1T00533 - S.E.(Chemical Engineering)(SEM-III)(Choice Base Credit Grading System) (R- 19) (C Scheme) / 50725 - Process Calculations

QP CODE: 10041220 DATE: 02/12/2023

(3 Hours) **[Total Marks: 80]**

N.B. (i) Question number 1 is compulsory.
(ii) Answer any three questions from rest.
(iii) Assume suitable data wherever necessary.

Q. 1 (A) Discuss recycle and purging operations. **[05]**

(B) Define the terms percent conversion, yield, selectivity and limiting reactant. **[05]**

(C) Calculate the standard heat of formation of liquid methanol. **[05]**
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) Calculate the equivalent weights of the following compounds **[05]**
(i) H_3PO_4 (ii) $CaCl_2$ (iii) NaOH (iv) Na_2CO_3 (v) H_2SO_4

Q. 2 (A) Show that: Pressure % = Mole % **[10]**

(B) To prepare 0.5 litre of 1 normal, 1 molar and 1 molal solution of H_2SO_4 with the density of H_2SO_4 solution to be 1.075 g/cm^3, calculate the amounts of H_2SO_4 required for each solution. **[10]**

Q. 3 (A) A gaseous mixture has the following composition by volume: **[10]**
CO_2 = 8%, CO = 14, O_2 = 6%, H_2O = 5% CH_4 = 1% and N_2 = 66%
Calculate (i) the average molecular weight of the gas mixture and (ii) the density of the gas mixture at 303 K and 101.325 kPa.

(B) The dilute acid containing 25% H_2SO_4 is concentrated by commercial grade sulphuric acid containing 98% H_2SO_4 to obtain desired acid containing 65% H_2SO_4. Find the quantities of the acids required to make 1000 kg of desired acid. **[10]**

Q. 4 (A) An evaporator system concentrating a weak liquor from 5% to 50% solids handles 100 kg of solids per hour. If the same system is to concentrate a weak liquor from 4% to 35%, find the capacity of the system in terms of solids that can be handled per hour assuming water evaporation capacity to be same in both the cases. **[10]**

(B) In production of chlorine gas by oxidation of hydrochloric acid gas, air is used 30% in excess of that theoretically required. Based on 4 kmol HCl, calculate: (a) Weight ratio of air to hydrochloric acid gas in feed. (b) If oxidation is 80% complete, find the composition of product stream on mole basis. **[10]**

Q. 5 (A) A coke is known to contain 90% carbon and 10% non-combustible ash (by weight): **[10]**
(i) How many moles of oxygen are theoretically required to burn 100 kg of coke completely?
(ii) If 50% excess air is supplied, calculate the analysis of gases at the end of combustion.

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

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

Data: ΔH_R^0 = -90.41 kJ/mol
$C_p^o = a + bT + cT^2 + dT^3$, kJ/(kmol.K)

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}

Q. 6 (A) The gas having the following composition at temperature of 775 K: **[10]**
SO_2 = 7.09%, O_2 = 10.55%, SO_3 = 0.45% and N_2 = 81.91%
Calculate the heat content of 1 kmol gas mixture over 298 K using the heat capacity data given below:
$C_p^o = a + bT + cT^2 + dT^3$, kJ/(kmol.K)

Gas	a	$b*10^3$	$c*10^6$	$d*10^9$
SO_2	24.7706	62.9481	-44.2582	11.122
O_2	26.0257	11.7551	-2.3426	-0.5623
SO_3	22.0376	121.624	-91.8673	24.3691
N_2	29.5909	-5.141	13.1829	-4.968

(B) A dryer is used to dry 100 kg/h wet solids from 20% to 1% moisture by weight by hot air. Fresh air containing 0.02 kg water vapour per kg dry air is available at 303 K and 101.325 kPa. Air leaving the dryer is found to contain 0.1 kg water vapour per kg dry air. If recycle ratio is maintained at 3 kg dry air in recycle air per kg dry air in fresh air, calculate the volumetric flow rate of fresh air assuming molecular weight of fresh air to be 28.8. **[10]**

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