Sem III (Chem) – CBGS 3/6/14

PC

Process Calculation

QP Code : **NP-18732**

(3 Hours) [Total Marks : 80

N.B.: (1) Question No. 1 is compulsory.
(2) Assume relevant data if required.
(3) Attempt any three of remaining five questions.

1. (a) Write short notes on Psychrometric chart. 5
   (b) The ground nut seed containing 45% oil and 45% solids are fed to expeller, the cake coming out of expeller is found to contain 80% solids and 5% oil. Find the % recovery of oil. 5
   (c) What do you mean by steady state material balance and unsteady state material balance ? Explain with one example each. 5
   (d) Describe the method of orsat analysis for various gases of combustion. 5

2. (a) The available nitrogen (N) in the urea sample in found to be 45% by weight. Calculate the actual urea content in the sample. 5
   (b) Nitrogen-hydrogen mixture with a molar ratio of 1 : 3 is used for the manufacture of NH_3 where 18% conversion is achieved. After separating NH_3 from the product, unconverted gases are recycled. The feed contain 0·2 moles of argon per 100 moles of $N_2 - H_2$ mixture. The tolerance limit of argon entering the reactor (i.e. in mixed feed) is 6 parts to 100 parts N_2–H_2 mixture by volume. Calculate the fraction of recycle that must be continually purged and overall yield of ammonia. 15

3. (a) The waste acid from a nitrating process contains 30% H_2SO_4, 35% NHO_3 and 35% H_2O by wt. The acid is to be concentrated to contain 39% H_2SO_4 and 42% HNO_3 by addition of concentrated sulphuric acid containing 98% H_2SO_4 and concentrated nitric acid containing 72% HNO_3 (by wt.). Calculate the qualities of three acids to be mixed to get 1000 kg of desired mixed acid. 10
   (b) Ethylene oxide is prepared by oxidation of ethylene· 100kmol of ethylene and 100kmol of O_2 are charged to a reactor. The percent conversion of ethylene is 85 and percent yield of C_2H_4O is 94·12. Calculate the composition of product stream leaving the reactor. The reaction taking place are : 10

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

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

4. (a) A stream flowing at a rate of 15000 mol/h containing 25 mole % N_2 and 75 mole% H_2 is to be heated from 298 K(25°C) to 473K (200°C). Calculate the heat that must be transferred using C_p data given below : **10**

$$C_p = a + b\,T + CT^2 + dT^3 \text{ kJ/(kmol·K)}$$

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
N_2	29·5909	–5·41	13·1829	–4·968
H_2	28·6105	1·0194	–0·1476	0·769

(b) A natural gas contains 85% methane and 15% ethane by volume. Calculate the GHV of this fuel in kJ/kg from the standard heat of combustion of methane and ethane. **10**

$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$, $\Delta H_c° = -802·62$ kJ/mol

$C_2H_6(g) + 3·5\ O_2 \longrightarrow 2\ CO_2(g) + 3H_2O(g)$, $\Delta H_c° = -1428·64$ kJ/mol

Latent heat of water vapour at 298 K = 2442·5 (kJ/kg).

5. (a) Prove for ideal gas : Pressure % = mole % = volume %. **8**

(b) Write short notes on :— **12**

(i) Hess's law

(ii) Limiting reactant and excess reactant

(iii) Heat of dilution and heat of dissolution.

6. (a) Calculate the standard heat of formation of chloroform gas from its elements using Hess's Law. **10**

Data :

$C(s) + O_2(g) \longrightarrow CO_2(g)$ $\Delta H_1 = -393·51$ kJ/mol

$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O\ (l)$ $\Delta H_2 = -285·83$ kJ/mol

$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \longrightarrow HCl\ (aq)$ $\Delta H_3 = -167·57$ kJ/mol

$CHCl_3(g) + \frac{1}{2}O_2(g) + H_2O\ (l) \longrightarrow CO_2(g) + 3\ HCl(aq)$ $\Delta H_c° = -509·9J$ kJ/mol

(b) The orsat analysis of the flue gases from a boiler house chimney by volume is as given below : **10**

CO_2 : 11·4% O_2 : 42% and N_2 : 84·4%

Assuming the complete combustion takes place :

(i) Calculate the % excess of air

(ii) Find the C : H ratio in the fuel.

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