



17315

21415

3 Hours/100 Marks

Seat No.

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- Instructions :** (1) **All** questions are **compulsory**.
(2) Illustrate your answers with **neat sketches wherever necessary**.
(3) Figures to the **right** indicate **full marks**.
(4) **Assume** suitable data, **if necessary**.
(5) **Use** of Non-programmable Electronic Pocket Calculator is **permissible**.

MARKS

1. A) Attempt **any four** of the following : **(2×4=8)**
- a) State Raoult's law and give its mathematical statement.
 - b) For a gaseous system state the relationship between partial pressure and total pressure.
 - c) Give mathematical statement of ideal gas law and state the value of universal gas constant and its unit in S.I. system.
 - d) Draw a material balance diagram for evaporation and write the material balance equations for solids for the same.
 - e) What is limiting component in a chemical reaction ? Define conversion with respect to limiting component.
 - f) State Hess's law of constant heat summation.
- B) Attempt **any two** of the following : **(2×6=12)**
- a) Calculate the density of air at N.T.P. assuming 79 mole% N₂ and rest oxygen in air.
 - b) 10,000 kg/hr of 10% NaOH solution is fed to an evaporator to obtain a thick liquor containing 55% NaOH. Calculate the amount of water evaporated and thick liquor rate.
 - c) 10 kg of carbon is burnt in a combustion chamber with air which is 20% in excess than theoretically required. Calculate the composition of gases leaving the combustion chamber, assuming complete combustion of carbon.

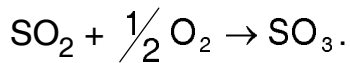
P.T.O.



MARKS

2. Attempt **any four** of the following : **(4×4=16)**

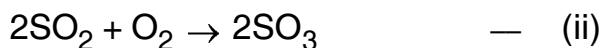
- a) State the steps involved in solving material balance problems without reaction.
- b) A gaseous mixture consists of 10% CO₂, 40% N₂, 30% O₂ and 20% CH₄ by weight. Express the composition of the gaseous mixture in mole%.
- c) A 10 kg solution contains 20% NaCl and 30% NaOH by weight, the rest is water. This solution is mixed with 5 kg of a new solution containing 10% NaOH and 25% NaCl by weight. Calculate the composition of the resulting mixture.
- d) A distillation column is fed with 5000 kg/hr of Benzene-toluene mixture containing 40% Benzene. The distillate obtained contains 90% Benzene and the bottom product contains 90% toluene. Calculate the flow rates of top and bottom product.
- e) Methane gas reacts with air, in a combustion chamber. If 100 kg of methane reacts with air and air fed is 50% excess than theoretically required. Calculate the composition of exit gases in mole% if the conversion of methane is only 40%.
- f) Sulphur tri-oxide is prepared by following reaction



If 10 kmoles of SO₂ reacts with 100 kmoles of air. Calculate the percent excess air used.

3. Attempt **any two** of the following : **(2×8=16)**

- a) An evaporator is fed continuously with 40000 kg/hr of a solution containing 12% NaOH, 12% NaCl, 76% water by weight. During evaporation water is boiled off and NaCl precipitated as crystal are removed. The concentrated liquor leaving the evaporator contains 50% NaOH, 1% NaCl and 49% H₂O. Calculate :
 - a) kg of water evaporated per hour
 - b) kg of salt precipitated per hour
 - c) kg of concentrated liquor produced per hour.
- b) Sulphuric Acid can be manufactured by following reactions :





MARKS

Assuming all reactions goes to completion and it is required to produce 20 tons/hr of 93.2% H_2SO_4 by weight. Calculate

- a) Tons/hr of sulphur required
 - b) Tons/hr of oxygen required
 - c) Tons/hr of water required.
- c) Calculate the standard enthalpy formation of $\text{CH}_3\text{COOH}_{(l)}$ using Hess's law from the following data :

Standard heat of combustion (ΔH_c°) = $-875 \frac{\text{kJ}}{\text{mol}}$ of CH_3COOH .

Standard heat of formation (ΔH_f°) of CO_2 = $-393.3 \frac{\text{kJ}}{\text{mol}}$.

Standard heat of formation (ΔH_f°) of H_2O = $-285.8 \frac{\text{kJ}}{\text{mol}}$.

4. Attempt **any two** of the following : **(2×8=16)**

- a) A gaseous mixture at 3 atmospheric pressure and 30°C contains 0.274 kmols HCl, 0.337 kmols of N_2 and 0.089 kmols of O_2 . Calculate
 - i) Volume occupied by this mixture
 - ii) Density of the gaseous mixture
 - iii) The partial pressure exerted by each component
 - iv) Composition in weight %.
- b) A spent acid from a nitrating process contains 35% HNO_3 , 35% H_2SO_4 and 30% H_2O by weight. This acid is strengthened by adding 95% H_2SO_4 and 76% HNO_3 . The final mixture contains 42% HNO_3 , 40% H_2SO_4 . Calculate the amount of spent acid and concentrated acids to be mixed to prepare 1000 kg of desired acid.
- c) In the Deacon process for manufacturing chlorine, hydrochloric gas is oxidized with air as follows
$$4\text{HCl} + \text{O}_2 \rightarrow 2\text{Cl}_2 + 2\text{H}_2\text{O}.$$
The air used is in excess of 30% than theoretically required and the oxidation is 80% complete. Calculate the composition by volume of gases leaving the reaction chamber.



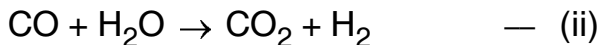
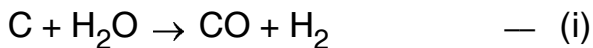
MARKS

(2×8=16)

5. Attempt **any two** of the following :

a) Soyabean seeds are extracted with hexane in an extractor. The seeds contain 18.6% oil 69% solids and 12.4% moisture. At end of extraction process, the cake is separated from hexane-oil mixture. The cake contains 0.8% oil, 87.7% solids and 11.5% moisture. Find the percentage recovery of oil.

b) Water gas is produced by passing steam over a hot bed of coke at 1000°C.



Calculate the consumption of coke and steam for producing 100 kmols of water gas containing 55.4% H₂, 44% CO and 0.6% CO₂ by volume. Coke contains 90% C by weight and yield is 90%.

c) 100 kg/hr of water at 25°C is to completely converted in to saturated steam at 100°C. Calculate the amount of heat required.

$$\text{Data : } C_p = 4.187 \frac{\text{kJ}}{\text{kg K}}$$

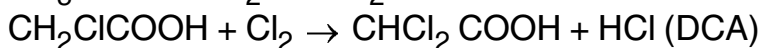
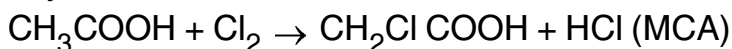
$$\text{Latent heat of vaporization} = 2240 \frac{\text{kJ}}{\text{kg}} .$$

6. Attempt **any two** of the following :

(2×8=16)

a) A gas containing 5% solute by volume and rest inerts is fed to an absorption tower at a rate of 1 m³/hr at 1 atmosphere and 25°C. In the absorption tower 90% of solute is absorbed. Calculate the composition of gas at the outlet in volume %. Also calculate the flow rate of gas at the outlet at 1 atmosphere and 25°C.

b) Monochloroacetic Acid (MCA) is manufactured in a semi batch reactor by action of glacial acetic acid with chlorine gas at 100°C. The MCA formed further reacts with chlorine to form dichloroacetic acid (DCA). To prevent formation of DCA, excess acetic acid is used. A small scale unit which produce 5000 kg/day MCA requires 4536 kg/day of chlorine gas. Also 263 kg/day of DCA is separated in crystallizer to get pure MCA. Find the % conversion and % yield of MCA. The reactions are



c) Define the following :

- | | |
|----------------------|-------------------------|
| a) Sensible heat | b) Latent heat |
| c) Heat of reaction | d) % conversion. |
| e) Adiabatic process | f) Absorption of gases. |
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