

GUJARAT TECHNOLOGICAL UNIVERSITY**BE SEM-III Examination May 2012****Subject code: 130504****Subject Name: Process Calculation****Date: 10/05/2012****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 Weights: C:12, H:1, O:16, S:32, Cl:35.5, N:14, Ca:40, K:39, Cu:63.5, Fe:55.8, Na:23, Zn : 65

- Q.1**
- (a) A force equal to 17.635 kgf is applied on a piston with a diameter of 6 cm. Find the pressure exerted on the piston in kPa, bar and psi. **03**
- (b) Ethanol is present in the aqueous solution to the extent of 1000 mg/l. Find TOC and ThOD of the solution in mg/l. **04**
- (c) In case of liquids, the local heat transfer coefficient for long tubes and using bulk temperature properties is expressed by the empirical equation **07**
- $$h = 0.026 G^{0.8} \times k^{0.67} \times c_p^{0.33} / (D^{0.2} \times \mu^{0.47})$$
- where h = heat transfer coefficient, Btu/(h.ft.².°F)
 G = mass velocity of liquid, lb/(ft².s)
 c_p = heat capacity, Btu/(lb. °F)
 D = diameter of tube, ft and
 K = Thermal conductivity in Btu/(h.ft. °F)
 μ = viscosity of liquid, (lb/ft.s)
 Convert the empirical equation into SI units.
- Q.2**
- (a) An aqueous solution of K₂CO₃ is prepared by dissolving 44 g K₂CO₃ in 100 g water at 293 K. Find molarity, normality and molality of the solution. Take density of solution as 1.3 kg/lit. **07**
- (b) The analysis of sewage gas sample from a municipal sewage treatment plant is given below on a volume basis. **07**

Methane	68%
Carbon dioxide	30%
Ammonia	2%
H ₂ S, SO ₂	Trace s

Find (a) the average molecular weight of the gas; and (b) the density of the gas at NTP.

OR

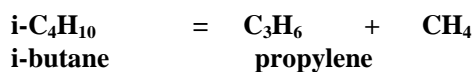
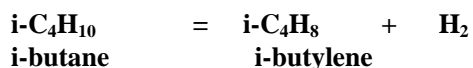
- (b) A weight of 1.20 kg of Carbon dioxide occupies a volume of 33 liter at 300 K. Using the Van der Waals equation of state, calculate the pressure. **07**
- Data: For CO₂, take $a = 3.60 \text{ [(m}^3\text{)}^2\text{-kPa]/(kmol)}^2$
 and $b = 4.3 \times 10^{-2} \text{ m}^3\text{/kmol}$
- Q.3**
- (a) 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. **07**

- Compute the % of the original carbon remaining burnt in the refuse.
- (b) A spent solution of Chloroacetic acid (Mol. Wt.: 94.5) in ether (Mol. Wt.: 74.0) 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.
- Data: Solubility of Chloroacetic acid in ether is 190g/100g ether at 298 K.

OR

- Q.3** A mixture of pyrites and zinc sulphide ore is burnt in a burner. The mixtures contains 75% pyrites and 25% zinc sulphide ore. The pyrites yield 92% FeS₂ and rest gangue. The zinc sulphide ore contains 68% ZnS and rest inerts. A sample of cinder yields 3.5% S. 70% of S in the cinder in the form of SO₃, absorbed in it, and rest is unoxidized FeS₂. All percentage are by weight. Based on 100 kg of mixed charge, calculate: (a) the amount of cinder formed with its analysis and (b) the percentage of sulphur left in the cinder based on the total sulphur charged. **14**

- Q.4** (a) Discuss recycling and bypassing and parallel operation. **04**
 (b) Discuss process flow diagram and process instrumentation diagram **03**
 (c) Selective dehydrogenation of alkanes to alkenes is a well established process. In this process, dehydrogenation of i-butane is carried out on a platinum impregnated catalyst at 50kPa g and 773 K. The feed to the reactor is pure i-butane along with 0.75kmol H₂ per kmol of i-butane. Hydrogen stream contains 90% H₂ and 10% methane (by mole). Following reactions are known to take place. **07**



Literature reports 50% per pass conversion in a battery of three reactors with 80% yields of i-butylene. Calculate the composition of the product stream leaving the final reactor.

OR

- Q.4** (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. **07**
- (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.

Solve the problem by using the data given in Table.

- Q.5 (a)** Using Watson equation, Calculate latent heat of vaporization of **07**
 (a) acetone at 313K (40°C) and
 (b) carbon disulphide (CS₂) AT 413 K

T ₁ (Boiling point temp)	component	Latent heat of vap at T ₁ , K (KJ/kmol)	T _c	n
329.4	Acetone(C ₃ H ₆ O)	29121	508.1	0.38
319.0	CS ₂	26736	552.0	0.38

- (b)** 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 1.2 % SO₂ by volume. Calculate the % SO₂ by mass in the outlet water. **07**

OR

- Q.5 (a)** A solution of ethyl alcohol containing 8.6% alcohol is fed at the rate of 1000 kg/hr to a continuous distillation column. The product (distillate) is a solution containing 95.5% alcohol. The waste solution from the column carries 0.1% of alcohol. All percentages are by mass. Calculate (a) the mass flow rates of top and bottom products in kg/h and (b) the percentage loss of alcohol. **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
