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# RN-8227

## B. E. - II (Sem. IV) (Mech.) Examination

**May / June – 2010**

## Fundamental Chem. Engg. Calculations & Stoichiometry

Time : **3** Hours] [Total Marks : **100**

**Instructions :**

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
**Fillup strictly the details of ☛ signs on your answer book.**

Name of the Examination :

☛ **B. E. - 2 (Sem. 4) (Mech.)**

Name of the Subject :

☛ **Fundamental Chem. Engg. Calcu. & Stoichiometry**

☛ Subject Code No. : **8 2 2 7** ☛ Section No. (1, 2,.....) : **1&2**

Seat No. :

Student's Signature

(2) Attempt **all** questions.

(3) Figures to the right indicate full marks.

(4) Assume suitable data whenever necessary.

(5) Atomic weight : H=1, S=32, O=16, K=39, C=12, N=14, C1=35.5, Na = 23.

(6) Use of scientific calculator casio fx 82, 83, or fx 100 or equivalent of other companies are allowed.

## SECTION - I

**1** (a) Answer following questions : **10**

(i) Convert 100°C to °R. **2**

(ii) Convert 3 kgt/cm$^2$ to bar. **2**

(iii) How many moles of $K_2CO_3$ will contain 117 kg K? **2**

(iv) Define conversion. **1**

(v) Define normality. **1**

(vi) Define NTP condition. **1**

(vii) 1 torr is equal to _____ mg Hg. **1**

(b) Glycerin, weighing 600 mg is dissolved in pure water to make a final solution of 1 liter. Find the TOC and ThOD of the solution. (Glycerine = $C_3H_8O_3$) **5**

(c) The volumetric flow rate of kerosene in 80 mm nominal diameter pipe is 70 imperial gallons per minute. Taking the density of kerosene as 0.8 kg/dm$^3$. Find the mass flow in kg/s. **5**

**2** Attempt any **two** : **7×2=14**

(a) A solution of sodium chloride in water contains 20% NaCl (by mass) at 333K. The density of the solution is 1.127 kg/l. Find the normality, molarity and molality of the solution.

(b) Spent acid from fertilizer plant has the following composition by weight :

$H_2SO_4$ = 20%, $NH_4HSO_4$ = 45%, $H_2O$ = 30% and organic compounds = 5%.

Find the total acid content of the spent acid in terms of $H_2SO_4$ after adding the acid content, chemically bound in ammonium hydrogen sulphate.

(c) Calculate the specific volume of superheated steam at 100 bar and 623.15 k using

(i) The ideal gas law

(ii) The vander waals equation.

If the actual specific volume of steam at the above conditions is 0.02242 (m$^3$/kg). Find the percent error in the above cases.

a = 5.5315 m$^3$/bar/(kmil)$^2$

b = 0.03046 m$^3$/k mol

3 Attempt any **two** : **8×2=16**

(a) The feed to a continuous fractioning column analyses by weight 28% benzene and 72% toluene. The analysis of the distillate shows 52% (wt) benzene and 5% (wt) benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg of feed per hour. Also calculate the percentage recovery to benzene.

(b) A sample of mixed acid contains 55% $HNO_3$ and 48% $H_2SO_4$ with 3% negative water (mass) basis. Find the actual constituent present in it.

The above mixed acids is prepared by mixing 100% $HNO_3$ and Oleum. Find the required strength of oleum and the proportions of the two acids in which they should be mixed.

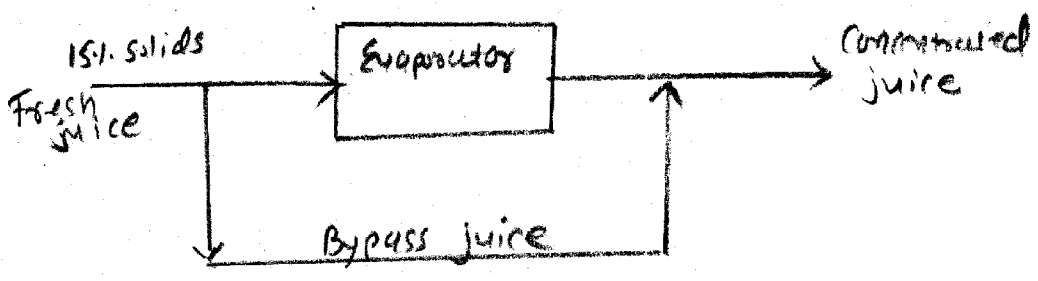
(c) Fresh juice contains 15% solids and 85% water by weight and is to be concentrated to contain 40% solids by weight.

In single evaporation system, it is found that volatile constituents of juice escape with water leaving the concentrated juice with a flat taste. In order to overcome this problem, part of the fresh juice by passes the evaporator. The operation is shown in figure

Calculate :

(i) The fraction of juice that by passes the evaporator

(ii) The concentrated juice produced (containing 40% solids) per 100 kg of fresh juice fed to the process.



## SECTION - II

4 (a) Attempt all : 4

(i) Heat

(ii) Latent heat of vaporisation

(iii) Dry-bulb temperature

(iv) Conversion

(b) Tallow is essentially glyceryltristearate. It is desired to saponity the fallow with caustic soda. For 100 kg fallow, calculate : 4

(i) The theoretical requirement of caustic soda

(ii) The amount of glycerine librated

$$\begin{array}{l} CH_2OOCH_{35}C_{17} \\ | \\ CHOOCH_{35}C_{17} \\ | \\ CH_2OOCH_{35}C_{17} \end{array} + 3NaOH = 3C_{17}CH_{35}COONa + \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

Glyceryl tristearate — caustic soda — sodium stearate — Glycerine

(c) What will be the yield of glauber salt ($Na_2SO_4 \cdot 10H_2O$) if a pure 32% solution is cooled to 293.15 k (20°C) without any loss due to evaporation. Solubility of $Na_2SO_4$ in water at 293.15 k (20°C) is 19.4 kg per 100 kg water. 6

(d) In production of sulphur trioxide 100 kmol $SO_2$ and 100 kmol $O_2$ are fed to the reactor. If the percent conversion of $SO_2$ is 80 calculate the composition of product stream on mole basis. **6**

**5** Attempt any **two** : **8×2=16**

(a) The feed containing 60 mole % A, 30 mole % B and 10 mole % inerts enters a reactor. The product stream leaving the reactor is found to contain 2 mole % A, reaction taking place is 2 A + B $\rightarrow$ C. Find the percentage of original 'A' getting converted to C.

(b) Temperature of oxygen is raised from 350 k (77°C) to 1500 k (1227°C). Calculate the amount of heat that must be supplied for raising the temperature of 1 kmol oxygen using the $C_p$ data given below

$C_p = a + bT + CT^2 + dT^3$

| Gas | $a$ | $b \times 10^3$ | $c \times 10^6$ | $d \times 10^9$ |
|---|---|---|---|---|
| $O_2$ | 26.0257 | 11.7551 | –2.3426 | –0.5623 |

(c) Carbon disulphide is to be recovered from a gas containing 15 mole % $CS_2$ and 85 mole % $N_2$ by contacting the gas with liquid benzene (solvent) in a continuous, counter current absorption tower. The liquid benzene absorbs $CS_2$ but not $N_2$. Mole ratio of benzene to gas fed is 2. During the operation Some of the benzene entering as liquid evaporates and leaves the

tower from top as vapour. If gas leaving the absorption tower contains 2 Mole% $CS_2$ and 2 Mole% benzene. Calculate

(i) the fraction of $CS_2$ recovered in the benzene outlet stream

(ii) mole fraction of $CS_2$ in benzene outlet stream.

**6** Attempt any **two** : **7×2=14**

(a) A solution of ferric chloride in water contains 64% $FeCl_3$ by weight. Calculate the amount of $FeCl_3.6H_2O$ which will crystallize at 300 k (27°C) from 1000 kg of feed solutions. The solubility of $FeCl_3$ in water at 300 K (27°C) is 68.3 per cent by weight $FeCl_3$.

$FeCl_3 + 6H_2O \rightarrow FeCl_3.6H_2O$

(b) Calculate the heat of formation of phenol crystals at 298.15 (25°C) from the elements using the following data :

Standard heat of formation of $CO_2(g)$ = –393.51 kJ/mol

Standard heat of formation of $H_2O$ (l) = –285.83 kJ/mol

Heat of combustion of phenol crystals at 298.15k (25°C) = –3053.25 kJ/mol.

(c) Dehydrogenation of i-butane is carried out at 50 kPa and 773 k (500°C) on a platinum catalyst. The feed to the reactor is pure i-butane along with 0.75 kmol

H2 per kmol i-butane. Hydrogen stream contains 90% $H_2$ and 10% $CH_4$ on mole basis. Reactions that are known to take place are :

$$i - C_4H_{10} \rightarrow i - C_2H_8 + H_2$$

i – butane  i – butylene

$$i - C_4H_{10} \rightarrow C_2H_6 + CH_4$$

i – butane  propylene  Methane

50% per pass conversion in a battery of three reactors with 88% yield of i-butylene is reported in literature. Find the composition of the product stream leaving the final reactor.