12/06/2025 SE CHEMICAL SEM-III C-SCHEME PC QP CODE: 10079609

Time: 3 hours **Marks: 80**

N.B. : 1) Question No.1 is compulsory
2) Answer any three questions from remaining questions
3) Assume data if necessary and specify assumptions clearly

Q.1 a) An aqueous of Acetic Acid **(CH_3COOH)** of 30% concentration (by mass) has density 1040 kg/m3. Find Molality, Normality and Molality of the solution. **[5 marks]**

b) A natural gas has the following composition by volume, Calculate the density of the gas at 288 K and 101.325. **[5 marks]**
CH_4 = 82 % , C_2H_6 = 12 % and N_2 = 6 %

c) Write short note on Heat of Reaction and Heat of Formation **[5 marks]**

d) Define limiting reactant, conversion, yield and selectivity , **[5 marks]**

Q.2 a) A dryer is fed with wet solid to reduce the moisture content from 80% to 15%. The product leaving the dryer is sent to oven to reduce the moisture content to 2%. If 1000 kg of wet solid is fed to the dryer, find out the weight of the products leaving the dryer and oven. Also determine the amount of water removed in dryer and in oven. **[10 marks]**

b) The spent acid from a nitrating process contains 21 % HNO_3, 55 % H_2SO_4 and 24 % H_2O by weight. This acid is to be concentrated to contain 28% HNO_3 and 62 % H_2SO_4 by addition of concentrated sulphuric acid containing 93% H_2SO_4 (by weight) and concentrated nitric acid containing 90% HNO_3 (by weight). Calculate the weights of spent acid, concentrated suphuric acid and concentrated nitric acid that must be combine to obtain 1000 kg of the desired mixture. **[10 marks]**

Q.3 a) A solution of potassium dichromate in water contains 15% potassium dichromate by weight. 1000 kg of this solution is evaporated to remove some of water. The remaining solution is cooled to 298 K. If the yield of potassium dichromate crystals is 75%, calculate the amount of water evaporated. Solubility of potassium dichromate in water is 115 kg per 1000kg water. **[10 marks]**

b) Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the reaction: **[10 marks]**

$$\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3$$

Data: ΔH^0_R= -46.222 kJ

C_p^0 = a+bT+cT^2 , J/(mol.K)

Component	a	B×10^3	C×10^6
NH_3	25.48	36.89	-6.305
N_2	27.31	5.2335	-4.1868
H_2	29.09	-8.374	2.0139

Q.4 a) Formaldehyde is Produced by dehydrogenation of methanol. **[10 marks]**

$CH_3OH \longrightarrow HCHO + H_2$

The per pass conversion is 67 %. The product leaving the reactor is fed to a separation unit battery where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to the reactor. If the production rate of formaldehyde is 1000 kg/h. Calculate: The combined feed ratio, Recycle ratio and The flow rate of methanol required to the process as fresh feed.

b) Oxidation of ethylene to produce ethylene oxide is given by reaction: **[10 marks]**

$C_2H_4 + \frac{1}{2}O_2 \longrightarrow C_2H_4O$

If air is used 20 % in excess of that theoretically required, calculate the quantity of air supplied based on 100 kmol of ethylene fed to the reactor.

Q.5 a) A vapour at 411 K and Standard atmospheric pressure, containing 0.72 mole fractions Benzene and 0.28 mole fractions Toluene serve as a feed to a fractionating column in which it is separated in to a distillate containing 0.995 mole fraction Benzene and bottoms with 0.97 mole fraction Toluene. The reflux ratio is desired to be 1.95 kmol/kmol of distillate product. For a feed of 100 kmol, compute the overall material and energy balances. Assume that there is no heat loss to the surrounding and the heat of solution is negligible. **[10 marks]**

Enthalpy of Vapours(overhead)=42170 kJ/kmol mixture
Enthalpy of liquid(overhead)=11370 kJ/kmol mixture
Specific enthalpy of bottom product= 18780 kJ/kmol mixture
Enthalpy of feed = 44500 kJ/kmol

b) Temperature of oxygen is raised from 850 K to 1500 K. calculate the amount of heat that must be supplied for raising the temperature of 1 kmol oxygen using C_P^0 data given below. **[10 marks]**

C_P^0 For oxygen = $26.0257 - 11.7551 \times 10^{-3} T - 2.3426 \times 10^{-6} T^2 - 0.5623 \times 10^{-9} T^3$.

Q.6 a) Calculate the standard heat of formation of liquid methanol. **[20 marks]**

Data:
Std. Heat of combustion of methanol= -726.55 kJ/kmol
Std. Heat of formation of gaseous CO_2 = -393.51 kJ/kmol
Std. Heat of formation of liquid H_2O = -285.84 kJ/kmol

b) In the production of SO_3, 100 Kmol of SO_2, and 200 Kmol of O_2 are fed to the reactor , The product stream are found to contain 80 Kmol of SO_3Find the percentage conversion of SO_2

c) Explain recycle and purge operation in detail

d) Explain Hess's law