B. Tech. Sem - III (Chemical Engg.) 2014 COURSE) (CBCS) :
SUMMER - 2019
SUBJECT: CHEMICAL PROCESS CALCULATIONS

Day: Tuesday | Time: 02.30 PM TO 05.30 PM
Date: 14/05/2019 | S-2019-2548 | Max. Marks: 60

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 Raoult's law **(04)**

b) A chemical engineer is interested to prepare 700 ml of 2 normal, 2 molar and 2 molal solution of H_2SO_4. Assuming the density of H_2SO_4 solution to be 1.84 gm/cm^3, calculate the quantities of H_2SO_4 to be taken to prepare these solutions. **(06)**

OR

Q.1 **a)** Prove that $\sum_{i=1}^{n} Xi = 1$, where Xi = mole fraction of ith component in mixture. **(04)**

b) A gas mixture has following composition by volume: **(06)**
SO_2 = 8.5 %, O_2 = 10 % and N_2 = 81.5%
Calculate: i) Average molecular weight of gas mixture
ii) Density of gas mixture at 473 K and 303.975 kPa
iii) Composition by weight

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

b) A feed containing 50% benzene and 50% toluene is fed to a distillation column at the rate of 5000 kg/hr. The top product contains 95 % benzene and the bottom product contains 92 % toluene by weight. **(06)**
Calculate : i) The mass flow rates of top and bottom products
ii) The percent recovery of benzene

OR

Q.2 **a)** Explain general procedure to solve problems in material balance without chemical reaction. **(04)**

b) An evaporator is fed with 15000 kg/hr of a solution containing 10 % NaCl, 15 % NaOH and rest water. In this operation, water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving the evaporator contains 45 % NaOH, 2 % NaCl and rest water. **(06)**
Calculate : i) kg/hr water evaporated
ii) kg/hr salt precipitated
iii) kg/hr thick liquor obtained

P.T.O.

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

b) In production of sulphur trioxide, 100 kmol of SO_2 and 100 kmol of O_2 are fed to a reactor. If percent conversion of SO_2 is 80, calculate the composition of product stream on mole basis. **(06)**

OR

Q.3 Monochloroacetic acid (MCA) is manufactured in a semibatch reactor by the action of glacial acetic acid with chlorine gas at 373 K in the presence of PCl_3 catalyst. MCA thus formed is further react with chlorine to form dichloroacetic acid (DCA). To prevent the formation of DCA, excess acetic acid is used. A small scale unit which produces 5000 Kg/day MCA, requires 4536 Kg/day of chlorine gas. Also, 263 kg/day of DCA is separated in the crystallizer to get almost pure MCA product. Find the % conversion, % yield of MCA and selectivity **(10)**

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-steps 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 no evaporation loss of water in dissolution tank, calculate the weight ratio of water fed to a dissolution tank (W_1) to bypass water to the dilution tank (W_2). **(10)**

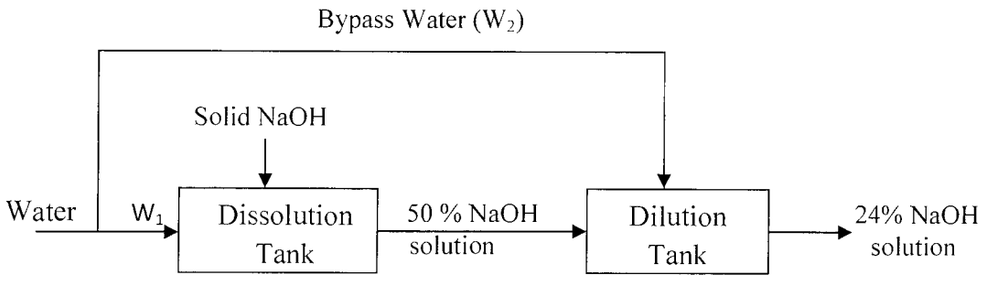

Figure 1: Bypass two-step operation for preparation of caustic soda solution.

OR

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

a) Recycle and Purge Operation

b) Humid heat and humid volume

...2...

Q.5 **a)** Explain Hess's law of constant heat summation with suitable example. **(05)**

b) Calculate standard heat of reaction for the following reaction: **(05)**

$CH_3OH\ (l) + \frac{1}{2}\ O_2\ (g) \rightarrow HCHO\ (g) + H_2O\ (l)$

Data:

Component	ΔH_f^0 , kJ/mol at 298 K
CH_3OH *(l)*	- 239.2
HCHO *(g)*	- 108.6
H_2O *(l)*	- 285.83

OR

Q.5 A natural gas has the following composition on mole basis: **(10)**
CH_4 = 84 %, C_2H_6 = 13% and 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:

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

Gas	a	b x 10^3	c x 10^6	d x 10^9
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

Q.6 **a)** Explain in detail gross and net calorific values of fuel. **(05)**

b) Calculate net calorific value at 298 K for a sample of fuel oil having C/H ratio 9.33 (by weight) and containing sulphur (s) to the extent of 1.3 % by weight. **(05)**
Data: GCV of fuel oil at 298 K = 41785 kJ/kg.
Latent heat of water vapour at 298 K = 2442.5 kJ/kg.

OR

Q.6 Calculate the grass and net calorific values of the natural gas in kJ/mol, kJ/kg and kJ/m^3 at 298 K having the 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 101.325 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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