1(a) Differentiate any two of the following
i) Venturimeter 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 lit/min. An orificemeter is introduced at a point of pipeline where the pressure head is 4.6 m of water. Find the smallest diameter of throat so that the pressure at the throat is never negative, assume coefficient of meter as unity.
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 a 3.0mm 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>ISS mesh</th>
<th>Aperture size (mm)</th>
<th>Mass fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Feed</td>
</tr>
<tr>
<td>+480</td>
<td>+4.760</td>
<td>0.548</td>
</tr>
<tr>
<td>-480+340</td>
<td>-4.760+3.353</td>
<td>0.146</td>
</tr>
<tr>
<td>-340+120</td>
<td>-3.353+1.201</td>
<td>0.109</td>
</tr>
<tr>
<td>-120+60</td>
<td>-1.201+0.592</td>
<td>0.045</td>
</tr>
<tr>
<td>-60+30</td>
<td>-0.592+0.296</td>
<td>0.034</td>
</tr>
<tr>
<td>-30</td>
<td>-0.296</td>
<td>0.118</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
4(a) Discuss any two of the following:
(i) Flotation
(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 $20^\circ$C. The slurry containing 60 wt% solids. The density of the glass spheres is $2467 \text{ kg/m}^3$ (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 $\text{ Kg/m}^3$ are to be fluidized using air at 2.0 atm abs. & $25^\circ$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.

(i) If the cross section of empty bed is 0.30 $\text{ m}^2$ and the bed contains 300 kg of solid, calculate the minimum height of the bed at minimum fluidization condition.

(ii) Calculate the pressure drop at minimum fluidization condition.

(iii) Calculate the minimum fluidization velocity
1. (a) The irreversible reaction, $2A + B \xrightarrow{k_1} A_2B$ has been studied kinetically and the following reaction mechanism has been suggested for the formation of the product

$$A + B \xrightarrow{k_1} AB^*$ \quad \text{(Intermediate product)} \xrightarrow{k_2}$$

$$AB^* + A \xrightarrow{k_3} A_2B \quad \text{with} \quad k_4 = 0$$

Derive the rate equation for the formation of the product $[r_{A,B}]$ if $k_4 = 0$.

(b) 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.

OR

(b') A certain reaction has a rate equation given by $[r_A] = 0.005 \, \text{C}_2 \, \text{mol/cm}^3 \, \text{min}$. If the concentration is to be expressed in mol/liter and time in hrs, what will be the value and units of rate constant.

(c) Express the rate of reaction ($r$) in various forms.

(d) Explain the transition state theory for the temperature dependency of a reaction rate and order and molecularity of non-elementary reactions.

2. (a) Explain the merits and demerits of integral and differential method of analysis of data.

(b) Define the pseudo order of reaction.

(c) A small reaction bomb fitted with a sensitive pressure measuring device is flushed out and filled with a mixture of 80.6% reactant A and 19.4% inert at 1.0 atm pressure and 14°C, a temperature low enough that the reaction does not proceed to any appreciable extent. The temperature is raised rapidly to 120°C and the readings as mentioned in the following table are obtained. The stoichiometry of the reaction is $A \xrightarrow{k} 2R$. After sufficient time the reaction proceeds to completion. Find the rate equation in units of moles, liters and minutes which will satisfactorily fit the data.

Contd... 2.
2. (c')
(i) The first order reversible liquid phase reaction, \( A \overset{k_1}{\underset{k_2}{\rightarrow}} R \) with \( C_{A_0} = 0.5 \text{ mol/liter} \) and \( C_{R_0} = 0.0 \) takes place in a batch reactor. After 8.0 minutes, conversion of \( A \) is 33.3% while equilibrium conversion is 66.7%. Find the rate equation for the reaction. Derive the equation (a) used.
(ii) Define the shifting order of reaction with an example.

3. (a)
For an elementary reaction, \( A + R \rightarrow R + R \), the reaction rate has been approximated by \( r_R = 0.1 \ C_A C_R \). Determine the ratio of volume requirement for a mixed flow to plug flow reactor for 50% conversion of \( A \) if all other parameters maintained are same in both the reactors. The compositions of the reactants entering into the reactor(s) is \( C_{A_0} = 0.99 \text{ mol/liter} \) and \( C_{R_0} = 0.01 \text{ mol/liter} \). Derive the equation(s) used.

(b) Why plug flow reactors are not arranged in series?

3. (a')
The liquid phase reaction \( A + B \overset{k_1}{\underset{k_2}{\rightarrow}} R + S \) is to take place in a mixed flow reactor of 120 liter. Two feed streams, one containing 2.8 mol A/liter and the other containing 1.6 mol B/liter are to be introduced (in equal volumes) into the reactor and 75% conversion of limiting component is desired. What would be the flow rate of each stream? Assuming a constant density throughout. Given \( k_1 = 7 \text{ liter/mol.min} \) and \( k_2 = 3 \text{ liter/mol.min} \)

(b') Explain the merits and demerits of a batch reactor and derive the performance equation of a batch reactor.

4. (a)
Explain the terms instantaneous and over-all fractional yield of \( R \) for multiple reactions and derive an expression to calculate the over-all yield of the desirable product for a plug flow reactor.

(b) A first order liquid phase reaction \( A \overset{k_1}{\underset{k_2}{\rightarrow}} R \) has been carried out in a mixed flow reactor. The conversion desired is 60%. Find the optimum temperature and the volume required if the flow rate of \( A \) is 50 liters/min. Given:
\( k_1 = 10 \ e^{3000T} \), 1/min
\( k_2 = 10^3 \ e^{3000T} \), 1/min

(c) Explain the optimum temperature progression profile for a batch and plug flow reactor for a single reaction.

OR

Contd....3,
For the parallel decomposition of A (all of the first order) carried out in a batch reactor.

\[
\begin{align*}
&K_1 = 10^8 \exp\left(-\frac{50000}{T}\right) \\
&K_2 = 10^5 \exp\left(-\frac{35000}{T}\right) \\
&K_3 = 10^9 \exp\left(-\frac{65000}{T}\right)
\end{align*}
\]

Find the temperature which maximizes the yield of R. Derive the equation used.
Question

1(a)
   i. Write a brief note on the development of Indian Petroleum Industry.
   ii. Explain Modern theory for the formation of crude oil.
   iii. What are the critical parameters you will select to evaluate a crude oil? How
        the hydrocarbon losses can be computed if the RVP is known?

1(b) Give brief accounts of: i) Sweet and sour crude oils ii) Resins and asphaltnes
     iii) Heavy and extra heavy crude oils iv) Specific gravity and API gravity

OR

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?

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

2(b) Discuss the operation of simulated distillation? What are its advantages and
     disadvantages over TBP distillation? How does TBP 15/5 distillation become an
     important tool at the hands of the refiner to know a crude oil?

OR

Contd………2
2(b) What are the problems associated with pipeline transport of waxy crude oil? Discuss the role of pour point depressants for treating such oils.

3(a) Explain the method of operation of a multidraw 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 CFP differ from each other? [3*2]

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(a) What are petrochemicals? Give their classification along with their important uses.

(b) Why ethylene and propylene are considered as basic building blocks in the petrochemical industry.

(c) Write short notes on any three of the following: [3*3]
   i. Give the mechanism behind alkylation reactions
   ii. Reaction mechanism behind thermal cracking
   iii. Production of nitrobenzene from benzene
   iv. Production of an aromatic sulfonic acid
Question

1(a) Among Cumulative and differential analysis of size measurement, which one is more precise and why?  

OR

1(a') What causes the solids to arch or bridge in the storage bin and prevent flow? How is it overcome?

1(b) Material is fed to a nominal 100μm screen and separated into oversize and undersize streams. Size distributions for the feed and two product streams are shown below. Calculate the effectiveness of the sieve if the desired fraction of the material is the material, which is smaller than 100μm.

<table>
<thead>
<tr>
<th>Size range (μm)</th>
<th>Feed Kg/h</th>
<th>Oversize Kg/h</th>
<th>Undersize Kg/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>+160-180</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>+140-160</td>
<td>10</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>+120-140</td>
<td>16</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>+100-120</td>
<td>20</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>+80-100</td>
<td>15</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>+60-80</td>
<td>15</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>+40-60</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>&lt;60</td>
<td>15</td>
<td>0</td>
<td>15</td>
</tr>
</tbody>
</table>

Contd........2
1(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>88 mesh</th>
<th>Aperture size (mm)</th>
<th>Feed</th>
<th>Oversize</th>
<th>Under size</th>
</tr>
</thead>
<tbody>
<tr>
<td>+480</td>
<td>+4.760</td>
<td>0.548</td>
<td>0.596</td>
<td>0.00</td>
</tr>
<tr>
<td>-480+340</td>
<td>-4.760+3.353</td>
<td>0.146</td>
<td>0.168</td>
<td>0.113</td>
</tr>
<tr>
<td>-340+120</td>
<td>-3.353+1.201</td>
<td>0.109</td>
<td>0.096</td>
<td>0.147</td>
</tr>
<tr>
<td>-120+60</td>
<td>-1.201+0.592</td>
<td>0.045</td>
<td>0.039</td>
<td>0.086</td>
</tr>
<tr>
<td>-60+30</td>
<td>-0.592+0.296</td>
<td>0.034</td>
<td>0.029</td>
<td>0.033</td>
</tr>
<tr>
<td>-30</td>
<td>-0.296</td>
<td>0.118</td>
<td>0.072</td>
<td>0.621</td>
</tr>
</tbody>
</table>

1(c) Classify Conveyors. Discuss the principle of pneumatic conveying with the help of Dilute Phase Pressure- Vacuum operation.

2(a) The power required to crush 100ton/hr of a material is 179.8KW, if 80% of the feed passes through a 51mm screen and 80% of the product passes through a 3.2mm screen.

(i) What is the Work index of the material?
(ii) What will be the power required for the same feed at 100ton/hr to be crushed to a product such that 80% is to pass through a 1.6mm screen?

2(b) What are the various laws of size reduction? State each one of them with their limitations.

2(c) With the help of neat sketch explain the working of conical Ball Mill.

3(a) Differentiate any two of the following:

(i) Classifier and Clarifier.
(ii) Cyclone separator and Electrostatic Precipitator.
(iii) Agitation and mixing.
(iv) Hindered settling and Free settling.

Contd......3...
3(b) Obtain the velocity of hindered settling for glass spheres of 74\(\mu\text{m}\) diameter in water. Assume \(\rho_s=2600\text{Kg/m}^3\), the volume fraction glass \(\approx 0.2\), Density of fluid is \(1000\text{Kg/m}^3\) and Viscosity of fluid is \(10^{-3}\text{Kg/m}\cdot\text{sec}\).

OR

3(c) A mixture of coal and sand particles having size smaller than \(1\times10^{-4}\text{m}\) in diameter is to be separated by screening and subsequent elutriation by water. Recommends a screen aperture size such that the oversize from the screen can be separated completely into sand-coal particles by elutriation. Calculate also the required water velocity. Assume that Stoke's Law is applicable. Density of sand=2650Kg/m\(^3\); Density of Coal=1350 Kg/m\(^3\); Density of Water=1000 Kg/m\(^3\); Viscosity of Water=\(1\times10^{-3}\text{Kg/m}\cdot\text{s}\); \(g=9.81\text{m/s}^2\).

4(a) Explain the process of fluidization with the help of a graph between pressure drop across the bed and superficial velocity. Give two important industrial applications of fluidized bed.

OR

4(a') Differentiate between filter media and filter aids with examples. Describe the working and construction of rotary drum filter with the help of a neat sketch.

4(b) A bed containing 32,700 kg of 100 mesh sharp sand is to be fluidized with air at 400°C and 17 atm abs in a cylindrical vessel 3.5 m in diameter. The ultimate density of the sand particle is 2690 kg/m\(^3\). The viscosity of air at operating conditions is 0.032 cp. Calculate;

(i) The minimum height of fluidized bed.

(ii) The pressure drop across the bed at the minimum porosity condition.

(iii) The critical superficial air velocity, given minimum porosity = 0.55, diameter of 100 mesh particle size = 0.147 mm.