Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III(New) EXAMINATION – SUMMER 2016

Subject Code:2130504 **Date:02/06/2016**

Subject Name:Process Calculation

Time:10:30 AM to 01:30 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **Answer the following questions:** **14**

1 Write down four different units of pressure.
2 Define Dalton's law.
3 Define mole.
4 Define degree of freedom.
5 What is Cox chart?
6 Define vapor pressure.
7 Define limiting reactant.
8 Define selectivity.
9 Define heat of reaction.
10 What is difference between sensible heat and latent heat?
11 If pipe diameter is increased at the same place in pipe line, what will happen to kinetic energy per unit mass of incompressible fluid flowing through pipe?
12 Define excess reactant.
13 Define calorific value of fuel.
14 Define orsat analysis of flue gas.

Q.2 **(a)** An orifice meter is used to measure the flow rate in pipes. The flow rate is related to the pressure drop by an equation of the form, **03**

$$u = C\sqrt{\frac{\Delta P}{\rho}}$$

Where, u = fluid velocity in m/s, ΔP =Pressure drop in N/m^2, ρ =density of flowing fluid in kg/m^3, C is proportionality constant. What is the unit of C in the SI system of units?

(b) What is the specific gravity of propane at 310.77K and 800 mmHg relative to air at 288.55K and 760 mmHg? **04**

(c) A natural gas has the following mole percent composition, **07**

CH_4 = 87%, C_2H_6 = 12% and C_3H_8 = 1%.

(1) What is the composition in weight percent?
(2) How many m^3 will be occupied by 80 kg of gas at 9°C and 600 kPa?

OR

(c) Vapour pressure benzene in the temperature range of 7.5 °C to 104 °C can be calculated using the following Antoine equation. **07**

$$\log_{10} P = 6.9057 - \frac{1211}{(t + 220.8)}$$

Where, P = Vapour pressure in torr
t = Temperature in °C
Convert the above equation in SI units.

Q.3 (a) Define Raoult's law. What are the applications and limitations of Raoult's law? **03**

(b) A sugar solution contains 5.2% sugar by weight in water. How many kg of 1.2% solution is required to dilute 100 kg of 5.2% solution to 4.2%? **04**

(c) A distillation column separates 10000 kg/hr of a 50% benzene-50% toluene mixture. The product D recovered from the condenser at the top of the column contains 95% benzene, and the bottom W from the column contains 96% toluene. The vapor stream V entering the condenser from the top of the column is 8000 kg/hr. A portion of the product from the condenser is returned to the column as reflux, and the rest is withdrawn for use elsewhere. Assumes that the compositions of the streams at the top of the column (V), the product withdrawn (D), and the reflux (R) are identical because the V stream is condensed completely. Find the ratio of the amount refluxed (R) to the product withdrawn (D). **07**

OR

Q.3 (a) Describe the reasons for performing bypassing and recycling operations in unit operations. **03**

(b) Tallow is essential glyceryl tristearate. It is desired to seponify the tallow with caustic soda. For 100 kg of tallow, calculate (a) the theoretical requirement of caustic soda, and (b) the amount of glycerin liberated. **04**

Data Given: Molecular weight of glyceryl tristearate = 890 kg/kgmol
Molecular weight of caustic soda = 40 kg/kgmol
Molecular weight of sodium stearate = 306 kg/kgmol
Molecular weight of glycerin = 92 kg/kgmol

(c) Immobilized glucose isomerase is used as a catalyst in producing fructose from glucose in a fixed-bed reactor (water is the solvent). For the system shown in the Figure 1, what percent conversion of glucose results on one pass through the reactor when the ratio of the exit stream to the recycle stream in mass units is equal to 8.33 ? **07**

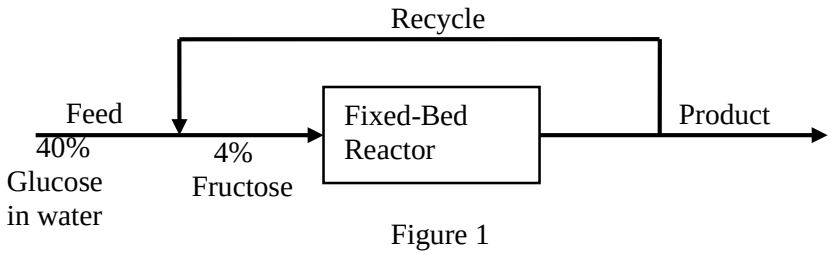

Figure 1

Q.4 (a) Describe proximate analysis of coal. **03**

(b) Calculate the enthalpy change in 24 gm of N_2 if heated from 300 K to 1500 K at constant pressure. **04**

Data given: Heat capacity equation $C_P^0 = a + bT + CT^2 + dT^3$ in J/(mol K)

For N_2	a	b	c	d
	29	0.2199×10^{-2}	0.5723×10^{-5}	-2.871×10^{-9}

(c) Define yield and conversion. **07**

Monochloroacetic acid (MCA) is manufactured in a semibatch reactor by the action of glacial acetic acid with chlorine gas at 100 °C in the presence of PCl_3 catalyst. MCA thus formed will further react with chlorine to form dichloroacetic acid (DCA). To prevent the formation of DCA excess acetic acid is used. A small scale unit which produces 5000 kg/day MCA, requires 4536 kg/day of chlorine gas. Also, 263 kg/day of DCA is separated into crystallizer to get almost pure MCA product. Find the %conversion, %yield of MCA.

OR

Q.4 **(a)** Calculate the standard heat of reaction for the following reaction: **03**

$$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$$

Data given:

Species	$NH_{3(g)}$	$O_{2(g)}$	$NO_{(g)}$	$H_2O_{(g)}$
$\Delta\hat{H}_f^0$ (kJ/mol) at 25 °C and 1 atm	-46.191	0	90.374	-241.826

(b) For o-xylene, calculate (a) latent heatof vaporization at T_B using Riedel equation, and (b) latent heat of vaporization at 25 °C using Watson equation. **04**

Data given:

For o-xylene: Pc = 3732 kPa, Tc = 630.3 K, T_B = 417.6 K

(c) Answer the following questions.

i. Briefly describe the term adiabatic reaction temperature. **03**

ii. Describe Pressure-Enthalpy chart for any pure component. What is the value of latent heat of vaporization at critical point? Why? **04**

Q.5 **(a)** If 10 kg of C_7H_{16} reacts completely with stoichiometric quantity of O_2, how many kg of CO_2 will be found as product? **03**

(b) If 3.2 moles of A, 1.1 moles of B & 2.4 moles of C are fed as reactant in the reactor, which will be limiting reactant. Following reaction takes place in the reactor: **04**

$$A + 3B + 2C \rightarrow \text{Product}$$

(c) A multiple contact counter current extractor is employed to extract oil from halibut livers with the help of ethyl ether. The fresh livers are charged to the extractor at the rate of 1000 kg/h and contain 25.7 % oil (by mass). Pure ether enters the bottom of the extractor. The overflow from the extractor contains 70% oil (by mass). The underflow rate is 0.23 kg solution/kg of oil-free solids and is known to contain 12.8% oil (by mass). Based on these operating conditions, make the material balance and find the flow rate of ether to the extractor. Also, compute the percentage recovery of oil. **07**

OR

Q.5 **(a)** Crude of is found to contain 87.1% carbon, 12.5 % hydrogen and 0.4 % sulphur (by mass). Its gross calorific value at 25 °C is measured to be 45071 kJ/kg oil. Calculate its net calorific value at 25 °C. **03**

Data given: Latent heat of water vapor at 25 °C = 2442.5 kJ/kg

(b) Describe the classification of fuels. **04**

(c) Compressed propane has been suggested as a source of economic power for vehicles. Suppose that in a test 20 kg of C_3H_8 is burned with 400 kg of air to produce 44 kg of CO_2 and 12 kg of CO. What was the % excess air? **07**

****