B.TECH SEM - III (2007 COURSE) (CHEMICAL ENGG.) : WINTER - 2017

SUBJECT : STOICHIOMETRY

Day : **Monday** Time : **10.00 AM TO 01.00 PM**
Date : **22/01/2018** **W-2017-2356** Max. Marks : 80

N.B.:

1) **Q.No.1** and **Q.No.5** are compulsory. Out of the remaining questions attempt **ANY TWO** questions from each section.
2) Answers to both the sections should be written in the **SEPARATE** answer books.
3) Use of non programmable **CALCULATOR** is allowed.
4) Draw neat and labeled diagrams **WHEREVER** necessary.
5) Figures to the right indicate **FULL** marks.

SECTION – I

Q.1 **a)** A producer gas has the following composition by volume: **[04]**
$CO = 21\%$, $CO_2 = 5\%$, $O_2 = 3\%$ and $N_2 = 71\%$.
Calculate the volume of gas in m^3 at 298 K and 99.325 kPa per kg of carbon present.

b) Dryer system handles 1000 kg/day of wet solids. Wet solids containing 50% solids and 50% water are fed to the first dryer. From the first dryer the product that comes out has 20% moisture. This is admitted to the second dryer from which the product coming out has 2% moisture. Calculate the percentage of original water that is removed in each dryer and final weight of the product. **[06]**

c) Explain bypass operation carried out in the chemical industry with their block diagram. **[04]**

Q.2 **a)** A solution containing 55% benzene (C_6H_6), 28% toluene ($C_6H_5CH_3$) and 17% xylene [$C_6H_4(CH_3)_2$] by weight is in contact with its vapour at 373K. Calculate the total pressure and molar composition of the liquid and vapour. **[07]**
Data : Vapour Pressure data at 373K :
Benzene = 178.60 kPa, Toluene = 74.60 kPa, Xylene = 28 kPa.

b) Make the following conversions: **[06]**
i) 294 gm/lit H_2SO_4 to normality.
ii) 54.75 gm/lit HCl to molarity.
iii) 3M K_2SO_4 to gm/lit.

Q.3 **a)** A multiple effect evaporator system has a capacity of processing 1000 kg per day of solid caustic soda when it concentrates weak liquor from 4 to 25% by weight caustic soda. When the same plant is fed with 10% weak liquor and if it is concentrated to 50% (both on weight basis), find the capacity of the plant in terms of solid caustic soda. Assume that the water evaporating capacity to be same in both cases. **[07]**

b) The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid. **[06]**

P.T.O.

Q.4 **a)** Chlorobenzene is nitrated using a mixture of nitric acid and sulphuric acid. During the pilot plant studies, a charge consists of 100 kg chlorobenzene (CB), 106.5kg 65.5% (by weight) nitric acid and 108.0 kg 93.6% (by weight) sulphuric acid. After two hours of operation, the final mixture was analysed. It was found that the final product contained 2% unreacted chlorobenzene. Also, the product distribution was found to be 66% p-nitrochlorobenzene (p-NCB) and 34% O-nitrochlorobenzene (O-NCB). Calculate : **[09]**

i) The analysis of charge

ii) The percentage conversion of chlorobenzene

iii) The composition of the product mixture.

b) Explain limiting reactant and excess reactant. **[04]**

SECTION – II

Q.5 **a)** Explain in detail ultimate and proximate analysis of coal. **[06]**

b) Calculate the enthalpy change between reactants and products if both are at 298.15 K and if 10 mol of formaldehyde is produced according to the following reaction: **[04]**

$CH_4\ (g) + O_2\ (g) \rightarrow HCHO\ (g) + H_2O\ (g)$

Data:

Component	$\Delta H_c^0,\ kJ/mol$
CH_4 (g)	– 890.65
HCHO (g)	– 563.46

c) Explain humid heat and humid volume. **[04]**

Q.6 **a)** A mixture of acetone vapour and nitrogen contains 14.8% acetone by volume. Calculate the following at 293K and pressure of 99.33 kPa. **[07]**

i) Partial pressure of acetone.

ii) Moles of acetone per moles of nitrogen.

iii) Relative saturation of mixture at 293K.

Data: vapour pressure of acetone at 293K = 24.638 kPa.

b) Explain in detail humidification and dehumidification operation **[06]**

Q.7 **a)** Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the following reaction: **[09]**

$CH_4\ (g) + C_2H_4\ (g) \rightarrow C_3H_8\ (g)$

Data: $\Delta H_R^0\ at\ 298K = -82.66\ kJ/mol$

$C_P^0 = a + bT + cT^2 + dT^3 .... (kJ/kmol.K)$.

Component	a	b × 10^3	c × 10^6	d × 10^9
CH_4 (g)	19.2494	52.1135	11.973	– 11.3173
C_2H_4 (g)	4.1261	155.0213	– 81.5455	16.9755
C_3H_8 (g)	– 4.2227	306.264	–158.6316	32.1455

b) Explain Hess's law of constant heat summation. **[04]**

Q.8 **a)** The ultimate analysis of a residual fuel oil (RFO) sample is as given below: C = 88.4%, H = 9.4%, S = 2.2% (by weight). Calculate: **[09]**

i) The theoretical dry air requirement.

ii) The actual dry air supplied.

iii) The Orsat analysis of flue gases.

b) Explain gross calorific value (GCV) and net calorific value (NCV) of fuel. **[04]**

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