17315

21415

3 Hours/100 Marks

Seat No. | | | | | | | | |

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% N_2 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% CO_2 40% N_2, 30% O_2 and 20% CH_4 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

      $SO_2 + \frac{1}{2} O_2 \rightarrow SO_3$.

      If 10 kmoles of SO_2 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% H_2O. 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 :

      $S + O_2 \rightarrow SO_2$ — (i)

      $2SO_2 + O_2 \rightarrow 2SO_3$ — (ii)

      $SO_3 + H_2O \rightarrow H_2SO_4$. — (iii)

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 $CH_3COOH_{(l)}$ using Hess's law from the following data :

Standard heat of combustion $\left(\Delta H_c^\circ\right) = -875 \frac{kJ}{mol}$ of CH_3COOH.

Standard heat of formation $\left(\Delta H_f^\circ\right)$ of $CO_2 = -393.3 \frac{kJ}{mol}$.

Standard heat of formation $\left(\Delta H_f^\circ\right)$ of $H_2O = -285.8 \frac{kJ}{mol}$.

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

$4HCl + O_2 \rightarrow 2Cl_2 + 2H_2O$.

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

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

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.

$C + H_2O \rightarrow CO + H_2$ — (i)

$CO + H_2O \rightarrow CO_2 + H_2$ — (ii)

Calculate the consumption of coke and steam for producing 100 kmols of water gas containing 55.4% H_2, 44% CO and 0.6% CO_2 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.

Data : $C_P = 4.187 \frac{kJ}{kg\,K}$

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

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 m^3/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

$CH_3COOH + Cl_2 \rightarrow CH_2Cl\,COOH + HCl$ (MCA)

$CH_2ClCOOH + Cl_2 \rightarrow CHCl_2\,COOH + HCl$ (DCA)

c) Define the following :

a) Sensible heat b) Latent heat

c) Heat of reaction d) % conversion.

e) Adiabatic process f) Absorption of gases.
