

   Perform the replacement study for a 3 year replacement period.

2 c. Five interdependent proposals are under consideration for a particular project. The present worth of capital requirement and benefits for each project are as follows:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW of Capital (Rs.)</td>
<td>80,000</td>
<td>50,000</td>
<td>72,000</td>
<td>43,000</td>
<td>81,000</td>
</tr>
<tr>
<td>PW of Benefits (Rs.)</td>
<td>70,000</td>
<td>55,000</td>
<td>76,000</td>
<td>52,000</td>
<td>84,000</td>
</tr>
</tbody>
</table>

   Select the best proposal on the basis of an incremental B/C analysis.

Contd...
3. a. What is the significance of decision making tools? Discuss any one decision making tool with suitable examples.

   b. What are the major areas of social responsibility of corporate sector? Discuss the implications of corporate involvement in social causes.

   OR

   3' a. Discuss the role of information in the manager's job. Also, state the characteristics of useful information.

   b. Discuss the Administrative model of decision making.

4. a. Why are organizational goals important? How are they classified? What are the differences between strategic goals and tactical goals?

   b. Differentiate between:
      i. Job enlargement and Job enrichment
      ii. Functional departmentalization and Product departmentalization

   OR

4' a. Discuss how control helps the organization. What are the steps involved in the control process?

   b. How is authority different from power? Differentiate between line and staff authority with suitable examples.

5. a. Explain the Q/R inventory system.

   A company needs 24,000 units/year of a certain component which will be used in its main product. The ordering cost is $150 per order and the carrying cost per unit per year is 18% of the purchase price per unit. The purchase price per unit is $75. Find the economic order quantity.

   b. Demand for part number 1012 was 210 in January, 100 in February and 150 in March. The forecast for January was 140 units. With a smoothing constant of 0.30 and using first order exponential smoothing, what is the April forecast? Is 0.30 a good choice as a smoothing constant?

   c. Define Quality. Discuss the two aspects of quality. Name some quality control tools and explain any one of them.
Maximum Marks: 60
Duration: Three Hours

Note: Answer all questions. All questions carry equal marks.

1. (a) Experimental studies of decomposition of A in a batch reactor at 400K in pressure unit is as follows:

\[-r_A = 2.3 \frac{[A]^2}{[B]^3}\]

where \( -r_A = \text{mol} / \text{m}^3 \cdot \text{s} \)

Transform the rate equation into concentration units and then evaluate the rate constant.

\([R = 8.26 \times 10^{-6} \text{ m}^3 \cdot \text{atm} / \text{mol} \cdot \text{K}]\)

(b) Explain the merits and demerits of the various types of reactors employed for the homogeneous reactions with the help of schematic diagrams.

(c) Explain the following terms used in the reaction engineering with an example:

- elementary reactions and order of reaction
- Explain the significance of Arrhenius plot and show that the Arrhenius law is a good approximation to the temperature dependency of both collision and transition state theory.

2. (a) Explain the integral and differential method of Analysis of data with reference to merits and demerits.

(b) Define the shifting order reactions with an example and explain the behavior of reaction with \( C_A \) vs \( t \) and \( (-r_A) \) vs \( C_A \) graphs.

(c) A small reaction bomb fitted with a sensitive pressure measuring device is flushed out and filled with pure dimethyl ether at 140°C, 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:

\[(CH_3)_2O \rightarrow CH_4 + H_2 + CO\]

Determine the rate equation in units of moles, liters and minutes which will satisfactorily fit the data, given in the table, reported by Hinselwood and Askew for the isothermal decomposition of dimethyl ether in the gas phase.

<table>
<thead>
<tr>
<th>Time, sec</th>
<th>Pressure increase, ( \text{mm of Hg} )</th>
<th>( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>390</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>1195</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td></td>
<td>619</td>
<td></td>
</tr>
</tbody>
</table>

At time \( t = 0 \), the pressure indicated by the measuring device is 312 mm of Hg.

OR

(c') (i) Define the rate of reaction for a variable volume batch reactor and calculate the fractional change in volume for the reaction

\[ A \rightarrow 4R \text{ if feed contains 50% } in 2 \text{ atm L} \]

(ii) Enzyme E catalyzes the transformation of reaction A to product R as follows:

\[ A \xrightarrow{\text{enzyme}} R \quad -r_A = \frac{200C_A C_E}{2 + C_A} \text{ mol/(lit.min)} \]

Contd....
3. (a) If we introduce enzyme (C_{E_0} = 0.001 \text{ mol/liter}) and reactant (C_{A_0} = 10 \text{ mol/liter}) into a batch reactor and let the reaction proceed. Find the time needed for the concentration of reactant drops to 0.025 \text{ mol/liter}. Note that the concentration of enzyme remains unchanged during the reaction.

Define the recycle reactor with the help of diagram and explain its importance in the reactor design.

(b) The graph between \( \frac{1}{(-r_A)} \) vs. \( X_A \) for the autocatalytic reaction is as follows:

\[
\frac{1}{(-r_A)} \uparrow \\
X_A \quad X_f
\]

show the reactor(s) system employed with or without recycle and explain the same.

(c) Show that the N plug flow reactors in series with a total volume V gives the same conversion as a simple plug flow reactor of volume V.

(d) In a system, N-equal size mixed flow reactors have been arranged in series. Show mathematically that the system will behave like a plug flow reactor if \( N \approx \alpha \) for the reaction, \( A \xrightarrow{k_{n=1}} R \). Density changes, if any may be assumed to be negligible.

OR

(d') A homogenous gas reaction \( A \rightarrow 3R \) has a reported rate at 215^\circ C as

\[ -r_A = 10^{-2}C_A \text{ (mol/liter.sec)} \]

Find the space time needed for 80% conversion of a 50\% A - 50\% R mixture feed to a plug flow reactor operating at 215^\circ C and 5 atm (\( C_{A_0} = 0.0625 \text{ mol/liter} \)).

OR

Define the space time for the flow reactors.

A company has one plug flow reactor and one mixed flow reactor in its store. Both reactors are of the same size, 1.0 liter capacity. It has been divided to use them to carry out a homogenous irreversible reaction, \( A \xrightarrow{k \text{ 1.0/hr}} R \). The volumetric flow rate is constant and equal to 1.0 liter/hr. The feed is pure A and the concentration of A entering the reactor is, \( C_{A_0} = 1.0 \text{ mol/liter} \). Calculate the concentration of A leaving the system.
4. (a) The reactions involved in the cracking of isopropyl dibenzene undergoes the following first order consecutive series reactions:

\[
\text{Isopropyl} \xrightarrow{k_1=0.1 \text{ min}^{-1}} \text{Isopropyl - sec- butyl benzene} \]

\[
\text{complex} \xrightarrow{k_2=0.1 \text{ min}^{-1}} \text{Isopropyl di - sec- butyl benzene} \]

What size plug for reactor will maximize the yield of Isopropyl-sec-butyl benzene and its concentration in the effluent stream from this reactor if the feed entering is pure Isopropyl dibenzene and its concentration is, \( C_{A0} = 1.0 \) mol/liter and the flow rate maintained is 100 liter/hr. Drive the equations used.

(b) For the parallel decomposition of \( A \),

\[
\text{A} \xrightarrow{k_1} \text{R} \quad k_1 = 10 \text{ e}^{-3000T}, \text{1/hr} \\
\text{A} \xrightarrow{k_2} \text{S} \quad k_2 = 10^6 \text{ e}^{-4500T}, \text{1/hr} \\
\]

occurring in a mixed reactor with space time of 1.0/hr. Find the temperature which maximizes the production of R. Feed is pure A (\( C_{A0} = 1.0 \) mol/liter). Find the concentration of R at the outlet of the reactor. Drive the equation(s) used.

OR

4'. (a) Explain the residence time distribution with the help of a mixed flow and plug flow reactor.

(b) The competitive liquid phase reactions:

\[
A + B \xrightarrow{k_1} R \text{ desired, } \frac{dC_R}{dt} = 1.0C_A C_B^{0.3} \text{ mol/liter.min} \\
A + B \xrightarrow{k_2} S \text{ undesired, } \frac{dC_S}{dt} = 1.0C_A^{0.5} C_B^{1.8} \text{ mol/liter.min} \\
\]

Find the fraction of impurity in the product stream for 90% conversion of pure A and pure B, each had a density of 20 mol/liter.

(i) for plug flow reactor
(ii) for mixed flow reactor

Determine the temperature to be maintained in a batch reactor operating isothermally for equilibrium conversion of 70% for the following elementary aqueous reaction:

\[
\text{A} \xrightarrow{k} \text{R} \quad \Delta G_{298}^0 = -14130 \text{ J/mol} \\
\Delta H_{298}^0 = -75300 \text{ J/mol} \\
\]

specific heats of product and reactant are equal and constant.

*****
Question

1(a) i. What is the modern theory for the formation of crude oil. Mention the name of important oil fields in India. Write a brief note on the status and vision of the Petroleum Refining Industry in India.
ii. Write the chemical composition of crude oil and associated Natural gas.

1(b) Give a brief discussion about corrosive and noncorrosive crude oils, resins and asphaltenes, and about bench mark crudes.

OR

1(b) Why it is important to know the base of crude oils? Describe briefly any three methods which are usually employed for determining the base of the crude oil.

2(a) What are the various types of hydrocarbons present in petroleum? Discuss in detail about these hydrocarbons along with their important properties.

OR

2'(a) What are the non-hydrocarbon constituents of crude oil? Give detailed classification of various impurities present in the crude oil along with their adverse effects.

2(b) What do you understand by 15/5 distillation? Explain the importance of debutanization of crude oil.

OR

2'(b) Explain briefly different types of average boiling points and their uses.

3(a) Explain the method of operation of a multistage atmospheric distillation column in an oil refinery. How does it differ from a conventional distillation? Give the different products of crude oil distillation along with their carbon numbers, boiling ranges and uses.

\[\text{Contd... 2.}\]
3 (b) Give a comparative account of the compositions and uses of LPG and Kerosene fraction.

OR

3' (b) What do you mean by cetane number? How it is calculated? How does it differ from cetane index?

4 (a) Give a brief historical background of the production of the petrochemicals in our country. Mention the name of important feed stocks which are employed for the production of petrochemicals.

4 (b) Why ethylene and propylene are considered as building blocks for the petrochemical Industry?

4 (c) Write short notes on any two of the following:
   i. reaction mechanism and application of Isomerization reactions
   ii. importance of catalytic reactions
   iii. importance of nitration reactions
1(a) What is meant by particle size reduction? Discuss its importance. What does sphoricity imply? [04]

1(b) For the sieve analysis given in the table below: [05]

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>% Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
<td>11</td>
</tr>
<tr>
<td>0.25</td>
<td>49</td>
</tr>
<tr>
<td>0.125</td>
<td>28</td>
</tr>
<tr>
<td>0.063</td>
<td>8</td>
</tr>
<tr>
<td>Through 0.063</td>
<td>4</td>
</tr>
</tbody>
</table>

Plot a cumulative sieve analysis and estimate the weight fraction of the particles of sizes between 0.300 to 0.350 mm and 0.350 to 0.400 mm.

OR

1(b') Discuss the type of flow achieved when the solid particles falls from the bottom of a silo. Estimate the pressure on the walls at the bottom of the silo, having a central discharge at the bottom, of 4 meter diameter and 20 meter height filled with plastic pellets.

Coefficient of friction ($\mu$) = 0.364

$\rho = 560$ kg/m$^3$

$K$ (Janssen coefficient) = 0.4

$g = 1$ km/m/s$^2$

1(c) List out the different types of conveyors used for solid transportation. Also discuss the working of a belt conveyor or screw conveyor [05]
2(a) Discuss the laws of crushing and the assumptions on which these laws are based along with their formula.

2(b) Discuss the classification of crushers on the basis of particle size. Explain the working of any one of the following size reducing equipment:
   a) Jaw crusher
   b) Ball mill

2(c) A crusher crushes rocks having a volume surface mean diameter of 0.2 meter and discharges product of volume-surface mean diameter of 0.04 meter. Assuming crushing constant $K_r$ to be $0.1 \text{ kW.m/kg}$, calculate power required to crush the rock fed at a rate of $3.5 \text{ kg/sec}$. What will be the power required to further reduce the rock from 0.04 meter to 0.01 meter.

3(a) A spherical particle (density $\rho_s$) falling in a fluid (density $\rho$, viscosity $\mu$) is acted upon by different forces. Derive the expression for the resultant force acting on the particle. Using this expression derive the expression of terminal velocity for the flow falling under stoke's law regime.

3(b) What is the difference between clarifier and classifier? Discuss sink and float method or differential method of separation used by sorting classifier.

OR

3(b') What is the difference between agitation and mixing? Draw a neat sketch to describe axial flow and radial flow. State how vortex formation can be avoided during mixing/agitation. Also draw the sketch showing vortex formation.

4(a) What is meant the term Fluidization? Explain the terms Dense, Lean, Aggregative and Particulate Fluidization.

OR

4(a') Derive the Ergun's equation for calculation of pressure drop.

4(b) What do you understand by the term loading and flooding in respect to a packed bed? Derive the relation for pressure drop in a packed bed.

OR

4(b') What do you understand by the term filtration? With the help of neat sketch, discuss the working of plate and frame filter press or rotary drum filter.

4(c) A 1m high bed made up of 2mm particles is to be fluidized by an oil (density = $900 \text{ kg/m}^3$, viscosity = $0.01 \text{ Pa.s}$). If at the point of incipient fluidization the bed voidage is 39% and pressure drop across the bed is 10 kPa. Estimate the density of particles. Assume Kozney CArner equation to be valid in this range.