CBCS SCHEME

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18BT41

Fourth Semester B.E. Degree Examination, July/August 2021
Stoichiometry

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions.***

1 a. A mixture of CH_4 and C_2H_6 has density of 1 kg/m^3 at 273 K and 101.325 KPa. Calculate the mole% and weight% CH_4 and C_2H_6 in the mixture. **(06 Marks)**

b. A natural gas has the following composition by volume. CH_4 = 82%, C_2H_6 = 12%, N_2 = 6%. Calculate (i) Density of gas at 288 K and 101.325 kPa. (ii) Composition by weight % and (iii) Average molecular weight. **(10 Marks)**

c. Define Daltons and Amagots law. **(04 Marks)**

2 a. A chemist is interested in preparing 500 ml of 1 Normal, 1 Molar 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 the solution. **(10 Marks)**

b. An aqueous solution of K_2CO_3 is prepared by dissolving 43 kg of K_2CO_3 in 100 kg of water at 293 K. Calculate molarity normality and molality in solution. The density of solution is 1.3 kg / *l*. **(10 Marks)**

3 a. Soybean seeds are extracted with heaxane in batch extractor. The flaked seeds are found to contain 18.6% oil, 69% solid and 12.4% moisture by weight. At the end of the extraction process cake (meal) is separated from hexane oil mixture. The cake is analyzed to contain 0.8% oil, 87.7% solids and 11.5% moisture (by weight). Find the percentage recovery of oil. **(10 Marks)**

b. It is desired to have a mixed acid containing 40% HNO_3, 43% H_2SO_4 and 17% H_2O by weight. Sulphuric acid of 98% by weight is readily available . Calculate (i) The strength of the nitric acid and (ii) Weight ratio of sulphuric acid to nitric acid. **(10 Marks)**

4 a. A feed to a continuous distillation column analysis by weight 28% benzene and 72% toluene. The analysis of the distillate shows 52 weight % benzene and 5% of benzene in bottom product. Calculate the amount of distillate and product per 1000 kg of feed per hour. Also calculate the percent recovery of benzene. **(10 Marks)**

b. Crude oil is analyzed to contain 87% carbon, 12.5% hydrogen and 0.5% sulphur (by weight). Calculate the net calorific value of crude oil at 298 K.
Data : Gross calorific value of crude oil at 298 K (25°C) is 45071 kJ/kg oil. Latent heat of water vapour at 298 K is 2442.5 kJ/kg. **(10 Marks)**

5 a. A combustion chamber is fed with butane and excess air. Combustion of butane is complete. The composition of combustion of gases on volume basis is given below :
CO_2 = 9.39%, H_2O = 11.73%, O_2 = 4.70%, N_2 = 74.18%. Find the % excess air used and mole ratio of air to butane used. **(10 Marks)**

b. In the production of chlorine gas by oxidation of HCl gas, air is used 30% in excess of that theoretically required. Based on 4 Kmol of HCl. Calculate (i) The weight ratio of air to HCl (ii) If oxidation is 80% complete, find the composition of the product stream on mole basis. **(10 Marks)**

6 a. A Coke is known to contain 90% carbon and 10% non combustible ash (by weight) (i) How many moldes of oxygen are theoretically required to burn 100 kg of coke completely. (ii) if 50% excess air is supplied. Calculate the analysis. **(10 Marks)**

b. Define the following :
(i) Yield. (ii) Selectivity. (iii) Percent excess.
(iv) Stochrometric ratio. (v) Percent conversion. **(10 Marks)**

7 a. A natural gas has the following composition on mole basis : CH_4 = 84%, C_2H_6 = 13%, N_2 = 3%. Calculate the heat to be added to heat 10 kmol of natural gas from 298 K to 523 K. Using the heat capacity data given below : $C_P^\circ = a + bT + cT^2 + dT^3$. **(10 Marks)**

Gas	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
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

b. Obtain an empirical expression relating the heat of the reaction and the temperature of the reaction for the following reaction:

$$SO_2(g) + \frac{1}{2}O_2(g) = SO_3$$

Using the same expression, calculate the heat of reaction at 773 K.
Use Data :

Component	$\Delta H^\circ f, kJ/mol$
$SO_3(g)$	−395720
$SO_2(g)$	−296810

$C_P^\circ = a + bT + cT^2 + dT^3$ (KJ/KmolK)

Component	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
SO_3	22.036	121.624	−91.867	24.369
SO_2	24.771	62.948	−44.258	11.122
O_2	26.026	11.755	−2.343	−0.562

(10 Marks)

8 a. A natural gas has the following composition on mole basis : CH_4 = 84%, C_2H_6 = 13% and N_2 = 3%. Calculate (i) the heat added to heat 2 kmol of gas mixture from 311 K to 533 K.

(ii) The heat to be added to heat 200 kg of natural gas from 311 K to 533 K.
Data : C_{Pm}° values in KJ/KmolK **(10 Marks)**

Gas	$C_{Pm}^\circ(311-298)$	$C_{Pm}^\circ(533-298)$
CH_4	36.0483	41.7800
C_2H_6	53.5240	67.4954
N_2	29.1317	29.3578

b. Calculate the heat of formation of n-propanol liquid using the following data:
Standard heat of formation of CO_2 (g) = −393.51 kJ/mol.
Standard heat of formation of H_2O (*l*) = −285.83 kJ/mol
Standard heat of combustion of n-propanol = −285.83 kJ/mol **(10 Marks)**

9 a. Assume that experimental measurements for a certain organism have shown that cells can convert $\frac{2}{3}$ of substrate carbon to biomass.

$$C_6H_{12}O_6 + aO_2 + bNH_3 \rightarrow c[C_{4.4}H_{7.3}N_{0.86}O_{1.2}] + dH_2O + eCO_2$$

(i) Calculate the stoichiometric coefficients
(ii) Calculate yield coefficients $Y_{X/S}$ and $Y_{X/O2}$ **(10 Marks)**

b. Write a brief note on the historical developments of bioprocessing technology. **(10 Marks)**

10 a. Mention different unit operations involved in typical bioprocess with a flow sheet. **(10 Marks)**

b. With a neat process flow diagram, explain the production of ethanol. **(10 Marks)**

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