1T00533 - S.E.(Chemical Engineering)(SEM-III)(Choice Base Credit Grading System) (R- 19) (C Scheme) / 50725 - Process Calculations QP CODE: 10013788 DATE : 05/06/2023

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) Write a note on Latent heat. [5]

b) Draw the material balance diagram for Distillation and Extraction. and write down their material balance. [5]

c) Define Normality, Molarity and Molality. [5]

d) Define Yield and Selectivity. [5]

Q.2 a) Propane is burned with excess air to ensure complete combustion. If 55 kg of CO_2 and 15 kg of CO are obtained when propane is burned completely with 500 kg air, determine the following [10]

i) The mass of propane burnt(in kg)

ii) The % excess air

b) In the production of chlorine gas by oxidation of hydrochloric acid gas, air is used 30 % in excess of that theoretically required. Based on 4 kmol of HCl fed, calculate: [10]

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

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

Q.3 a) 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]

[10]

b) An aqueous solution of methanol containing 20 % (weight) methanol is to be separated into a distillate product containing 97 % (weight) methanol and a bottom product containing 2 % (weight) methanol. For treating 100 kg of feed with a reflux ratio of 3.5 on a weight basis, calculate the following: [10]

i) The amounts of distillate and bottom products

ii) The amount of vapor condensed in the condenser per kg of distillate

iii) The amount of vapor condensed in the condenser per kg of feed

Q.4 a) Obtain an empirical equation for calculating the heat of reaction at any temperature T(in K) for the reaction: [14]

$CO_{(g)} + 2H_{2(g)} \longrightarrow CH_3OH_{(g)}$

Data: ΔH_R^0 = -90.41 kJ/mol

Component	a	B	c	d
$CO_{(g)}$	29.0277	-2.8165×10^{-3}	11.6437×10^{-6}	-4.7063×10^{-9}
$H_{2(g)}$	28.6105	1.0194×10^{-3}	-0.1476×10^{-6}	0.769×10^{-9}
$CH_3OH_{(g)}$	21.137	70.843×10^{-3}	25.86×10^{-6}	-28.497×10^{-9}

b) A stream of nitrogen flowing at a rate of 100 kmol/h is heated from 303 K to 373 K. Calculate the heat that must be transferred : [6]

C_P^0 for nitrogen = $29.5009 - 5.141 \times 10^{-3} T + 11.1829 \times 10^{-6} T^2 - 4.968 \times 10^{-9} T^3$. (kJ/kmol.K)

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]

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) Formaldehyde is Produced by dehydrogenation of methanol. [10]

$CH_3OH \longrightarrow HCHO + H_2$

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

i) the combined feed ratio

ii) The flow rate of methanol required to the process as fresh feed.

Q.6 Attempt any four from the following [20]

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

b) Write a note on Hess's law and Standard heat of reaction

c) Calculate the standard heat of formation of liquid methanol.
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

d) 10 kg of liquid A of specific gravity 1.17 is mixed with 5 kg of liquid B of specific gravity 0.83. Assuming that there is no volume change on mixing, what is the specific gravity of the mixture? (take density of water 1000 kg/m^3)

e) Formaldehyde is produced from methanol in a catalytic reactor. The production rate of formaldehyde is 1000 kg/h. If the conversion of methanol is 65 %. Calculate the required feed rate of methanol.

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