(1) Exam - SE chemical sem III CBGS
(2) Subject - process calculation -
(3) ~~Subject cod~~
Exam Date - 13/12/17
(4) QP code - 24093

Q 1(A) Basis - 200 kg NaCl, 600 kg KCl

Wt. of NaCl in mix = 200 kg

Wt of KCl in mix = 600 kg

Wt. % of NaCl = $\frac{200}{800} \times 100 = 25$

Wt % KCl = 100 - 25 = 75

Moles NaCl = $\frac{200}{58.5}$ = 3.419 kmol

moles KCl = $\frac{600}{74.5}$ = 8.05 kmol.

Total Moles of mixture = 3.419 kmol + 8.05 kmol

= 11.469 kmol -

Mole % NaCl = $\frac{3.419}{11.469} \times 100$

= 29.81

Mol % KCl = 100 - 29.81

= 78.19 kmol.

Q1 B

formula of calculating weight percent to get the answer.

Q1B **Solution : Basis :** 100 kg urea sample.

The sample contains 45% N by weight.

Amount of N in the sample $= 0.45 \times 100 = 45$ kg

Atomic weight of N = 14, Molecular weight of NH_2CONH_2 = 60

The relationship between urea and N on the molar basis is

$$1 \text{ kmol } NH_2CONH_2 \equiv 2 \text{ katom N}$$

On the weight basis, it becomes

$$60 \text{ kg } NH_2CONH_2 \equiv 28 \text{ kg N}$$ → 45 = x kg of N

It means that when the sample contains 28 kg N, its urea content must be 60 kg

$$\therefore \quad \text{Actual urea in the sample} = \frac{60}{28} \times 45 = 96.43 \text{ kg}$$

$$\text{Weight \% actual urea content of the sample} = \frac{\text{kg urea}}{\text{kg sample}} \times 100$$

$$= \frac{96.43}{100} \times 100 = \mathbf{96.43} \quad \text{... Ans.}$$

Q 2 (a)

$x_{C_6H_6} = 0.5$

$x_{C_6H_5CH_3} = 0.5$

$M_{avg} = 85$

feed $= \frac{500}{85} = 5.882$ kmol

$F = 5.882 = D + W$

$0.5 \times 5.882 = 0.95D + 0.1W$

$D = 2.768$

$W = 3.114$

Benzene in feed $= 0.5 \times 5.882 = 2.94$ kmol $\times 78$

$= 229.3481$ kg

Toluene in feed $= 0.5 \times 5.882 \times 92$

$= 270.572$ kg

Benzene in distillate $= 0.95 \times 2.768$

$= 205.1$ kg

Toluene in distillate $= 12.733$ kg

Toluene in residue $= 257.8$ kg

~~Toluene in fee~~

Benzene in residue $= 24.29$ kg

Q 2 B-

Example 3.37 : *The feed water to a reverse osmosis plant contains 5000 ppm solids. The feed to product ratio is 4 : 3 (on weight basis). The treated water leaving the plant contains 600 ppm solids. Find the dissolved solids content of concentrated stream (rejected stream).*

Solution : Basis : 4 kg feed water.

Dissolved solids in the feed = 5000 ppm

1 ppm = 1 mg/kg

We know that :

$$\begin{bmatrix}\text{Amount of dissolved} \\ \text{solids in the feed water}\end{bmatrix} = \frac{5000}{1} \times 4 = 20000 \text{ mg}$$

As the ratio of feed to product is 4 : 3, the quantity of the product stream (treated water) is 3 kg for 4 kg feed.

We have :

Feed = Product stream + Concentrated stream

Amount of concentrated stream = 4 – 3 = 1 kg

$$\begin{bmatrix}\text{Amount of dissolved} \\ \text{solids in the treated water}\end{bmatrix} = \frac{600}{1} \times 3 = 1800 \text{ mg}$$

Let 'x' ppm be the dissolved solids content of the concentrated stream.

Material Balance of Dissolved Solids :

$$\begin{bmatrix}\text{Dissolved solids} \\ \text{in feed water}\end{bmatrix} = \begin{bmatrix}\text{Dissolved solids} \\ \text{in product}\end{bmatrix} + \begin{bmatrix}\text{Dissolved solids} \\ \text{in conc. stream}\end{bmatrix}$$

$$20{,}000 = 1800 + \frac{x}{1} \times 1$$

Solving, we get x = 18200

∴ Dissolved solids content of the concentrated stream = **18200 ppm**

Q 3 A

Consumption ...

Example 4.39 : *Calculate the consumption of 96% NaCl and 93% H_2SO_4 for 500 kg of HCl if the conversion is 92%. The reaction taking place is :*

$$2\,NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$$

Solution : Basis : 500 kg of HCl production.

Reaction : $2\,NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$

Molecular weights : $NaCl = 58.5$, $H_2SO_4 = 98$, $HCl = 36.5$

From the reaction : 2 kmol NaCl $\equiv$ 2 kmol HCl ... on mole basis

117 kg NaCl $\equiv$ 73 kg HCl ... on weight basis

Conversion is 92%. As the purity of NaCl is 96%,

Actual amount of NaCl required / consumed

$$= \frac{117}{73}\left(\frac{500}{0.92 \times 0.96}\right) = \mathbf{907.4\ kg}$$

From the reaction : 1 kmol H_2SO_4 $\equiv$ 2 kmol HCl

98 kg H_2SO_4 $\equiv$ 73 kg HCl

As the conversion is 92% and purity of H_2SO_4 is 93%,

Actual amount of H_2SO_4 required / consumed

$$= \frac{98}{73} \times \left[\frac{500}{0.92 \times 0.93}\right] = \mathbf{784.5\ kg}$$

Q 3B

3B **Example 4.60 :** *A furnace is fir... flue gas... 10.6% CO_2, 6% O_2 and the rest N_2 by volume. Find the C : H ratio in the fuel oil, assum... that the fuel oil does not contain nitrogen.*

Solution : Basis : 100 kmol of dry flue gases.

It contains 10.6 kmol CO_2, 6 kmol O_2 and 83.4 kmol N_2

We have : $1 \text{ mol } CO_2 = 1 \text{ mol } O_2$

$\therefore$ $O_2 \text{ in } 10.6 \text{ kmol } CO_2 = \frac{1}{1} \times 10.6 = 10.6 \text{ kmol}$

$$O_2 \text{ accounted} = O_2 \text{ in } CO_2 + O_2 \text{ in flue gas}$$

$$= 10.6 + 6 = 16.6 \text{ kmol}$$

N_2 balance : N_2 in air supplied = N_2 in flue gas = 83.4 kmol

O_2 available from air (i.e., O_2 in the air supplied) based on 83.4 kmol N_2

$$= \frac{21}{79} \times 83.4 = 22.17 \text{ kmol}$$

$$O_2 \text{ unaccounted} = O_2 \text{ in air} - O_2 \text{ accounted}$$

$$= 22.17 - 16.6 = 5.57 \text{ kmol}$$

5.57 kmol O_2 must have been utilised for the burning of hydrogen by the reaction:

$$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$$

$$\text{Hydrogen burnt} = \frac{1}{(1/2)} \times 5.57 = 11.14 \text{ kmol}$$

$$\text{Weight of carbon burnt} = 10.6 \times 12 = 127.2 \text{ kg}$$

(As 1 katom C $\equiv$ 1 kmol CO_2)

$$\text{Weight of hydrogen burnt} = 11.14 \times 2 = 22.28 \text{ kg}$$

Carbon/hydrogen (w/w) ratio in the fuel $= \frac{127.2}{22.28}$ = **5.71 or 5.71 : 1**

Q4A

Initial moisture (water) in the wet solids $= 0.2\,(100) = 20$ kg

Solids (bone-dry) in the wet solids $= 100 - 20 = 80$ kg

Let the final moisture in the product solids be y kg.

Solids (dried) contain 1% moisture.

$$\therefore \quad \left(\frac{y}{80 + y}\right) \times 100 = 1.0$$

$$\therefore \quad y = 0.81 \text{ kg}$$

Moisture removed from the solids $= 20 - 0.81 = 19.19$ kg/h

Let the moisture in the mixed air be $x \; \frac{\text{kg water}}{\text{kg dry air}}$

Moisture / Water Balance at inlet to the Dryer :

Moisture in mixed air = Moisture in fresh air + Moisture in recycle air

$$x \cdot M' = 0.02\,F' + 0.1\,R'$$

$$= 0.02\,F' + 0.1 \times 3F' \quad \ldots\ldots \text{(as } R' = 3\,F')$$

$$\therefore \quad x \cdot M' = 0.32\,F'$$

We have, $M' = 4F'$

$$\therefore \quad x\,(4F') = 0.32\,F'$$

$$\therefore \quad x = 0.08$$

Material Balance of Moisture over Dryer :

Moisture gained by air = Moisture removed from solids

$$0.1\,M' - 0.08\,M' = 19.19$$

$$\therefore \quad M' = 959.5 \text{ kg/h}$$

We have, $M' = 4F'$

$$\therefore \quad F' = 959.5/4 = 239.8 \text{ kg/h}$$

Water associated with dry air in the fresh air $= \frac{0.02}{1} \times 239.8 = 4.8$ kg/h

$\therefore$ Fresh air fed to the dryer $= 239.8 + 4.8 = 244.6$ kg/h

Moles/h fresh air entering the dryer $= n'$

$$\therefore \quad n' = \frac{244.6}{28.8} = 8.5 \text{ kmol/h}$$

If V' is the volumetric flow rate of the fresh air, then

$$V' = \frac{n'RT}{P}$$

where, $n' = 8.5$ kmol/h, $P = 101.325$ kPa, $R = 8.31451\ \text{m}^3\cdot\text{kPa/(kmol}\cdot\text{K)}$, $T = 303$ K

$\therefore$ Volumetric flow rate of the fresh air $= \frac{8.5 \times 8.31451 \times 303}{101.325} = \mathbf{211.34\ m^3/h}$ ... Ans.

Q 5 A,B

Date: / /

Q.4 b) Limiting reactant –

defined as reactant that would disappear first if a reaction goes to completion.

Excess Reactant –

defined as reactant which is in excess of theoretical or stoichiometric requirement as determined by desired reacn.

Percent excess –

$$\text{Percent excess of A} = \left[\frac{\text{moles of A supplied} - \text{moles of A theoretically required}}{\text{moles of A theoretically required}}\right] \times 100$$

Conversion –

is the fraction of reactant that has been converted into reaction products.

$$\text{conversion} = \frac{\text{mols of A reacted}}{\text{mols of A charged}} \times 100$$

Yield – ratio of quantity of desired product actually produced to its maximally obtainable quantity.

$$\text{selectivity} - \frac{\text{moles of desired product formed}}{\text{moles of undesired product formed}}$$

Q.5 b) $Q = n\int_{T_1}^{T_2} C_p^\circ \, dT$

$n = 1$, $T_1 = 303\,K$, $T_2 = 523\,K$

$Q = 4234.9 + 4735 + 459.9 + 187.8$

$Q = 9242\,kJ$

a) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H_1 = -393.51\,kJ/mol$

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H_2 = -285.83\,kJ/mol$

$C_6H_5OH_{(s)} + 7.5O_{2(g)} \rightarrow 6CO_{2(g)} + 3H_2O_{(l)}$ $\Delta H_C = -3053.25\,kJ/mol$

$6C + 3H_2 + \frac{1}{2}O_2 \rightarrow C_6H_5OH$ $\Delta H = ?$

reaction (4) = 6 Reaction (1) + 3 Reacn (2) − ΔHC

$= (-2361.06) + (-857.49) - (-3053.25)$

$= -3218.55 + 3053.25 = -165.3\,kJ/mol$