

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-IV • EXAMINATION – SUMMER • 2014****Subject Code: 140504****Date: 25-06-2014****Subject Name: Fundamental Chemical Engineering Calculations
And Stoichiometry****Time: 10:30 am - 01:00 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) The absolute pressure in the vessel is 500 mm Hg. Convert the pressure in kPa, bar. **03**
 (b) The conductance of a fluid-flow system is defined as the volumetric flow rate, referred to a pressure of one torr (133.322 Pa). For an orifice, the conductance C can be computed from **04**

$$C = 89.2 A \sqrt{\frac{T}{M}} \text{ ft}^3 / \text{s}$$

Where A = area of opening, ft²

T = temperature, °F

M = molecular weight

Convert the empirical equation into SI units.

- (c) A gas mixture has the following composition by volume. **07**

C ₂ H ₄	30.6%
C ₆ H ₆	24.5%
O ₂	1.3%
CH ₄	15.5%
C ₂ H ₆	25.0%
N ₂	3.1%

Find (a) the average molecular weight of the gas mixture,

(b) the density of the gas mixture in kg/m³ NTP.(c)the composition by mass

- Q.2** (a) An aqueous solution of Na₂SO₃ is prepared by dissolving 86 kg Na₂SO₃ in 200 kg water at 293 K. Find molarity, normality and molality of the solution. Take sp. gravity of solution as 2.63 **07**
 (b) The feed water to the reverse osmosis plant has dissolved solids to the extent of 3000 mg/lit. The feed to product ratio (on mass basis) is 4:3. The treated water (product) from the plant contains 500 mg/lit of solids. Find the dissolved solids in the reject stream. **07**

OR

- (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

- Q.3 (a)** A spent lye sample obtained from a soap making unit contains 9.8% glycerol and 10.5% salt (NaCl). It is concentrated at the rate of 6000 kg/hr in a double effect evaporator until the final solution contains 80% glycerol and 6% salt. Assume that about 4.5% of the initial glycerol is lost by entrainment. All percentages are by weight. Find (a) The evaporation taken place in the system.(b) the amount of salt crystallized out the salt box of the evaporator. **07**

- (b)** A sample of coal from Andrew Yules colliery. West Bengal is found to contain 67.2% carbon and 22.3% ash (weight basis). The refuse obtained at the end of combustion is analyzed to contain 7.1% carbon and the rest ash. Compute the % of the original carbon remaining unburnt in the refuse. **07**

OR

- Q:3 (a)** It is required to make 1000 kg mixed acid containing 60% H₂SO₄, 32% HNO₃ and 8% water by blending (i) spent acid containing 10% HNO₃, 50% H₂SO₄, 40% H₂O(ii) aqueous 90% HNO₃ (iii) aqueous 98% H₂SO₄. All percentages are by weight. Calculate the quantities of each of three acids required for blending. **07**

- (b)** Using Antoine equation, Calculate vapour pressure of Acetaldehyde (C₂H₄O) at 250K **03**

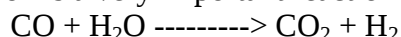
Antoine constants for acetaldehyde are A = 7.134, B = 1600, C = 18.65.

- (c)** Using Watson equation, Calculate laten heat of vaporization of (1) acetone at 370 K **04**

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 ₃ H ₆ O)	29121	508.1	0.38

- Q:4 (a)** A pilot plant reactor was charged with 50 kg naphthalene and 200 kg (98% by mass) of H₂SO₄. The reaction was carried out for 3 hours at 160⁰C (433 K). The reaction goes to near completion. The product distribution was found to be 18.6% monosulphonate naphthalene and 81.4% disulphonate naphthalene. Calculate (a) the quantities of monosulphonate (MSN) and disulphonate (DSN) products, and (b) the complete analysis of the product. **07**

- (b)** The shift reaction is a very important reaction in the gas processing industry. **07**



If a and b are the percent carbon monoxide in the dry inlet and outlet gas mixtures to and from the shift converter respectively. Prove that moles of CO converted (x) per 100 moles of inlet gas mixture can be calculated by using the formula,

$$x = \frac{100(a - b)}{100 + b}$$

OR

- Q.4 (a)** Crystals of MgCl₂.6H₂O have a solubility of 190 g per 100 g ethanol at 298.15 K. It is desired to make 700 kg of saturated solution. Calculate the quantities of the crystals and ethanol required to make above solution. **04**

- (b)** Define the following terms: **03**
- (1) excess reactant
 - (2) percentage conversion
 - (3) yield

- (c) 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 ³	c x 10 ⁶	d x 10 ⁹
CO ₂	21.3655	64.2841	-41.0506	9.7999
H ₂ O	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

- Q.5 (a) Isothermal and isobaric absorption of SO₂ is carried out in a packed tower containing Raschig rings. The gases enter the bottom of the tower containing 14.8% SO₂ by volume. Water is distributed at the top of the column at the rate of 16.5 lit/s. The total volume of the gas handled at 101.3 kPa and 303 K is 1425 m³/h. The gases leaving the tower are found to contain 1% SO₂ by volume. Calculate the % SO₂ by mass in the outlet water. 07

- (b) A spent solution of Chloroacetic acid (ClCH₂COOH) in ether (C₂H₅-O-C₂H₅) contains 20 mole % chloroacetic acid. It is desired to make 1 ton of a saturated solution at 298 K. Find the quantities of spent solution and Chloroacetic acid required to make the above solution. 07

Data: Solubility of Chloroacetic acid in ether is 190g/100g ether at 298 K.

OR

- Q.5 (a) 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

- (b) Liquid benzene, C₆H₆ at 303 K is mixed and dissolved continuously in liquid toluene, C₇H₈ at 373 K in the molar proportion 3:2 in an insulated mixing tank. If the heat of mixing is assumed to be zero, what is the temperature of the mixed solution? 07

Heat capacity data for Benzene and Toluene

Temperature, K	Heat capacity(c), KJ/kg.K	
	Benzene	Toluene
283	1.591	1.524
338	2.018	-
358	-	2.236

Assume the variation of the heat capacity is linear with temperature, i.e. $c = a + bT$ KJ/(kg.K)

Where a and b are constants.
