Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III EXAMINATION – WINTER 2015

Subject Code:130504 Date:23/12/2015

Subject Name: Process Calculation

Time: 2:30pm to 5:30pm Total Marks: 70

Instructions:

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

Atomic Weight: C=12, H=1, O=16, Cl=35.5, N=14, S=32

Q.1 **(a)** Vapor pressure of benzene in the temperature range of 7.5˚C to 104˚C can be calculated using the following Antoine equation. **07**

$$log_{10}P = 6.9057 - \frac{1211.0}{(t + 220.8)}$$

Where P= Vapor Pressure in Torr

t= temperature in ^{o}C

Convert the above equation in SI Units

(b) 1. The volumetric flow rate of kerosene in an 80mm nominal diameter pipe is 7.5 imperial gallons per minute. Taking the density of kerosene as 0.8 kg/dm^3, find the mass flow rate in kg/s. **07**

2. 240 Btu/lb ˚ F = _____ J/gm K

Q.2 **(a)** A vent Stream from ethylbenzene plant has a composition: 66% H_2, 33% CH_4 and 1 % other components. It is passed through a pressure swing adsorption unit where hydrogen is recovered as 98% pure stream with 2 % CH_4 as an impurity. Recovery of hydrogen is 85% at a feed pressure of 50 bar. Calculate the composition of reject stream. **07**

(b) Explain in brief bypass, recycle and purge operation. **07**

OR

(b) The feed water to the reverse osmosis plant has dissolved solids to the extent of 5000 mg/L. The feed to product ratio (on mass basis) is 4:3. The treated water (Product) from the plant contains 600 mg/L of solids. Find the dissolved solids in the reject streams. **07**

Q.3 **(a)** Derive the energy balance equation for steady state flow process of an incompressible fluid. **07**

(b) The orsat analysis of the flue gases from a boiler house chimney gives CO_2: 11.4%, O_2: 4.2%, and H_2:84.4 % (mole%). Assuming that complete combustion has taken place, (a) Calculate the % excess air and (b) find C: H ratio in the fuel. **07**

OR

Q.3 **(a)** Write a short note on Proximate analysis of Coal. **07**

(b) Chlorobenzene is nitrated using a mixture of nitric acid and sulphuric acid. During the pilot studies, a charge consisted of 100 kg of chlorobenzene, 106.5 kg of 65.5% (by mass) nitric acid, and 108 kg of 93.6% (by mass) sulphuric acid. After two hours of operation, the final mixture was analyzed. It was found that the final product contained 2% unreacted chlorobenzene. Also, the product distribution was found to be 66 % p-nitrochlorobenzene and 34% O-nitrochlorobenzene. Calculate **07**

(a) The analysis of charge
(b) The % conversion of chlorobenzene and
(c) The composition of the product mixture.

Q.4 **(a)** A mass of 1 kg of carbon dioxide occupies a volume of 33 L at 27 ˚C. Using the van der Waals equation of state, calculate the pressure. **07**
Data for CO_2: take a=3.6 $[(m^3)^2kPa]/[kmol]^2$, and b = $4.3*10^{-2}$ $m^3/kmol$

(b) An aqueous solution of acetic acid of 35% concentration (by mass) has a density of 1.04 kg/L at 25 ˚C. Find the molarity, normality and molality of the solution. **07**

OR

Q.4 **(a)** Glycerin, weighing 600 mg, is dissolved in pure water to make a final solution of 1 liter. Find the TOC and ThOD of the solution. **07**

(b) A gas mixture has the following composition by volume: **07**

Component	**% Composition (by vol)**
Ethylene	30.6
Benzene	24.5
Oxygen	1.3
Methane	15.5
Ethane	25.0
Nitrogen	3.1

Find (1) The average molar mass of the gas mixture (2) The composition by mass & (3) The density of the mixture in kg/m^3 at NTP

Q.5 **(a)** Explain the classification of fuels. **07**

(b) Chlorinated Diphenyl (Diphyl A-30) is heated from 40 ˚ C to 280 ˚C at the rate of 4000 kg/h in an indirectly fired heater. In this particular temperature range, the heat capacity of the fluid is given by the equation **07**

$C_1 = 0.7511 + 1.465 * 10^{-3}T$ kJ/kg K

Where T is in K.

Calculate the heat to be supplied to the fluid in the heater.

OR

Q.5 **(a)** Explain the followings terms: **07**

1. Standard heat of formation and Standard heat of combustion
2. Sensible heat and latent heat

(b) Obtain an expression relating the heat of reaction and the temperature of the reaction **07**

$SO_{2(g)} + (1/2)O_{2(g)} = SO_{3(g)}$

Using the same expression, calculate the heat of reaction at 502 ˚C

Following data for C_P :

Component	a	$b*10^3$	$c*10^6$	$d*10^9$
SO_3	22.036	121.624	-91.867	24.369
SO_2	24.771	62.948	-44.258	11.122
O_2	26.026	11.755	-2.343	-0.562

Standard heat of formation for SO_3 and SO_2 are -395720 and -296810 kJ/kmol respectively.

****