Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV (OLD) - EXAMINATION – SUMMER 2017

Subject Code:140504 **Date: 12/06/2017**

Subject Name: Fundamental Chemical Engineering & Stoichiometry

Time: 10:30 AM to 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 weight: Cl =35.5, Br =80, O =16,C=12, H=1, N=14**

Q.1 **(a)** A 100kg mixture of 27.8% of acetone (A) and 72.2% of chloroform (B) by mass is to be batch-extracted with a mixed solvent at 25° C. The mixed solvent of an unknown composition is known to contain water (S_1) and acetic acid (S_2). The mixture of the original and the mixed solvent is shaken well, allowed to attain equilibrium and separated into two layers. The compositions of the two layers are given below. **07**

	Composition, mass %			
Layer	A	B	S_1	S_2
Upper layer	7.5	3.5	57.4	31.6
Lower layer	20.3	67.3	2.8	9.6

Find (a) The quantities of the two layers,

(b) The mass ratio of the mixed solvent to the original mixture.

(c) The composition of mixed solvent (mass basis).

(b) (1) Vapour 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= vapour pressure in Torr (mmHg), and

t= Temperature in °C

(2) A force equal to 192.6 N is applied on a piston with a diameter of 5 cm. find the pressure excreted on the piston in kPa, bar and psi.

Q.2 **(a)** Glycerin ($C_3H_8O_3$), weighting 600mg, is dissolved in pure water to make a final solution of 1 litre. Find the TOC and THOC of the solution. **07**

(b) Explain any two operations with block diagram and material balance which are carried out in chemical industry. **07**

OR

(b) A feed to a continuous fractioning column analyses by weight 28 percent benzene and 72 percent toluene. The analysis of the distillate shows 52 weight percent benzene and 5 weight percent benzene was found in bottom product. Calculate the amount of distillated and bottom product per 1000 kg of feed per hour. Also calculate the percent recovery of benzene. **07**

Q.3 **(a)** Oxidation of ethylene to produce ethylene oxide is given by reaction: **07**

$$C_2H_4 + 0.5\ O_2 \rightarrow C_2H_4O$$

If air is used 20% excess of that theoretically required, calculate the quantity of air supplied based on 100 kmol of ethylene fed to the reactor.

(b) A feed containing A, B and inerts enters a reactor. The reaction taking place is : **07**

$$2A + B \rightarrow C$$

The product stream leaving the reactor is having the following composition by mole:

A = 23.08%, B = 11.54%, C = 46.15% and inerts = 19.23%

Find the analysis of feed on mole basis.

OR

Q.3 **(a)** A mixture of pure carbon dioxide and hydrogen is passed over a nickel catalyst. The temperature of the catalyst bed is 588 K and the reactor pressure 2.02 MPag. The gas mixture leaving the reactor is analysed to contain 57.1% CO_2, 41.1% H_2, 1.68% CH_4 and 0.12% CO by volume on a dry basis. The reactions taking place in reactor are: **07**

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$$

$$CO + H_2 \rightarrow CO + H_2O$$

Find: (a) the conversion of CO_2 per pass (b) the yield of CH_4 in terms of CO_2 reacted and (c) the composition of fed.

(b) The carbon monoxide is reacted with hydrogen to produce methanol. Calculate from the reaction : (a) the stoichiometic ratio of H_2 to CO. (b) kmol of CH_3OH produced per kmol CO reacted (c) the weight ratio of CO to H_2 if both are fed to reactor in stoichiometic proportion (d) the quantity of CO required to produce 1000 kg of CH_3OH **07**

Q.4 **(a)** Define the following: (a) Potential energy (b) work (c) heat capacity (d) relation between Cp and Cv (e) Hess's law (f) heat of formation (g) latent heat of fusion **07**

(b) A sample of sodium chloride in water contains 20% Nacl (by mass) at 60° C. the density of solution is 1.127 kg/L. find the molarity, normality and molality of the solution. **07**

OR

Q.4 **(a)** Chlorinated diphenyl is heated from 313 K to 533 K in an indirectly fired heater at the rate of 4000 kg/h. calculate the heat required to be added to the fluid in the heater. The heat capacity of the fluid in this temperature range is given by equation given below: **07**

$C = 0.7511 + 1.465*10^{-3}$ T. KJ/(kg.K) where T is in K.

(b) By electrolyzing a mixed brine, a gaseous mixture is obtained at the cathode having the following composition by weight: **07**

Cl_2 = 67%, Br_2 = 28% and O_2 = 5%

Calculate: (a) composition of gas by volume

(b) average molecular weight

(c) Density of gas mixture at 298 K and 101.325 kPa.

Q.5 **(a)** An absorption tower packed with tellerette packings is used to absorb carbon dioxide in an aqueous monoethanol amine (MEA) (chemical formula: $HOCH_2CH_2NH_2$) solution. The volumetric flow rate of the incoming dry gas mixture is $1000 m^3/h$ at 45° C and 101.3 kPa. The CO_2 content of the gas is 10.4 mole% while the outgoing gas mixture contains 4.5 mole% CO_2. A 3.2 M MEA solution is introduced at the top of the tower at the rate of 0.625 L/s. Dissolved CO_2 concentration of the entering solution is 0.166 kmol/kmol of MEA. Find the concentration of dissolved CO_2 in the solution leaving the tower. **07**

(b) A natural gas has the following composition on mole basis: **07**

CH_4 = 84%, C_2H_6 = 13%,and N_2 = 3%

Calculate the heat to be added to heat 10 kmol of natural gas from 298 K to 523 K using heat capacity data given below:

Gas	a	$b*10^3$	$c*10^6$	$d*10^9$
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_6	5.4129	178.0872	-67.3749	8.7147
N_2	29.5909	-5.141	13.1829	-4.968

OR

Q.5 **(a)** A mixture containing 47.5% acetic acid and 52.5% water (by mass) is being separated by the extraction in a counter current multistage unit. The operator temperature is 24 ° C and the solvent used is pure iso propyl ether. Using the solvent in the ratio of 1.3 kg/kg feed, the final extraction composition on a solvent free basis is found to be 82% by mass of acetic acid. The raffinate is found to contain 14% by mass of acetic acid on a solvent free basis. Calculate the percentage of acid of the original feed which remains unextracted. **07**

(b) Calculate the heat of reaction at 298.15 K of the following reaction: **07**

$3CaSO_4$ (s) + SiO_2 (s) → $3CaO.SiO_2$ (s) + $3SO_2$ (g) + $1.5O_2$ (g)

Data:

Component	**$\Delta H°_f$, kJ/mol at 298.15 K**
$CaSO_4$ (s)	-1432.7
SiO_2 (s)	-903.5
$3CaO.SiO_2$ (s)	-2879
SO_2 (g)	-296.81
O_2 (g)	0.0

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