Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E. Sem-IV Remedial Examination Nov/ Dec. 2010

Subject code: 140504

Subject Name: Fundamental Chemical Engineering Calculations & Stoichiometry

Date: 08 / 12 / 2010 **Time: 03.00 pm – 05.30 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Atomic Weights: C:12, H:1, O:16, S:32, Zn:65.4, K:39. Mg: 24.3, N:14, Cu:63.5, Fe:55.8, Ca: 40, Na : 23**

Q.1 **(a)** Calculate the available nitrogen in the following: **04**

(1) Commercial ammonium sulphate (96% pure)

(2) Pure sodium nitrate($NaNO_3$) (100%)

(b) The diameter and height of vertical cylindrical tank are 5 ft and 6 ft 6 in respectively. It is full up to 75% height with carbon tetrachloride, the density of which is 1.6 kg/L. Find the mass in kilograms. **03**

(c) The pressure loss in a pumping a fluid through a bed of solid particle is proportional to the empirical equation. Convert the equation into the metric units. **07**

$$\Delta p = \mu^{0.15} N \zeta^{0.85} v^{1.85} / D^{1.15} \text{ lbf/ft}^2$$

where Δp= pressure loss in lbf/ft^2

N= depth of packing in ft

D= diameter of tube, ft and

ζ = density in lb/ft^3

μ = viscosity of fluid, (lb/ft.s)

v= average velocity in ft/s.

Q.2 **(a)** An aqueous solution of acetic acid of 35% concentration (by mass) has density 1.04 kg/l at 298.15. Find the molarity, normality and molality of the solution. **07**

(b) The strength of an aqueous hydrogen peroxide solution is 60 volumes. Its density is measured to be 1.075 kg/l at 293 K. Find the mass % of H_2O_2 in the solution (A quantity of 1litre of 60 volume H_2O_2 will liberate 60 lit oxygen at 101.325 kPa a and 288.75 K). **07**

OR

(b) Soya bean seeds are extracted with hexane in batch extractors. The flaked seeds contain 18.6% oil, 69%solids and 12.4% moisture. At the end of the extraction process, deoiled cake (DOC) is separated from the hexane oil mixture. DOC analysis yields 0.8% oil, 87.7% solids and 11.5% moisture. Find the percentage recovery of oil. All percentages are by mass. **07**

Q.3 **(a)** A mixed acid is to be prepared from spent acid, 99% H_2SO_4, 95% HNO_3 and water, if necessary. Determine the followings **07**

(1) the mass of sulphuric acid, nitric acid and water necessary to convert 1000 kg of spent acid containing 40% H_2SO_4, 20% HNO_3, 40% H_2O to a mixed acid containing 50 % H_2SO_4, 40% HNO_3,10% H_2O .

(2) The mass of water that must be evaporated from 1000 kg of spent acid to produce a mixed acid containing 66% H_2SO_4, 33% HNO_3, 1% H_2O. All percentages are on mass basis.

(b) Explain the following terms with reference to chemical process **07**

1. Process flow sheet
2. P & I diagram
3. Degree of freedom
4. Limiting component
5. Recycling operation
6. By passing operation
7. Parallel operation

OR

Q.3 A sample of iron pyrite contains 88% FeS_2 and rest gangue. It is roasted with air 150% in excess of the theoretical requirement for oxidation of FeS_2 as per the reaction **14**

$4\ FeS_2 + 11O_2 = 2\ Fe_2O_3 + 8\ SO_2$

$4\ FeS_2 + 15O_2 = 2\ Fe_2O_3 + 8\ SO_3$

The residue of the burner contains 2.6% S. 40% of this sulphur is in the form of FeS_2 while the rest is in the form of SO_3 absorbed in the cinder. Also assume that 92% of the sulphur burnt produces SO_2 and the rest 8% oxidize to SO_3. Based on 100 kg pyrites charged , Calculate (a) the mass of cinder produced, (b) the percentage of the sulphur lost in the cinder, (c) the analysis of the burner gas on SO_3 free basis, and (d) the volume of dry air required in m^3 at 300 K and 100 KPa a.

Q.4 **(a)** Ethyl alcohol is industrially produced by fermentation of molasses. A sample of molasses contains 45% (mass) fermentable sugars (in the form of sucrose). The reactions taking place in the fermenter are as follows: **07**

$\mathbf{C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6}$

Sucrose d-Glucose d-Fructose

$\mathbf{C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2}$

Monosaccharide alcohol

Calculate the theoretical production of rectified spirit (having density of 0.785 kg/l) in liters per tone of molasses.

(b) The Analysis of limestone gives 60% $CaCO_3$, 33.5% $MgCO_3$ and rest inert. It is treated with 12% aqueous sulphuric acid (by mass) to obtain pure CO_2. An excess of 15 % of the acid over the stoichiometric amounts is used to ascertain that the reaction goes to completion. Based on the treatment of 500 kg limestone, Calculate (a) the amount of 100% (by mass) sulphuric acid required (b) the amount of residue , (c) the analysis of the residue left in the vessel and (d) the moles of CO_2 produced. **07**

OR

Q.4 **(a)** Flue gas leaving the boiler stack at 523 K have the following composition on mole basis. **07**

$CO_2 = 11.31\%$

$H_2O = 13.04\%$

$O_2 = 2.17\%$ and

$N_2 = 73.48\%$

Calculate the heat lost in 1 kmol of gas mixture above 298 K using heat capacity data given below:

$$C_p^{\ 0} = a + bT + cT^2 + dT^3 \quad kJ/kmol\ K$$

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

(b) Using Watson equation, Calculate laten heat of vaporization of (1) acetone at 313K (40^{o}C) (2) carbon disulphide (CS_2) at 413 K **07**

T_1 (Boiling point temp) K	Component	Laten heat of vap at T_1, K (kJ/kmol)	T_c K	n
329.4	Acetone(C_3H_6O)	29121	508.1	0.38
319.0	Carbon disulphide(CS_2)	26736	552.0	0.38

Q.5 **(a)** A heat exchanger for cooling hot oil uses 10000 kg/hr of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/hr enters at 423 K and leaves at 338 K and has an average heat capacity of 2.51 KJ/kg K. Calculate the outlet temperature of the water. **04**

(b) Using Antoine equation, Calculate vapour pressure of Acetaldehyde (C_2H_4O) at 250K **03**

Antoine constants for acetaldehyde are A = 7.134, B = 1600, C = 18.65.

(c) A crystallizer is charged with 7500 kg of an aqueous solution at 377 K, 29.6 % (by mass) of which is anhydrous sodium sulphate. The solution is cooled. During the cooling operation, 5 % of initial water is lost by evaporation. As a result, crystals of Na_2SO_4. 10 H_2O crystallize out. If the mother liquid is found to contain 18.3% (by mass) anhydrous Na_2SO_4, calculate the yield of crystals and the quantity of mother liquor. **07**

OR

Q.5 **(a)** Isothermal and isobaric absorption of SO_2 is carried out in a packed tower containing Raschig rings. The gases enter the bottom of the tower containing 14.8% SO_2 by volume. Water is distributed at the top of the column at the rate of 16.5 l/s. The total volume of the gas handled at 101.3 kPa and 303 K is 1425 m^3/h. The gases leaving the tower are found to contain 1% SO_2 by volume. Calculate the % SO_2 by mass in the outlet water. **07**

(b) Define the following terms with reference to air-water humidification operation: **07**

(1) Dry-bulb temperature
(2) Absolute humidity
(3) Percentage humidity
(4) Relative humidity
(5) Humid heat
(6) Humid volume
(7) Dew point

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