Note: Answer all questions.

Duration: Three Hours

1. Answer any three parts:

(a) Find the constants $m$ and $n$ so that the surface $mx^2 - nxyz = (m + 2)x$ will be orthogonal to the surface $4x^2y + z^3 = 4$ at the point $(1, -1, 2)$.

(b) Find the directional derivative of $\phi = (x^2 + y^2 + z^2)^{\frac{1}{2}}$ at the point $(3, 1, 2)$ in the direction of the outer normal to the surface $x^2 - y^2 + z = 2$ at the point $(1, -1, 2)$.

(c) Verify $\nabla \cdot \nabla \vec{A} = \nabla (d\vec{A}) - \nabla^2 \vec{A}$ for $\vec{A} = xy^2 \hat{i} + x^2y \hat{j} + xy^3z^2 \hat{k}$.

(d) Show that the $\vec{E} = \frac{r}{r^3}$ is irrotational and find the scalar potential function $\phi$ such that $\vec{E} = -\nabla \phi$ given that $\phi$ is zero at origin. (5+5+5)

2. (a) Verify Gauss-divergence theorem for $\vec{F} = xi + yj + zk$ and the surface $S$ is smaller part of the sphere $x^2 + y^2 + z^2 = a^2$ cut off by the plane $z = \frac{1}{2}a$.

(b) By using Green's theorem show that the area bounded by a simple closed curve $C$ is given by $\frac{1}{2} \int_C (x \, dy - y \, dx)$ and hence find the area of the loop of folium of Descartes $x^3 + y^3 = 3axy$, $a > 0$.

OR

(b') Verify Stokes' theorem for the function $\vec{A} = z\hat{k} + x\hat{j} + y\hat{k}$ where $C$ is the unit circle in the xy-plane bounding the hemisphere $z = \sqrt{1 - x^2 - y^2}$. (8+7)

3. (a) Evaluate any two of the following:

(i) $L \left( \frac{3}{t^2} e^{-zt} + \int_0^t \frac{1-e^{-u}}{u} \, du \right)$

(ii) $L^{-1} \left[ \frac{5s^3 + 3}{(s-1)(s^2 + 2s + 5)} \right]$ 

(iii) $L^{-1} \left[ \frac{1}{(s^2 + \phi)^2} \right]$ by using convolution theorem.

Contd....2.
(b) Solve the integral equation \( y(t) + \int_0^t y(t) \, dt = 1 - e^{-t} \) by Laplace transform method.

OR

(b') Express the following function \( f(t) \) in terms of unit step function and hence obtain its Laplace transform:

\[
f(t) = \begin{cases} 
  t, & \text{for } 1 \leq t \leq 2 \\
  1 - t, & \text{for } 2 \leq t \leq 3
\end{cases}
\]

(c) Solve, by Laplace transform method, the differential equation:

\[
(D^2 + 2D + 5)x = e^{-t} \sin t, \quad x = 0, Dx = 1 \text{ at } t = 0.
\]
1(a). A poundal is the force required to accelerate a mass of 1 lbm at a rate of 1 ft/s², and a slug is the mass of an object that will accelerate at a rate of 1 ft/s² when subjected to a force of 1 lbf. A force of 355 poundal is exerted on a 25.0 slug object. At what rate (m/s²) does the object accelerate?

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.

1'(a). A mixture of 10.0 mol% ethanol (C₂H₅OH), 75.0 mol% ethyl acetate (C₄H₇O₂), and 15.0 mol% acetic acid (C₂H₄O₂). Calculate the average molecular weight of the mixture and mass fraction of each compound in the mixture.

1'(b). Obtain T-x-y data for benzene toluene system at 1 atm. for the entire range of temperature. Draw the T-x-y diagram from these data and use it to calculate the bubble point temperature of the mixture (70.0 mol% benzene, 30.0 mol% toluene) and the mule fraction of the vapor that is in equilibrium with this mixture at bubble point. The vapor pressure of benzene and toluene can be obtained from the Antoine equation (p in mm Hg, T in °C):

For benzene:

\[ \log_{10} p^* = 6.89272 - \frac{1203.531}{T + 219.888} \]

For toluene:

\[ \log_{10} p^* = 6.95805 - \frac{1346.773}{T + 219.693} \]

2(a). Three hundred gallons (1 gal = 3.785412 L) of mixture of 75.0 wt% ethanol and 25 wt% water (mixture specific gravity = 0.877) and quantity of a 40.0 wt% ethanol - 60 wt% water mixture (specific gravity = 0.952) are blended to produce a mixture containing 60.0 wt% ethanol.
2(b). A hydrocarbon gas is burned with air. The dry-basis product gas composition is 1.5 mole% CO, 6.0% CO₂, 8.20% O₂, and 64.3% N₂. There is no atomic oxygen in the fuel. Calculate the ratio of hydrogen to carbon in the fuel gas and speculate what the fuel might be. Also calculate the percent excess air fed to the reactor.

OR

2(b). An evaporation-crystallization process is used to obtain solid potassium sulfate from an aqueous solution of this salt. The fresh feed to process contains 19.6 wt% K₂SO₄. The wet filter cake consists of solid K₂SO₄ crystals and a 40.0 wt% K₂SO₄ solution, in ratio 10 kg crystals/kg solution. The filtrate, also a 40% solution is recycled to join the fresh feed. Of the water fed to evaporator, 45% is evaporated. Calculate the production rate of solid K₂SO₄, the rate at which the fresh feed must be supplied to achieve this production rate, and the ratio kg recycle/kg fresh feed for a water evaporation rate of 175 kg/s in the evaporator.

3(a). Liquid water at 30 °C and liquid water at 90 °C are combined in a ratio (1 kg cold water/2 kg hot water). Assuming a suitable basis and neglecting the kinetic and potential energy changes and expansion work and assuming that the mixing is adiabatic, calculate the final water temperature. Given that

<table>
<thead>
<tr>
<th>T (°C)</th>
<th>30</th>
<th>50</th>
<th>70</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>u (kJ/kg)</td>
<td>125.7</td>
<td>219.2</td>
<td>293.0</td>
<td>376.9</td>
</tr>
</tbody>
</table>

3(b). Calculate the heat of vaporization of water (kJ/mol) at 50 °C and low pressure from the following data showing clearly the path you construct for the calculation:

Heat of vaporization of water at normal boiling point = 40.656 kJ/mol;

Heat capacity of water vapor \( C_p \) in kJ/mol°C; \( T \) in °C:

\[
C_p = 0.03346 + 6.880 \times 10^{-5}T + 7.604 \times 10^{-7}T^2 - 3.593 \times 10^{-12}T^3
\]

Compare your results with the value reported in steam table as 42.730 kJ/mol

OR

3(b'). Trichloroethylene, a widely used degreasing solvent for machine parts, is produced in a two step reaction sequence:

\[
\begin{align*}
C_2H_4(g) + 2Cl_2(g) &\rightarrow C_2H_2Cl_4(l) + H_2(g); \quad \Delta \tilde{H}_r^\circ = -326.2 \text{ kJ/mol} \\
C_2H_2Cl_4(l) &\rightarrow C_2H_2Cl_2(l) + HCl(g)
\end{align*}
\]

The standard heat of formation of liquid trichloroethylene, ethylene, and hydrogen chloride gas are -276.2 kJ/mol, 52.28 kJ/mol, and -92.31 kJ/mol respectively. Using Hess's law, calculate the standard heat of formation of tetrachloroethane and the standard heat of reaction of second reaction and the reaction:

\[
C_2H_4(g) + 2Cl_2(g) \rightarrow C_2H_2Cl_2(l) + H_2(g) + HCl(g)
\]
4. Methanol is added to a storage tank at a rate of 1200 kg/h and is simultaneously withdrawn at a rate $m_w$ that increases linearly with time. At $t = 0$ the tank contains 750 kg of liquid and $m_w = 750$ kg/h. Five hours later $m_w$ 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.

An air conditioner cools 226 m$^3$/min of humid air at 36 °C and 98% relative humidity to 10 °C.

(i) Do a degree of freedom analysis to prove that enough information is available to determine the required cooling rate.

(ii) Calculate the rate of condensation of water in the unit and the cooling duty.
B.TECH. AUTUMN (III SEMESTER) EXAMINATION
(Chemical/Petro-Chemical Engineering)
FLUID MECHANICS
(CH-213/PK-232)
Credits: 04

Maximum Marks: 60
Note: Answer all questions. Assume any missing data with proper justification.

1. (a) Consider a fluid having a flow-field \( \dot{\mathbf{v}} = (6 + 2xy + t^2)\mathbf{i} - (3y^2 + 10t)\mathbf{j} + 25k \). Obtain the stress distribution and stress at a point (1,1,1) for a
   i) Newtonian fluid (\( \mu = 3 \) units)
   ii) Bingham Plastic fluid (\( \tau_0 = 2 \) units, \( \mu_0 = 1 \) units)

OR

(a') Define shear stress and rate of strain tensor. Show that the rate of deformation of a fluid under the action of shear force equals to the velocity gradient. Comment on the deformation produced by the velocity field \( \dot{\mathbf{v}} = x^2 \mathbf{i} + (2x^3 - y)\mathbf{j} \).

1. (b) Develop the relationship for variation of pressure with altitude in a gas at (i) Constant density, (ii) Isothermal Condition, and (iii) Isentropic Condition. Calculate the pressure, temperature and density of the atmosphere at an altitude of 1200 m if at zero altitude the temperature is 15 °C and the pressure 101 kN/m². Assume the conditions are isentropic (\( \gamma = 1.4 \)).

1. (c) State Archimedes Principle. Discuss the stability of a Submerged body in fluid.

2. (a) Derive Bernoulli's equation for flow of an incompressible fluid. State clearly the assumptions made. Explain why kinetic energy correction is required.

OR

(a') Define and derive the relationship for vorticity and circulation of flow. Prove that the circulation around a contour is equal to the sum of the vorticities within the area of the contour.

2. (b) Concentration of fish in the river Ganga at Har Ki Pauri at Haridwar depends on location as well as time, depending on the devotees offerings to fish. If from a fixed time \( t = 0 \), and position \( x = 0 \), the concentration changes as \( C = 100 - 2t - x \) per m² with \( t \leq 20; x \leq 50 \), determine the rate of change of concentration of fish
   i) observed by a devotee at the bank (\( x = 0 \));
   ii) as noticed by an observer swimming in \( x \) direction at the rate of 2 m/s passing through the point \( x = 20 \) m at a time \( t = 20 \) s.
2. (c) Identify the following statements as true or false with reasons.

i) Irrotational flow implies continuity of flow.

ii) Existence of stream function implies continuity of flow.

iii) For a possible irrotational flow, there must be a Laplacian.

iv) Intersection of two streamlines implies a stagnation point.

v) A fluid for which density changes with pressure will always give rise to a compressible flow.

3. (a) A ventilation system fan is to be exported to a high altitude region with an air density of 0.092 kg/m³ and is expected to deliver 2 m³/s at a pressure differential of 200 kPa. If the fan is to be driven at 1400 rpm on installation, calculate the flow rate and pressure rise required on test at sea level, air density 1.25 kg/m³, and the appropriate fan test speed if conditions of dynamic similarity are to be achieved. Assume no change in air viscosity with the change in altitude involved.

   OR

   (a') The drag of a sonar transducer is to be predicted, based on wind tunnel test data. The prototype, a 1 ft diameter sphere, is to be towed at 5 knots (nautical miles per hour) in seawater at 5°C. The model is 6 inch in diameter. Determine the required test speed in air. If the drag of the model at these test conditions is 5.83 lbf, estimate the drag of the prototype. (For air at STP ρ = 0.00238 slug/ft³ and ν = 1.57x10⁻⁵ ft²/s. For Seawater at 5°C, ρ = 1.99 slug/ft³ and υ = 1.69x10⁻⁵ ft²/s).

3. (b) The pump performance is known to depend upon pressure drop ΔP, flow rate Q, shaft power W, rotation speed ω, the fluid properties ρ and υ, and the parameter of the pump geometry D. Perform dimensional analysis on these variables using Buckingham Pi theorem to obtain the dimensionless form of the functional relationship. Explain the significance of each of the dimensionless groups thus formed.

3. (c) State and explain the principle of Dimensional Homogeneity. What are the advantages and disadvantages of dimensional analysis? Explain the significance of similitude study.

4. (a) Discuss in detail variable head and variable area meters. For each of them derive the relationship for determining the flowrate of an incompressible fluid.

4. (b) With the help of a neat diagram write about different types of valves and pipe fittings used in chemical industry.
Q.1 (a) Using the truth table and waveforms (showing the binary counting sequence) explain the operation of MOD-16 ripple counter. How it is modified to realize a MOD-10 counter?  

Q.1 (b) (i) Realize 2-input 'XOR' gate using only 2-input NAND gates.  
(ii) What are decoders? Draw a logic circuit of 2 to 4 line decoder. Also give its truth table.  

OR

Q.1(b') A certain 10-bit digital-ramp ADC has following specifications:  
Clock frequency = 1MHz; Threshold voltage of comparator (V_T) = 0.1 mV; DAC full scale output = 10.23 V. Determine the following values:  
1. The digital equivalent obtained for analog input (V_A) = 3.728 V  
2. The conversion time for given analog input (V_A)  
3. The resolution of this converter  

Q.2(a) Explain the principle of pressure measurement using inductive and capacitive transducers.  

OR

Q.2(a') (i) Explain the working of a linear variable differential transformer (LVDT).  
(ii) A strain gauge has a factor of 4. If this strain gauge is attached to a metal bar that stretches from 25 cm to 25.2 cm, calculate the percentage change in its resistance. If the unstrained value of resistance is 120 ohm, what would be its value after strain is applied.  

Q.2(b) Explain the operating principle of a Ramp type digital voltmeter, using a block diagram. Also gives the advantages of a digital voltmeter over an analog voltmeter.
Q.2(c) Describe the principle of operation of frequency counter, using a block diagram.

Q.3(a) Draw the block diagram of the basic computer system organization. Discuss the function of each component briefly.

Q.3(b) Draw the pin-diagram of 8085 microprocessor and explain the function of status signals.

OR

Q.3(b') Draw the simplified block diagram of 8085 microprocessor. What is the size of address bus in an 8085 microprocessor.

Q.3(c) Write a note on Registers used in 8085 microprocessor.

Q.3(d) Explain the function of a program counter, stack counter and status flag in INTEL 8085 microprocessor.
2012 – 2013
B.TECH. AUTUMN (III SEMESTER) EXAMINATION
(PETROCHEMICAL ENGINEERING)
INTRODUCTION TO PETROCHEMICAL TECHNOLOGY
(PK – 212N)
Credits: 04

Maximum Marks: 60
Duration: Three Hours

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

1. (a) Explain in brief the systematic development of Petrochemical industry in our country. [03]
(b) Explain the classification of petrochemicals with example. [03]
(c) Describe the process of steam cracking of hydrocarbons essentially consisting of ethane-propane feed with the help of a process flow sheet for the manufacturing of ethylene and propylene as employed at UP Petrochemical complex, Pata. Mention the major engineering problems encountered in the process and also the effects of operating parameters on the yield. [09]

OR

1. (a) Define the term petrochemical, incisor and finished product(s) with an example as employed in the petrochemical industry. [03]
(b) Mention basic raw materials/feed stocks supplied by the petroleum refineries for the manufacture of petrochemical with the help of a schematic diagram. [05]
(c) Describe the process of manufacture of olefins from the cracking of Naphtha or gas oil with the help of a process flow sheet. [07]

2. (a) Why ethylene and propylene are called building blocks of petrochemical industry? [03]
(b) List the important petrochemicals derived starting from C1, C2 and benzene to value added products with the help of chemical reactions. [09]
(c) Explain the terms, Dry and wet natural gas and which gas is more important from the petrochemical industry point of view. [03]

3. (a) Explain with the help of an example the catalytic and non-catalytic reactions of hydrocarbons as applicable from the viewpoint of Petrochemical Industry. [06]
(b) Explain in detail the various reforming processes with reference to process variables such as feed stock, temperature, pressure, space velocity, catalyst poison and hydrogen to hydrocarbon ratio. [09]

Contd......2
4. (a) Define the term isomerization and its application in petrochemical industry with reference to examples.

(b) Explain the hydrodealkylation process and its merits and demerits. Explain the various alkylation processes.

(b') Explain the significance of disproportionation reaction in petrochemical industry and its advantages of over the reforming process. Describe the effect of operating parameters on the yield of product production.

(c) Define Nitration with reference to petrochemical industry. What are the various hydrocarbon group(s) which can be easily nitrated for the production of Petrochemicals.
2012 2013

B.TECH. AUTUMN (III SEMESTER) EXAMINATION
(PETRO-CHEMICAL ENGINEERING)

FLUID MECHANICS & MECHANIAL OPERATIONS
(PK—213 N)
Credits: 05

Maximum Marks : 60
Duration: Three Hours

Note: Answer all the questions.
Use of graph paper is allowed.

QL. (a) What are different types of fluid machines? Discuss the various parts of centrifugal
pumps with neat sketch, also describe NPSH and Cavitations. (4)

(b) An inverted U tube manometer is connected to two horizontal pipes A and B
through which water is flowing. The vertical distance between the axis of the pipes is 30 cm. When
an oil of specific gravity 0.8 is used as a gauge fluid, the vertical heights of the column in the two
limbs of the vertical manometer (when measured from the respective centres of the pipes) are
found to be same and equal to 3.5 cm. Determine the difference of pressure between the pipes. (8)

OR

(b'). Crude oil of specific gravity 0.8 flows upward at a volume rate of flow 50 liters per
second through a vertical venturimeter with an inlet diameter of 200 mm and a throat diameter
of 100 mm. The coefficient of discharge of venturimeter is 0.98. The vertical distance between the
pressure tapings is 300 mm.

(i) If two pressure gauges are connected at the tapings such that they are positioned at the levels
of their corresponding tapping points, determine the difference of readings in N/cm² of the two
pressure gauges.

(ii) If the mercury differential manometer is connected, in place of pressure gauges, to the tapping
such that the connecting tube up to mercury are filled with oil, determine the difference in the
level of the mercury column. (8)

Q2. (a) Prove that when the screen diameter (davg) of a particle is nearly equal to its volumetric
diameter (dv), then its specific surface ratio (n) is equal to its shape factor (λ). (6)

(b) Calculate the Specific Surface & Sauter diameter for the following sample of Galena
(Specific gravity = 7.43). Show the detailed calculations. (6)

Contd...... 2
<table>
<thead>
<tr>
<th>Size range (µm)</th>
<th>Mass of particle (gram)</th>
<th>n(Specific Surface ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-704+352</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>-352+176</td>
<td>37.2</td>
<td>1.7</td>
</tr>
<tr>
<td>-176+88</td>
<td>62.5</td>
<td>1.6</td>
</tr>
<tr>
<td>-88+44</td>
<td>75</td>
<td>1.5</td>
</tr>
<tr>
<td>Pan</td>
<td>50</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Q3(a) Explain different reasons which make crushing a most energy efficient process. (5)

OR

(vi) Explain the working and construction of a Ball Mill. (5)

(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 (7)

Q4(a) (b) Discuss any two of the following: (3+3)

(i) Flotation

(ii) Wall effect on Settling

(iii) Electrostatic precipitator

(iv) Hindered settling

Contd...... 3
(b) Calculate the settling velocity of glass spheres having a diameter of $1.554 \times 10^{-9} \text{m}$ in water at 20°C. The slurry containing 50 wt% solids. The density of the glass spheres is 2467 kg/m$^3$.

(Take density of water = 998 kg/m$^3$, viscosity of water = $1.005 \times 10^{-3}$ Pa.S). (6)

QS(a) Derive the equation of minimum fluidisation velocity for a fluid flowing through a fluidised bed. (6)

(b) Describe the process of filtration. Differentiate between filter media and filter aids with examples. (6)

OR

(b') Describe the working and construction of a filter press with the help of a neat sketch. (6)
1. (a) Explain the following terms used in the reaction engineering kinetics.
(i) Elementary and non-elementary reaction.
(ii) Order and molecularity of non-elementary reactions.
(iii) Single and multiple reactions.
(b) Explain the temperature dependency of a reaction rate from Transition state theory and show that rate is proportional to $T^e e^{-E/R T}$ for a bimolecular reaction and show that Arrhenius law is a good approximation to the temperature dependency of both collision and transition state theory.
(c) Explain the significance of Arrhenius plot.

2. (a) The reactions involved in the cracking of a heavy hydrocarbon undergoes the following consecutive reactions.

\[ \begin{align*}
A \rightarrow_{k = 1/ \text{hr}} R \rightarrow_{k = 1/ \text{hr}} \text{S (Residue)}
\end{align*} \]

Determine the time at which the moles of R (light faction) produced per mole of A feed are at their maximum value and also the maximum value of R per mole of A. Derive the equations used. Feed is pure A at $t = 0$.

(b) Explain the integral and differential method of analysis of batch reactor data.
(c) Explain the shifting order reactions with an example and obtain the value of rate constants.

OR

2. (a) Enzyme B catalyses the transformation of reactant A to produce R as follows

\[ A \rightarrow_{\text{enzyme}} R \quad \gamma_A = \frac{200 C_A C_{A0}^2}{2 + C_A} \text{ ml/lit/min} \]

If we introduce enzyme ($C_{I0} = 0.001 \text{ mol/liter}$) and reactant ($C_{A0} = 10 \text{ mol/liter}$) into a batch reactor and let the reaction proceed. Find the time needed for the concentration of reactant drops to 0.025 mol/liter. Note that the concentration of enzyme remains unchanged during the reaction.

Contd.....2
(b) For an elementary reaction, \(\text{A} + \text{R} \rightarrow \text{R} + \text{R}_{2}\), the reaction rate has been approximated by \(\gamma_{R} = 0.1 \ C_{\text{A}} C_{\text{R}}\). Determine the time required for 50% conversion of \(\text{A}\) if the compositions of the reactants maintained in the reactor at \(t = 0\) is \(C_{\text{A}_0} = 0.99\ \text{mol/liter}\) and \(C_{\text{R}_0} = 0.01\ \text{mol/liter}\). Derive the equation used.

3. (a) Explain why plug flow reactor is more efficient than mixed flow reactor for single reaction? In a system, \(N\) equal size mixed flow reactors have been arranged in series. Show with the help of mathematical derivation that the system will behave like a plug flow reactor if \(N \rightarrow \infty\). Density changes, if any, may be assumed to be negligible.

(b) For an elementary reaction \(\text{A} \rightarrow \text{R}_{2}\), the rate is approximated as \((-\gamma_{\text{A}}) = 0.1 \ C_{\text{A}}^{2}\).

Determine the ratio of mixed flow reactor to plug flow reactor if the level / extent of conversion required is 60%. The feed entering in both the reactors is pure \(\text{A}\) and is equal to \(C_{\text{A}_0} = 1.0\ \text{mol/liter}\).

OR

(b') The homogeneous gas decomposition of phosphine

\[4\text{PH}_3 \rightarrow \text{P}_4 (g) + 6\text{H}_2 (g)\]

proceeds at 640°C with the first order rate, \(-\gamma_{\text{PH}_3} = \frac{10}{\text{hr}} C_{\text{PH}_3}\), what size of plug flow reactor operating at 640°C and 400 KPa can produce 70% conversion of a feed containing 40% mole of pure phosphine per hour.

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

(b) For the decomposition of \(\text{A}\), \(\text{A} \rightarrow \text{R}_{2}\ \rightarrow \text{R} \rightarrow \text{S}\) occurring in a mixed flow reactor with space time of 1.0 hr\(^{-1}\). Find the temperature which maximizes the production of \(\text{R}\). Fed is pure \(\text{A} (C_{\text{A}_0} = 1.0 \ \text{g mole/liter})\). Find the concentration of \(\text{R}\) at the outlet of the reactor. Derive the equation(s) used.

OR

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

\[ k_1 \rightarrow R_{(desirable)} \]
\[ k_2 \rightarrow S \]
\[ K_3 \rightarrow T \]
\[ k_1 = 10^6 e^{-3600/T} \]
\[ k_2 = 10^5 e^{-3300/T} \]
\[ k_3 = 10^9 e^{-6000/T} \]

Find the temperature which maximizes the yield of R and also the \( R_{\text{max}} \) in the batch reactor at this temperature. Derive the equations used.

(c) For the parallel decomposition,

\[ A \]
\[ k_1 \rightarrow R_{(desirable)} \]
\[ k_2 \rightarrow S \]
\[ k_3 \rightarrow \]

\[ r_R = k_1 C^*_A \]
\[ r_S = k_2 C^*_A \]
\[ r_T = k_3 C^*_A \]

if \( k_1 = k_2 = 1 / \text{hr} \).

then discuss qualitatively the types of reactor if \( a_1 > a_2 \) and \( a_3 > a_1 \).
1(a). Discuss the Modern theory to explain the origin of petroleum. (2)
(b). What is India's vision for 2020 in petroleum refining? Mention the name of any four Indian petroleum refineries along with their refining capacity. (2)
(i) Kerogen and Oil shale  (ii) Resins and Asphaltenes  (iii) Porphyrins. (3*3)

b') Write explanatory notes on:

- Heavy and extra heavy crude oil.
- Natural gas and natural gas liquids
- Corrosive and noncorrosive crude oils. (3+3)

2(a). What are the hydrocarbon components of petroleum? Discuss in detail the about paraffins and naphthenes along with their important properties. (9)

OR

(a') What are the non-hydrocarbon constituents of crude oil? Give detailed classification of sulfur and nitrogen compounds present in the crude oil along with its adverse effects. (9)

OR

b') What do you mean by TBP distillation? Describe briefly the different sequences followed for the operation of a TBP distillation. (9)

(b). What do you mean by API gravity? Why it is preferred for expressing the density of crude oils. (3)

(c). Discuss briefly different types of average boiling points. (3)

3(a). Briefly describe the process of electric desalting. Discuss the atmospheric distillation process with the help of a neat sketch. Give the different products of crude oil distillation mentioning their boiling range, carbon number and uses. (10)
OR

(a'). Write short notes on the following petro products:
- Motor Gasoline
- Aviation Turbine fuels

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

OR

(b'). How is bitumen manufactured? What is its composition and critical performance characteristics?

4(a). What are petrochemicals? Give their classification. Are they different from synthetic organic chemicals?

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

OR

(b'). What is the difference between halogenations of an olefin and toluene?

(c). Write down the reaction mechanism and application of isomerization reaction.

(d). Briefly describe the reaction mechanism behind catalytic cracking.
Maximum Marks : 60

Note: Answer all the questions.
Use of graph paper is allowed.

Q1(a) Differentiate any one of the following

i) Ideal and Actual Screen
ii) Capacity and Effectiveness of Screens

Q1(b) Classify conveyors. Discuss the use of idlers and take-ups in belt conveyors.

Q1(c) Prove that when the hold up of solid is very large in a Bin, further addition of solids will not materially change the total pressure on the bin floor, hence prove the Jansew equation.

OR

Q1(c) Give the Sphericity of Rasching ring whose length & diameter are equal.

Q1(d) Table salt is being fed to a vibrating screen at the rate of 150 kg/hr. The desired product is -30 + 20 mesh fraction. A 30 mesh and a 20 mesh screen are therefore used (double deck), the feed being introduced on the 30 mesh screen. During the operation, it was observed that the average proportion of oversize (from 30 mesh screen): oversize (from 20 mesh screen): undersize (from 20 mesh screen) is 2 : 1.5 : 1. Calculate the effectiveness of the screeners from the following data:

<table>
<thead>
<tr>
<th>Mesh</th>
<th>Feed</th>
<th>Oversize from 30 Mesh Screen</th>
<th>Oversize from 20 Mesh Screen</th>
<th>Undersize from 20 Mesh Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>-85 + 60</td>
<td>0.097</td>
<td>0.197</td>
<td>0.026</td>
<td>0.0005</td>
</tr>
<tr>
<td>-60 + 40</td>
<td>0.186</td>
<td>0.389</td>
<td>0.039</td>
<td>0.0009</td>
</tr>
<tr>
<td>-40 + 30</td>
<td>0.258</td>
<td>0.337</td>
<td>0.022</td>
<td>0.0036</td>
</tr>
<tr>
<td>-30 + 20</td>
<td>0.281</td>
<td>0.066</td>
<td>0.526</td>
<td>0.3490</td>
</tr>
<tr>
<td>-20 + 15</td>
<td>0.091</td>
<td>0.005</td>
<td>0.061</td>
<td>0.2990</td>
</tr>
<tr>
<td>-15 + 10</td>
<td>0.87</td>
<td>0.006</td>
<td>0.026</td>
<td>0.3470</td>
</tr>
</tbody>
</table>

Contd...... 2
Q2(a) What do you mean by centrifuging of Ball mill? Derive the expression for the critical speed \((N_c)\) of ball mill by assuming that the \(R\) and \(r\) be the radii of the mill and the balls respectively and \(m\) is the mass of the balls.

\[\text{OR}\]

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

(b) A grinder is to be used (which is 8% efficient) to handle 10 tonnes per hour of a siliceous ore (Specific Gravity = 2.65). The feed and the product analyses are given below:

<table>
<thead>
<tr>
<th>Screen Size (mm)</th>
<th>Feed Mass Fraction</th>
<th>Product Mass Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.327—2.362</td>
<td>0.143</td>
<td>0.0</td>
</tr>
<tr>
<td>-2.362—1.651</td>
<td>0.211</td>
<td>0.0</td>
</tr>
<tr>
<td>-1.651—1.168</td>
<td>0.230</td>
<td>0.0</td>
</tr>
<tr>
<td>-1.168—0.833</td>
<td>0.188</td>
<td>0.098</td>
</tr>
<tr>
<td>-0.833—0.589</td>
<td>0.120</td>
<td>0.234</td>
</tr>
<tr>
<td>-0.589—0.417</td>
<td>0.076</td>
<td>0.277</td>
</tr>
<tr>
<td>-0.417—0.295</td>
<td>0.03</td>
<td>0.149</td>
</tr>
<tr>
<td>-0.295—0.208</td>
<td>0.0</td>
<td>0.101</td>
</tr>
<tr>
<td>-0.208—0.147</td>
<td>0.0</td>
<td>0.068</td>
</tr>
<tr>
<td>-0.147—0.104</td>
<td>0.0</td>
<td>0.044</td>
</tr>
<tr>
<td>-0.104</td>
<td>0.0</td>
<td>0.029</td>
</tr>
</tbody>
</table>

The grinder operates on a 24 hour basis for 300 days per year and electricity cost 70 p. per kWh. Estimate the annual power cost of grinding the ore if the work index is 13.57 kWh per tonne.

Q3(a) What are the different forces acting on the particle of density \(\rho_s\) when it is falling through the liquid of density \(\rho_l\). Drive the terminal settling velocity of this particle as proposed by the Newton.

\[\text{Contd...... 3}\]
(b) Calculate the settling velocity of glass spheres having a diameter of \(1.551 \times 10^{-4} \text{m}\) in water at 20°C. The slurry containing 60 wt\% solids. The density of the glass spheres is 2467 kg/m³. (Take density of water = 998 kg/m³, viscosity of water = \(1.005 \times 10^{-3}\) Pa.s).

(c) Discuss the effect of wall and presence of other particle ( hindered settling) on particle dynamics when it flows through the liquid.

**OR**

(c') Differentiate the process of Elutriation and centrifugal settling.

Q4 (a) Derive Carman-Kozeny equation. Write down the limitations by which this equation suffers.

(b) Explain the process of fluidization with the help of a graph between pressure drop across the bed & superficial velocity of fluid. Give some industrial applications of fluidization.

**OR**

(b') Describe Loading and Flooding points in a packed tower. Derive the relation of pressure drop across the Filter bed cake.

(c) Discuss the working and construction of rotary drum filter with the help of a neat sketch.
2012 – 2013
B.TECH. AUTUMN (III SEMESTER) EXAMINATION
(PETRO-CHEMICAL ENGINEERING)
PETROLEUM REFINING PROCESS
(PK. 311 N)
Credits: 04

Maximum Marks : 60
Note: Answer all the questions.

Q1(a) Explain in brief the operation of ADU and VDU. 6
(b) Differentiate between:
   (i) TBP distillation and Simulated distillation 6
   (ii) Crude oil distillation and conventional distillation
   (iii) Thermal cracking and Catalytic cracking
(c) What is overflash? Give the significance of overflash in Atmospheric and Vacuum Distillation of crude oil.

Q2(a) Explain in brief Dual Gasification flexi-coking process with its need, reactions and advantages over other coking processes with neat sketch. 10

OR

(a') Discuss with the help of a process flow sheet conventional visbreaking process with special reference to modification for maximization of diesel oil production. Mention the advantages of high conversion soaker visbreaking over conventional soaker visbreaking. 5
(b) What causes coking in furnace tubes? How can you determine that furnace is due for decoking. Explain the process of decoking of furnace tubes.

Q3(a) Discuss the technological aspects and principles of operation of FCC. 6
(b) Mention at least four applications of Hydrotreating Processes. 4
(c) Explain why catalytic polymerization processes becomes important to refiners? 2
(d) Mention the important catalyst available for catalytic isomerization with their merits and demerits. 3
Q3'(a) Explain with the help of a neat sketch the hydrocracking process with respect to feedstock, catalyst and reaction conditions.

(b) Only strong acids can catalyze the alkylation reactions. Why?

(c) Explain with the help of a process flow sheet $\text{H}_2\text{SO}_4$ alkylation (Stratco or Exxon) process with reference to process variables. Mention three advantages of each HF and H$_2$SO$_4$ alkylation.

Q4(a) Explain in brief wax sweating principles and applications. Mention the limitations of wax sweating process.

(b) Explain with the help of a process flow sheet hydrofinishing process for wax manufacture with its significance.

OR

(b') Discuss with the help of a process flow sheet Dilchill dewaxing process with its advantages.

(c) Mention the various solvents used in solvent extraction of lube oil fractions with their merits and demerits.