

**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

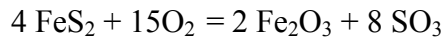
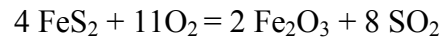
- Q.1**
- (a) Calculate the available nitrogen in the following: **04**  
 (1) Commercial ammonium sulphate (96% pure)  
 (2) Pure sodium nitrate(NaNO<sub>3</sub>) (100%)
- (b) The diameter and height of vertical cylindrical tank are 5 ft and 6 ft 6 in respectively. It is full up to 75% height with carbon 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  $\Delta p$ = pressure loss in lbf/ft<sup>2</sup>  
 N= depth of packing in ft  
 D= diameter of tube, ft and  
 $\zeta$  = density in lb/ft<sup>3</sup>  
 $\mu$  = 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<sub>2</sub>O<sub>2</sub> in the solution (A quantity of 1litre of 60 volume H<sub>2</sub>O<sub>2</sub> 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<sub>2</sub>SO<sub>4</sub>, 95% HNO<sub>3</sub> 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<sub>2</sub>SO<sub>4</sub>, 20% HNO<sub>3</sub>, 40% H<sub>2</sub>O to a mixed acid containing 50 % H<sub>2</sub>SO<sub>4</sub>, 40% HNO<sub>3</sub>,10% H<sub>2</sub>O .  
 (2) The mass of water that must be evaporated from 1000 kg of spent acid to produce a mixed acid containing 66% H<sub>2</sub>SO<sub>4</sub>, 33% HNO<sub>3</sub>, 1% H<sub>2</sub>O. 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

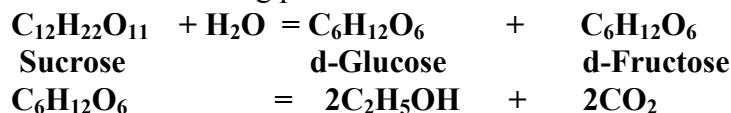
**OR**

- Q.3** A sample of iron pyrite contains 88% FeS<sub>2</sub> and rest gangue. It is roasted with air 150% in excess of the theoretical requirement for oxidation of FeS<sub>2</sub> as per the reaction 14



The residue of the burner contains 2.6% S. 40% of this sulphur is in the form of FeS<sub>2</sub> while the rest is in the form of SO<sub>3</sub> absorbed in the cinder. Also assume that 92% of the sulphur burnt produces SO<sub>2</sub> and the rest 8% oxidize to SO<sub>3</sub>. 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<sub>3</sub> free basis, and (d) the volume of dry air required in m<sup>3</sup> 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



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<sub>3</sub>, 33.5% MgCO<sub>3</sub> and rest inert. It is treated with 12% aqueous sulphuric acid (by mass) to obtain pure CO<sub>2</sub>. 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<sub>2</sub> produced. 07

**OR**

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

$$\begin{aligned} \text{CO}_2 &= 11.31\% \\ \text{H}_2\text{O} &= 13.04\% \\ \text{O}_2 &= 2.17\% \text{ and} \\ \text{N}_2 &= 73.48\% \end{aligned}$$

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

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

Gas	a	b x 10 <sup>3</sup>	c x 10 <sup>6</sup>	d x 10 <sup>9</sup>
CO <sub>2</sub>	21.3655	64.2841	-41.0506	9.7999
H <sub>2</sub> O	32.4921	0.0796	13.2107	-4.5474
O <sub>2</sub>	26.0257	11.7551	-2.3426	-0.5623
N <sub>2</sub>	29.5909	-5.141	13.1829	-4.968

- (b) Using Watson equation, Calculate laten heat of vaporization of (1) acetone at 313K (40°C) (2) carbon disulphide (CS<sub>2</sub>) at 413 K 07

T <sub>1</sub> (Boiling point temp) K	Component	Laten heat of vap at T <sub>1</sub> , K (kJ/kmol)	T <sub>c</sub> K	n
329.4	Acetone(C <sub>3</sub> H <sub>6</sub> O)	29121	508.1	0.38
319.0	Carbon disulphide(CS <sub>2</sub> )	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<sub>2</sub>H<sub>4</sub>O) 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<sub>2</sub>SO<sub>4</sub> · 10 H<sub>2</sub>O crystallize out. If the mother liquid is found to contain 18.3% (by mass) anhydrous Na<sub>2</sub>SO<sub>4</sub>, calculate the yield of crystals and the quantity of mother liquor. 07

**OR**

- Q.5** (a) Isothermal and isobaric absorption of SO<sub>2</sub> is carried out in a packed tower containing Raschig rings. The gases enter the bottom of the tower containing 14.8% SO<sub>2</sub> 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<sup>3</sup>/h. The gases leaving the tower are found to contain 1% SO<sub>2</sub> by volume. Calculate the % SO<sub>2</sub> 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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