QP Code : 30717

(3 Hours) [Total Marks : 80

B. : (1) Question number **One** is **compulsory**.
(2) Answer **any Three** questions from the rest.
(3) Assume suitable **data** wherever **necessary**.

(a) A mixture of CH_4 and C_2H_6 has density 1.0 kg/m^3 at 273 K and 101.325kPa pressure. Calculate the mole % and weight % of CH_4 and C_2H_6 in the mixture. 5

(b) A single effect evaporator is fed with 10000 kg/h of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight caustic (NaOH). 5
Calculate (i) kg of water evaporated (ii) kg/h thick liquor obtained.

(c) A sample of petrol contains 15% H_2 and 85% C by weight. Calculate the amount of air required for the complete combustion of 1 kg of petrol. Find the composition of the dry products on volume basis if 15% excess air is supplied. 5

(d) Define : 5
(i) Wet bulb temperature
(ii) Relative humidity.

(a) Prove that for a ideal gas mixture mol % = volume % = pressure %. 10

(b) Make the following conversions : 10
(i) 294 g/1 of H_2SO_4 to normality
(ii) 5 N H_3PO_4 to g/1
(iii) 54.75 g/1 HCl to molarity
(iv) 3M K_2SO_4 to g/1
(v) 4.8 mg/ml $CaCl_2$ to normality.
(Given atomic weights: H = 1; Cl = 35.5; O = 16; P = 31; K= 39).

(a) The waste acid from a nitrating process contain 30% H_2SO_4, 35% HNO_3 and 35% H_2O by weight. The acid is to be concentrated to contain 39% H_2SO_4 and 42% HNO_3 by addition of concentrated sulphuric acid containing 98% H_2SO_4 and concentrated nitric acid containing 72% HNO_3 (by wt.). Calculate the quantities of three acids to be mixed to get 1000 kg of desired mixed acid. 10

TURN OVER

(b) A feed to a continuous fractionating column analyses by wt. 28% benzene and 72% tolune. The analysis of the distillate shows 52 wt.% benzene and 5 wt.% benzene as found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feeder hour. Also calculate % recovery of benzene. 10

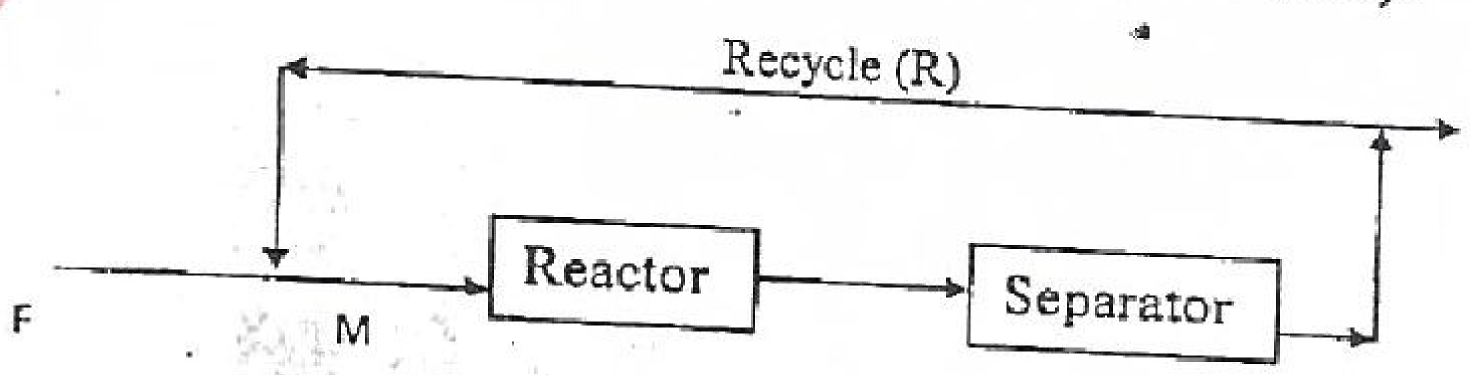
4. (a) A storage tank of a Demineralised Water (DM) has a holding capacity of 1500 m^3 upto an overflow point. The inflow of DM water to the tank is 25 l/s having silica (as SiO_2) content of 0.005 mg/1. The supply of DM water to the high pressure boilers from the tank amount to 25 l/s. With time, the DM water quality deteriorates and the silica content in the feed DM water increases to 0.02 mg/1. Assume that the inflow into and the outflow from the tank remains constant at 25 l/s. Calculate the time required for the silica content in the storage tank to increase to 0.01 mg/l. 10

(b) In production of chlorine gas by oxidation of HCl gas , air is used 30% in excess of that theoretically required. Based on 4 kmol HCl, Calculate : 10

(i) the weight ratio of air to hydrochloric acid gas in feed.

(ii) if oxidation is 80% complete, find the composition of product stream on mole basis.

5. (a) N_2-H_2 mixture with a molar ratio of 1:3 is used for the manufacture of NH_3 where 18% conversion is achieved. After separating NH_3 from the product, the unconverted gases are recycled. The feed contains 0.2 moles of argon per 100 moles of N_2-H_2 mixure. The tolerance limit of argon entering the reactor (i.e. inmixed feed) is 6 parts to 100 parts N_2-H_2 mixure by volume. Calculate the fraction of recycle that must be continuously purged and overall yield of NH_3 (F = feed; M = mixed feed). 10



(b) Calculate the standard heat of formation of chloroform gas from its elements using Hess's law. 10

Data :

$C (s) + O_2 (g) \longrightarrow CO_2 (g)$ $\Delta H_1 = -393.51$ kJ/mol

$H_2 (s) + 0.5\ O_2 (g) \longrightarrow H_2O (l)$ $\Delta H_2 = -285.83$ kJ/mol

$0.5H_2 (g) + 0.5Cl_2 (g) \longrightarrow HCl (aq)$ $\Delta H_3 = -167.57$ kJ/mol

$CHCl_3 (g) + 0.5O_2 (g) + H_2O (l) \longrightarrow CO_2 (g) + 3HCl (aq)$

$\Delta H^\circ_c = -509.95$ kJ/mol

(a) Air containing 21 mol% O_2 and 79 mol% N_2 is to be heated from 303 K to 423 K. Calculate the heat required to be added if the air flow rate is 3 m^3 (NTP) per minute using data given below : 10

$C_p^\circ = a + bT + cT^2 + dT^3$ (kJ/kmol-K)

gas	a	b x 10^3	c x 10^6	d x 10^9
O_2	26.0257	11.7551	-2.3426	-0.5623
N_2	29.5909	-5.141	13.1829	-4.968

(b) Obtain an empirical equation for calculating the heat of reaction at any temperature T (K) for the reaction. 10

$CO (g) + 2 H_2 \rightarrow CH_3OH (g)$

Data : standard heat of reaction $\Delta H^\circ_R = -90.41$ KJ/mol;

C_p data :

For CO_2 (g) $Cp = 29.03 - 2.82 \times 10^{-3}T + 11.64 \times 10^{-6}T^2$

For H_2 (g) $Cp = 28.61 + 1.02 \times 10^{-3}T + 0.15 \times 10^{-6}T^2$

For CH_3OH (g) $Cp = 21.14 + 70.84 \times 10^{-3}T + 25.86 \times 10^{-6}T^2$

C_p is in J/mol-K and T in K.
