B. Tech. Sem - III (Chemical Engg.) 2014 COURSE) (CBCS) :
WINTER - 2018
SUBJECT: CHEMICAL PROCESS CALCULATIONS

Day: Friday
Date: 30/11/2018

Time: 10.00 AM TO 01.00 PM
Max. Marks: 60

W-2018-2283

N.B:

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

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)**

OR

Q.1 **a)** For ideal gas, prove that PV = nRT, where P = total pressure, V = volume, T = temperature, R = Universal gas constant and n = number of moles. **(04)**

b) A gas mixture has following composition by volume: **(06)**
CO_2 = 8%, CO = 14%, O_2 = 6%, H_2O = 5%, CH_4 = 1% and N_2 = 66%
Calculate: **i)** Average molecular weight of gas mixture.
ii) Density of gas mixture at 303 K and 101.325 kPa.

Q.2 **a)** Explain evaporation operation used in chemical industry with their block diagram and material balance. **(04)**

b) A feed to a continuous fractionating column analyses by weight 28% benzene and 72% toluene. The analysis if distillate shows 52 weight percent benzene and 5 weight percent benzene was found in bottom product. Calculate the amount of distillate and bottom product for 1000 kg/hr of feed. Also calculate the percent recovery of benzene. **(06)**

OR

Q.2 A 100 kg mixture of 27.8% acetone (A) and 72.2% chloroform (B) by weight is batch extracted with a mixed solvent at 298 K. The mixed solvent of an unknown composition contains water (S_1) and acetic acid (S_2). The mixture of the original mixture and the mixed solvent is shaken well, allowed to attain equilibrium, and separated into two layers. The composition of the two layers are given below: **(10)**

Layers	Composition by weight %			
	A	B	S_1	S_2
Upper	7.5	3.5	57.4	31.6
Lower	20.3	67.3	2.8	9.6

Calculate : **i)** Quantities of two layers
ii) Weight ratio of mixed solvent to original mixture
iii) The composition of mixed solvent (weight basis)

P.T.O.

Q.3 **a)** Explain in detail limiting reactant and excess reactant with suitable example. **(04)**

b) A feed containing 60 mole % A, 30 mole % B, and 10 mole % inerts enters a reactor. 80 % of original A reacts according to the reaction $2A + B \rightarrow C$. Find the composition product stream on mole basis. **(06)**

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 orthonitrochlorobenzene (O-NCB) by weight. **(10)**

Calculate: **i)** The analysis of charge.
ii) % conversion of chlorobenzene
iii) Composition of product mixture

Q.4 In a drying operation, it is necessary to maintain moisture content of feed to a calciner at 15 % by weight in order to prevent lumping and sticking. This is achieved by mixing the feed having 30 % by weight moisture with a recycle stream of dried material having 3% by weight moisture. The drying operation is shown in figure1 given below. **(10)**

Calculate: **i)** Fraction of dried product to be recycled
ii) Water removed from calciner
iii) Product obtained

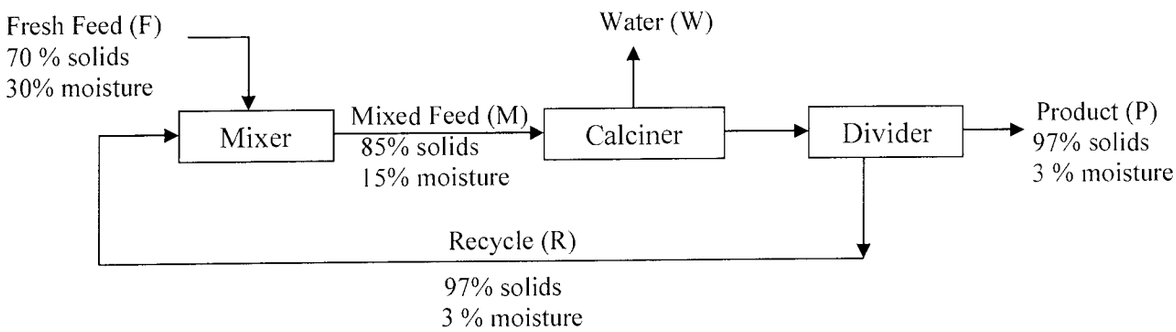

Figure 1: Drying of solids

OR

Q.4 Write short notes on following: **(10)**

a) Humidification and dehumidification

b) Bypass operation

...2...

Q.5 **a)** What is heat capacity? Derive the relationship between Cp and Cv for ideal gas. **(05)**

b) Calculate standard heat of reaction for the following reaction: **(05)**
C_2H_6 *(g)* $\rightarrow$ C_2H_4 *(g)* + H_2 *(l)*
Data:

Component	ΔH_c^0 , kJ/mol
C_2H_6*(g)*	- 1560.69
C_2H_4*(g)*	- 1411.2
H_2*(l)*	- 285.83

OR

Q.5 Flue gases leaving the boiler stack at 523 K 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 298 K, using the heat capacity data given below:
C_p^0 = a + bT + cT^2 + dT^3, kJ/(kmol.K)

Gas	a	b x 10^3	c x 10^6	d x 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 in detail calorific values of fuel. **(05)**

b) The gross calorific value of gaseous propane at 298 K is 2219.71 kJ/mol. Calculate its net calorific value in kJ/mol. Take latent heat of water vapour at 298 K = 2442.5 kJ/kg. **(05)**
(Reaction: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$).

OR

Q.6 Refinery gas has following composition by volume: **(10)**
H_2 = 74 %, CH_4 = 13.5 %, C_2H_6 = 7.4 %, C_3H_8 = 3.6 %, n- C_4H_{10} = 1.2% and n-C_5H_{12} = 0.3 %
Data:

Component	- ΔH_c^0 (gross), kJ/mol	- ΔH_c^0 (net), 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
n-C_5H_{12}	3535.77	3271.67

ΔH_f^0 of H_2O *(g)* = - 241.82 kJ/mol at 298 K

ΔH_f^0 of H_2O *(l)* = - 285.83 kJ/mol at 298K

Specific volume at 298 K and 101.325 kPa = 24.465 m^3/kmol.
Calculate gross calorific value and net calorific value of the refinery gas in kJ/mol, kJ/kg and kJ/m^3.

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