B. TECH. SEM - III (CHEMICAL ENGG.) 2014 COURSE) (CBCS)
: SUMMER - 2018
SUBJECT : CHEMICAL PROCESS CALCULATIONS

Day : **Thursday** **S-2018-2227** Time : **02.30 PM TO 05.30 PM**
Date : **24/05/2018** Max. Marks : 60

N.B.:

1) All questions are **COMPULSORY**.
2) Figures to the right indicate **FULL** marks.
3) Use of non-programmable **CALCULATOR** is allowed.
4) Assume suitable data if **NECESSARY**.

Q.1 **a)** For ideal gas prove that $\rho_{mix} = \frac{PM_{avg}}{RT}$, where ρ_{mix} = density of gas mixture, M_{avg} = average molecular weight of gas mixture. **[04]**

b) A gas mixture has following composition by volume: **[06]**
$N_2 = 70.85\%$, $O_2 = 18.8\%$, $H_2O = 1.2\%$, $NH_3 = 9.5\%$.
Calculate: **i)** The average molecular weight of gas mixture.
ii) The density of gas mixture at a temperature of 923 K and 810.325 kPa.

OR

Q.1 **a)** State and explain Dalton's Law. **[04]**

b) An aqueous solution of K_2CO_3 is prepared by dissolving 43 kg of K_2CO_3 in 100 kg of water at 293K. Density of solution is 1.3 kg/lit. Calculate normality, molarity and molality of solution. **[06]**

Q.2 **a)** Explain liquid-liquid extraction operation used in chemical industry with their block diagram and material balance. **[04]**

b) 10,000 kg/hr of solution containing 20% methanol is continuously fed to a distillation column. Distillate is found to contain 98% methanol and waste solution from the column carries 1% methanol. All percentages are by weight. **[06]**
Calculate : **i)** The mass flow rates of distillate and bottom product
ii) The percent loss of methanol.

OR

Q.2 **a)** Explain classification of material balance problems with suitable example. **[04]**

b) An aqueous solution of pyridine containing 27% (by weight) pyridine and 73% (by weight) water is to be extracted with chlorobenzene. The feed and solvent are mixed well in batch extractor and the mixture is then allowed to stand for phase separation. The extract phase contains 11% pyridine, 88.1% chlorobenzene and 0.9% water by weight. The rafffinate phase contains 5% pyridine and 95% water by weight. Calculate : **[06]**
i) The quantities of two phases (layers).
ii) The weight ratio of solvent to feed based on 100 kg of feed.

Q.3 **a)** Explain in detail yield and selectivity. **[04]**

b) In manufacture of acetic acid (CH_3COOH) by oxidation of acetaldehyde (CH_3CHO), 100 kmol of acetaldehyde is fed to a reactor per hour. The product leaving the reactor contains 14.81% acetaldehyde, 59.26% acetic acid and rest oxygen (on mole basis). Find the percentage conversion of acetaldehyde. **[06]**

P.T.O.

OR

Q.3 Chlorobenzene (C_6H_5Cl) is nitrated using a mixture of nitric acid (HNO_3) and sulphuric acid. During the pilot plant run, a charge (feed) consists of 100 kg chlorobenzene (CB), 106.5 kg of nitric acid of 65.5% strength, 108 kg of sulphuric acid of 93.6% strength. After two hours of operation, the final product mixture was analysed and found to contain 2% unreacted chlorobenzene. Also, the product distribution was found to be 66% paranitrochlorobenzene (P-NCB) and 34% orthonitrochlorobenzene (O-NCB) by weight. Calculate: **[10]**

i) The analysis of charge (feed).
ii) The percentage conversion of chlorobenzene.
iii) The composition of the product mixture.

Q.4 In a textile industry, it is desired to prepare 24% caustic soda solution by weight. Due to very high heat of dissolution of caustic soda in water, the above solution is prepared by two step process. First caustic soda is dissolved in the correct quantity of water in a dissolution tank to produce 50% (by weight) solution. After complete dissolution and cooling, the solution is taken to a dilution tank where some more water is added to produce 24% by weight caustic soda solution. The two step process is shown in figure 1 given below. Assuming the no loss of water in dissolution tank, calculate the weight ratio of water fed to the dissolution tank (W_1) to bypass water to the dilution tank (W_2). **[10]**

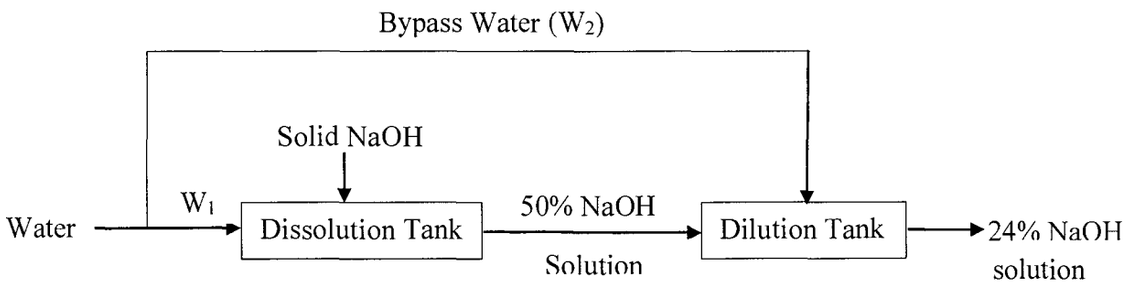

Figure 1: Bypass two-step operation for preparation of caustic soda solution.

OR

Q.4 Write short notes on the following: **[10]**

a) Humidification and Dehumidification
b) Recycle and purge operation

Q.5 a) What is heat capacity? Derive the relationship between C_P and C_V for ideal gas. **[05]**

b) Calculate the standard heat of reaction at 298K of the following reaction: **[05]**
CH_3Cl (g) + KOH (s) → CH_3OH (*l*) + KCl (s)

Component	ΔH_f^0, kJ/mol at 298K
CH_3Cl (g)	– 102.936
KOH (s)	– 424.764
CH_3OH (*l*)	– 239.2
KCl (s)	– 436.747

OR

Q.5 Flue gases leaving the boiler stack at 523K have the following composition by volume: **[10]**

CO_2 = 11.31%, H_2O = 13.04%, O_2 = 2.17% and N_2= 73.48%.

Calculate the heat lost in 1 kmol of gas mixture above 298K, using heat capacity data given below:

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

Gas	a	b × 10^3	c × 10^6	d × 10^9
CO_2	21.3655	64.2841	– 41.0506	9.7999
H_2O	32.4921	0.0796	13.2107	– 4.5474
O_2	26.0257	11.7551	– 2.3426	– 0.5623
N_2	29.5909	– 5.141	13.1829	– 4.968

Q.6 a) Explain ultimate and proximate analysis of coal. **[05]**

b) Crude oil is found to contain 87% carbon, 12.5% hydrogen and 0.5% Sulphur (by weight). Gross calorific value of crude oil at 298 K is 45071 kJ/kg oil. Calculate the net calorific value of crude oil at 298 K. **[05]**

Data: Latent heat of water vapour at 298K = 2442.5 kJ/kg.

OR

Q.6 Calculate the gross and net calorific values of the natural gas at 298K having following molar composition: **[10]**

CH_4 = 89.4%, C_2H_6 = 5%, C_3H_8 = 1.9%, n – C_4H_{10} = 1%, CO_2 = 0.7% and N_2 = 2%.

Specific volume at 298 K and 101.3 kPa = 24.465 m^3/kmol.

Data:

Component	GCV, kJ/mol	NCV, kJ/mol
CH_4	890.65	802.62
C_2H_6	1560.69	1428.64
C_3H_8	2219.17	2043.11
n – C_4H_{10}	2877.40	2657.32

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