1T00533 - S.E.(Chemical Engineering)(SEM-III)(Choice Base Credit Grading System) (R-2020-21) (C Scheme) / 50725 - Process Calculations

QP CODE: 10013789 DATE:01/12/2022

Time : 3 Hours **Marks : 80**

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

Q.1 (a) Prove that, Pressure% = Mole% . [5]

(b) Write note on liquid-liquid and solid-liquid Extraction based on material balance without chemical reactions. [5]

(c) Explain percent excess and percent conversion. [5]

(d) Describe Combined feed ratio and Purge ratio. [5]

Q.2 (a) A chemist is interested in preparing 500 ml of 1 normal, 1molar and 1 molal solution of H_2SO_4. Assuming the density of H_2SO_4 solution to be 1.075 g/cm^3, calculate the quantities of H_2SO_4 to be taken to prepare these solutions. [10]

(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 and concentrated nitric acid containing 90% HNO_3. 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]

Q.3 (a) A feed to a continuous fractionating column analyses by weight 28 percent benzene and 72 percent toluene. The analysis of the distillate shows 52 weight percent benzene and 5 weight percent benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 100 kg of feed per hour. Also calculate the percent recovery of benzene. [10]

(b) A gas mixture has the following composition by volume: SO_2 = 8.5%, O_2 = 10% and N_2 = 81.5%. Find (i) the density of gas mixture at a temperature of 473 K and 202.65 kPa g and (ii) composition by weight. [10]

Q.4 (a) Gaseous benzene (C_6H_6) reacts with hydrogen in presence of Ni catalyst as per the reaction: [10]

C_6H_6 (g) + $3H_2$ (g) → C_6H_{12} (g)

30% excess hydrogen is used above that required by the above reaction. Conversion is 50% and yield is 90%. Calculate the requirement of benzene and hydrogen gas for 100 moles of cyclohexane.

b) A natural gas has the following composition on mole basis: [10]

CH_4 = 84%, C_2H_6 = 13% and N_2 = 3%

Calculate the heat to be added to heat 10 kmol of natural gas from 298 K to 523 K using 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
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_6	5.4129	178.0872	-67.3749	8.7147
N_2	29.5909	-5.141	13.1829	-4.968

Q.5 (a) Calculate the standard heat of formation of chloroform gas from its elements using Hess's law. [6]

Data:

$C(s)+O_2(g)\rightarrow CO_2(g)$ ΔH_1 = - 393.51 kJ/mol

$H_2(g)+\frac{1}{2}O_2(g)\rightarrow H_2O(l)$ ΔH_2 = - 285.83 kJ/mol

$\frac{1}{2}H_2(g)+\frac{1}{2}Cl_2(g)\rightarrow HCl(aq)$ ΔH_3 = - 167.57 kJ/mol

$CHCl_3(g)+\frac{1}{2}O_2(g)+H_2O(l)\rightarrow CO_2(g)+3HCl(aq)$ ΔH^oC = - 509.95 kJ/mol

(b) Calculate the enthalpy change between reactants and products if both are at 298.15 K and if 60 mole of CO_2 is produced according to the following reaction, [6]

$2C_4H_{10}(g)+13O_2(g)\rightarrow 8CO_2(g)+10H_2O(l)$

Data:

Component	ΔH_f^o , kJ/mol at 298.15 K
$C_4H_{10}(g)$	- 125.79
$CO_2(g)$	- 393.51
$H_2O(l)$	- 285.83

(c) Formaldehyde is produced by dehydrogenation of methanol. [8]

$CH_3OH \rightarrow HCHO + H_2$

The per pass conversion is 67%. The product leaving the reactor is fed to separation unit where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to reactor. If the production rate of formaldehyde is 1000 kg/h, calculate (i) Combined feed ratio and (ii) Recycle ratio.

Q.6 (a) A mixture of NaCl and KCl was treated with H_2SO_4 and 1.175 kg of mixed sulphate (Na_2SO_4 and K_2SO_4) was obtained. If the original sample is 1 kg, estimate the percentage of Cl_2 in the sample. [10]

(b) Give the step wise procedure to calculate the reboiler load in a distillation unit. List the parameters required for the computation of the above. [10]

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