B.Tech. Third Semester (Chemical Engineering) (CGS)

10987 : Process Calculations : 3 CH 05 / 3 PP 05 / 3 CT 05

P. Pages : 3 **AW - 2998**

Time : Three Hours Max. Marks : 80

* 0 0 7 4 *

Notes :
1. All question carry marks as indicated.
2. Answer **three** question from Section A and **three** question from Section B.
3. Due credit will be given to neatness and adequate dimensions.
4. Assume suitable data wherever necessary.
5. Diagrams and chemical equations should be given wherever necessary.
6. Illustrate your answer necessary with the help of neat sketches.
7. Discuss the reaction, mechanism wherever necessary.
8. Use of cell phone is not allowed in the exam.
9. Use of pen Blue/Black ink/refill only for writing the answer book.

SECTION - A

1. a) A chemist is interested in preparing 500 ml of 1 normal, 1 molar and 1 molal solution of H_2SO_4. Assuming the density of H_2SO_4 Solution to be 1.075 g/cm^3, calculate the quantities of H_2SO_4 to be taken to prepare these solutions. **7**

b) Spent acid from fertilizer plant has the following composition by weight : **7**
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.

OR

2. a) A sample of a gas having volume of 0.5 m^3 is compressed in such a manner so that pressure is increased by 60%. The operation is done for a fixed mass of a gas at constant temperature. Calculate the final volume of the gas. **7**

b) A gaseous mixture has the following composition by volume : **7**
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.

3. The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of conc. H_2SO_4 acid containing 95% H_2SO_4 and conc. HNO_3 acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid. **13**

OR

4. a) The ground nut seeds containing 45% oil and 45% solids are fed to expeller the cake coming out of expeller is found to contain 80% solids and 5% oil. Find the percentage recovery of oil. **7**

b) A feed to a continuous fractionating column analyses by weight 28% benzene and 72% toluene. The analysis of the distillate shows 52 weight % benzene and 5 weight % 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 % recovery of benzene. **6**

5. In production of chlorine gas by oxidation of hydrochloric acid gas, air is used 30% in excess of that theoretically required. Based on 4 Kmol HCl, calculate **13**

i) the weight ratio of air to hydrochloric acid gas in feed.

ii) If oxidation is 80% complete, find the composition of product stream on mole basis.

OR

6. Ethylene oxide is prepared by oxidation of ethylene. 100K mole of ethylene and 100K mole of O_2 are charged to a reactor. **13**
The percent conversion of ethylene is 85 and percent yield of C_2H_4O is 94.12.
Calculate the composition of product stream leaving the reactor. The reaction taking place are :

$$C_2H_4 + \frac{1}{2}O_2 \longrightarrow C_2H_4O$$

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

SECTION - B

7. The gas having the following composition is at temperature of 775 K : **14**
SO_2 = 7.09%, O_2 = 10.55%, SO_3 = 0.45% and N_2 = 81.91%.
Calculate the heat content of 1 Kmol gas mixture over 298K using the heat capacity data given below : $C_p^o = a + bT + cT^2 + dT^3$ kJ/(Kmol.K)

Gas	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
SO_2	24.7706	62.9481	–44.2582	11.122
O_2	26.0257	11.7551	–2.3426	–0.5623
SO_3	22.0376	121.624	–91.8673	24.3691
N_2	29.5909	–5.141	13.1829	–4.968

OR

8. a) A stream flowing at a rate of 15000 mol/hr containing 25 mole % N_2 and 75 mole % H_2 is to be heated from 298 K to 473 K. Calculate the heat that must be transferred using C_p^o data given below : **8**

$C_p^o = a + bT + cT^2 + dT^3$ kJ / (K mol.K)

Gas	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
N_2	29.5909	–5.41	13.1829	–4.968
H_2	28.6105	1.0194	–0.1476	0.769

b) In a liquid phase heating system, Diphenyl DT is used as a thermic fluid. The thermic fluid enters an indirect fired heater at a temperature of 453 K and leaves the heater at a temperature of 533 K. Calculate the heat to be supplied in the heater per kg of the liquid heated. **6**

Data : The heat capacity of the fluid is given by

$C = 1.436 + 2.18 \times 10^{-3} T$ kJ / (kg.K) where T is in K.

9. Obtain an empirical equation for calculating the heat of reaction at any temperature T in K for the reaction : $CO_{(g)} + 2H_{2(g)} \longrightarrow CH_3OH_{(g)}$ **13**

Data : $\Delta H_R^o = -90.41$ kJ / mol

$C_P^o = a + bT + cT^2 + dT^3$ kJ / (Kmol.K)

Component	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
$CO_{(g)}$	29.0277	–2.8165	11.6437	–4.7063
$H_{2(g)}$	28.6105	1.0194	–0.1476	0.769
$CH_3OH_{(g)}$	21.137	70.843	25.86	–28.497

OR

10. a) Discuss in brief the concept of adiabatic process and adiabatic flame temperature. **4**

b) Calculate the standard heat of reaction of the following reaction : **9**

$C_5H_{12(\ell)} + 8O_{2(g)} \longrightarrow 5CO_{2(g)} + 6H_2O_{(\ell)}$

Data :

Component	ΔH_f^o kJ/mol at 298 K
$C_5H_{12(\ell)}$	–173.49
$CO_{2(g)}$	–393.51
$H_2O_{(\ell)}$	–285.83

11. The ultimate analysis of a residual fuel oil sample is given below : **13**
C = 88.4%, H = 9.4% and S = 2.2% by weight. It is used as a fuel in a power generating boiler with 25% excess air. Calculate :

a) The theoretical dry air requirement
b) The actual dry air supplied and
c) The orsat analysis of flue gases.

OR

12. a) What do you mean by calorific value ? Discuss in brief the concept of Net Calorific Value (NCV) and Gross Calorific Value (GCV). **4**

b) A sample of fuel oil has C/H ratio 9.33 (by weight) and contains 1.3% sulphur (weight basis). The net calorific value of the fuel oil is 39685 kJ/kg at 298 K. Calculate the gross calorific value using latent heat of water at 298 K. **9**
Data : Latent heat of water vapour at 298 K = 2442.5 kJ/kg.

****