

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-III • EXAMINATION – SUMMER 2013****Subject Code: 130504****Date: 29-05-2013****Subject Name: Process Calculation****Time: 02.30 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 mass: O: 16, C:12, K:39, H:1, N:14, S:32, Zn:65.4,

- Q.1** (a) In the Caustic soda plant, in multiple effect evaporator, the second effect is maintained under vacuum of 410 torr. Find the absolute pressure in kgf/cm², kPa, atm, N/m², bar, psi and mm Hg. **07**
- (b) An aqueous solution of K₂CO₃ is prepared by dissolving 86 kg K₂CO₃ in 200 kg water at 293 K. Find molarity, normality and molality of the solution. Take sp. gravity of solution as 1.3. **07**

- Q.2** (a) What is Fundamental quantity and Derived quantities? Give units of following in terms of fundamental quantity: Area, Volume, Work, Power, Mass flow rate and Specific heat. **07**
- (b) A gas mixture has the following composition by volume: **07**
Ethylene: 31%, Benzene: 24%, Oxygen: 1%, Methane: 15%, Ethane: 25%, Nitrogen: balance. Find:
(a) the average molecular mass of the gas mixture and
(b) the density of the gas mixture in kg/m³ at NTP.

OR

- (b) A weight of 1.10 kg of Carbon dioxide occupies a volume of 33 liter at 300 K. **07**
Using the Van der Waals equation of state, calculate the pressure.
Data: For CO₂, take $a = 3.60 \text{ [(m}^3\text{)}^2\text{-kPa)]/(kmol)}^2$
and $b = 4.3 \times 10^{-2} \text{ m}^3\text{/kmol}$

- 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 11.3% HNO₃, 44.4% H₂SO₄ and 44.3% H₂O, (ii) aqueous 90% HNO₃ and (iii) aqueous 98% H₂SO₄. All percentage are by weight. Calculate the quantities of each of the three acids required for blending. **07**
- (b) The average molecular mass of a flue gas sample is calculated by two different engineers. One engineer uses the correct molecular mass of 28 for N₂ and determines the average molecular mass to be 30.08, the other engineers, using an incorrect value of 14, calculates the average molecular mass to be 18.74. **07**
(a) Calculate the volume% of N₂ in the flue gases.
If the remaining components of the flue gases are CO₂ and O₂, calculate the volume % of each of them.

OR

- Q.3** (a) Classify the material balance. Discuss the various methods involved for solving material balance problems without chemical reactions. **07**
- (b) Write short note on recycling and bypassing operations. **07**

- Q.4** Zinc sulphide ore containing 74% ZnS and 26% inerts are roasted in a burner. Assume complete combustion of the ore to SO₂ with dry air at 300K and 750 **14**

mm Hg. The burner is supplied with 55% excess air over the stoichiometric amount required for the complete roasting of the ore. The gases are passed through V_2O_5 catalyst bed where nearly 98% of SO_2 gets converted to SO_3 . The converter gases are passed through an absorption tower where all SO_3 is absorbed in the form of H_2SO_4 of 90% strength. It is desired to produce 1000 kg/h of 90% acid by spraying pure water at the top of absorption tower. Calculate: (a) the analysis of the burner gases, (b) the analysis of the converter gases, (c) the quantity of the ore to be roasted per hour and (d) the volumetric flow rate of the air entering the converter in m^3/h .

OR

Q.4 (a) With a typical example, explain the terms: Conversion, Yield, Selectivity, Limiting component and Excess component. **07**

(b) The heat capacity of carbon monoxide is given by the following equation. **07**

$$C_p = 6.395 + 6.77 \times 10^{-4} t + 1.3 \times 10^{-7} t^2 \text{ cal/(gmol } ^\circ\text{C)}$$

Where t is in $^\circ\text{C}$

What is the enthalpy change associated with heating carbon monoxide from 500°C to 1000°C ?

Q.5 Liquid benzene, C_6H_6 at 303 K is mixed and dissolved continuously in liquid toluene, C_7H_8 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? **14**

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.

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) Discuss in brief about Proximate analysis and Ultimate analysis of coal. **07**
