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

GUJARAT TECHNOLOGICAL UNIVERSITY
BE SEM-IV Examination-Nov/Dec-2011

Subject code: 140504 **Date: 02/12/2011**

Subject Name: Fundamental Chemical Engineering Calculations & stoichiometry

Time: 02.30 pm -5.00 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 **(a)** In an absorption tower, packed with rasching rings is used to absorb carbon dioxide in an aqueous monoethanol amine (MEA) solution. The volumetric flow rate of the incoming dry gas mixture is 1000 m^3/hour at 318^0 K and 101 kPa a. The CO_2 content of the gas mixture 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 0.6251 lps. 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 storage tank of DM water has a holding capacity of 2000 m^3 upto an overflow point. The inflow of Dm water to the tank is 25 litre/second having silica (as SiO_2) content of 0.005 mg/l. The supply of Dm water to the high pressure boilers from the tank amounts to 25 litre/second. with time the DM water quality deteriorates and the silica content in the feed DM water increased to 0.02 mg/l. Assume that inflow into and outflow from the tank remains constant at 25 litre/second. Calculate the time for the silica content in the storage tank to increase to 0.012 mg/l. **07**

Q.2 **(a)** A gas mixture has the following composition by volume, Ethylene = 30.6 %, Benzene = 24.5 %, Oxygen = 1.3 %, Methane =15.5 %, Ethane = 25 %, Nitrogen = 3.5 %. **07**

Find, (a)The average molecular weight of the gas mixture
(b)The composition by weight
(c)The density of mixture in kg/m^3 at STP

(b) A gas mixture containing 87 % CH_4 and 13 % C_2H_6 by volume is burned with air. Orsat analysis of the flue gas after complete combustion shows 5.3 % $CO_2$by volume but no CO. The air enters at 0^0 C, 760 mm Hg and contains no water vapor. Calculate the percent excess air used for combustion. **07**

OR

(b) Tin is melted in an open pan using a jacket. The jacket is fed with the vapors of an eutectic mixture of diphenyl - diphenyl oxide at 171 kPa a. Tin is fed to the pan at 303^0 K. Calculate the quantity of eutectic mixture of the diphenyl - diphenyl oxide condensed per 100 kg of tin melted at its melting temperature. Assuming no subcooling of vapors. **07**

Data :
Molecular weight of Tin = 118.7
Melting point of Tin =505^0 K
Latent heat of fusion, λ_f = 7201 kJ/kmol
Heat capacity of solid Tin, c = 21.14 + 0.02T, kJ/kmol
where T, ^{0}K
Latent heat of diphenyl - diphenyl oxide, λ = 278 kJ/kg

Q.3 **(a)** In a textile industry, it is desired to make 24% solution (by weight) of NaOH for a mercerisation process. Due to very high heat of dissolution of NaOH in water, the above solution is prepared by two step process: **07**
First in a dissolution tank, caustic soda is dissolved in the correct quantity of water to produce 50 % (by weight) caustic soda solution. After complete dissolution and cooling, the solution is taken to dilution tank where some more water is added to produce 24 % solution. Assuming no evaporation loss of water in dissolution tank.
Calculate the weight ratio of water fed to dissolution tank to bypassed water to dissolution tank.

(b) 98 grams of sulphuric acid (H_2SO_4) are dissolved in water to prepare one litre of solution. Find normality, molarity and molality of the solution. Density of solution is 1.4 gm/cm^3. **07**

OR

Q.3 **(b)** Water is pumped from the bottom of a well 60 meter deep at the rate of 4 litres/second into storage tank 15 meter above the ground. A cooler is provided in between, which removes 15 KW from the water. Heat is lost from the whole system at a rate of 10 KW. A 1.2 BKW pump is used. Assume 65 % of the rated power goes into the work of pumping and rest is assumed to be negligible. Calculate the changes in internal energies between storage tank and bottom of the well. **07**

Q.4 **(a)** A coal having the ultimate analysis, C = 67.2 %., H = 5.5 %, S = 0.4 %, O = 6.1 % and ash 20.8 % (by weight) is used for gasifying. Free moisture in the coal is found to be 2.6 % (by weight). The producer gas obtained from the coal has the molar composition N_2 = 51.0 %, CO = 25 %, H_2 = 16 %, CO = 6 % and CH_4 = 2 % (on dry basis; SO_2 neglected). The dew point of the produces gas is measured to be 295^0 K at 100.7 kPa a. **07**

1) Compute Nm^3 of producer gas obtained per kg coal used
2) Nm^3 of air supplied / kg coal gasified?
3) Quanity of steam supplied / kg coal is used? Vapor pressure of water at 295^0 K = 2.642 kPa a

(b) Air (B) and water vapor (A) sample has a dry bulb temperature 55^0 C and an absolute humidity 0.03 kg water / kg dry air at 1 standard atmospheric pressure. **07**

vapor pressure of water at 55^0C= 118 mm Hg = 15730 N/m^2

Determine (1) percentage humidity (2) Molal absolute humidity (3) Relative humidity (4) Dew point (5) Humid volume.

OR

Q.4 **(a)** A gaseous mixture containing 30 % O_2, 20 % N_2 and 50 % SO_2 (all by weight %) is to be heated from 25^0 C to 100^0 C. find out how much heat (kcal) is to be supplied to carry out the task. **07**

Specific heat data (c_p)

Component	C_p (cal/gm mole, ^{0}C)
O_2	$7.129 + 0.1407 \times 10^{-2} T - 0.6438 \times 10^{-5} T^2$
N_2	$6.919 + 0.1365 \times 10^{-2} T - 0.0227 \times 10^{-5} T^2$
SO_2	$9.299 + 0.933 \times 10^{-2} T - 0.7418 \times 10^{-5} T^2$

Where T is in ^{0}C.

Q.4 **(b)** A multiple effect evaporator system has a capacity of tonne processing one tonne per day of solid caustic soda when it concentrates weak liquor from 4 to 25 % (both on weight basis). When the plant is fed with 5 % weak liquor and if it is concentrated to 50 % (both on weight basis). Find the capacity of the pant in terms of solid caustic soda, assuming the water evaporating capacity to be same in both cases. **07**

Q.5 **(a)** Define GCV and NCV and which equipment is used for measuring them. Also, give significance of NCV and GCV. **07**

(b) Carbon tetrachloride is made as following : **07**

$$CS_2 + 3Cl_2 \rightarrow CCl_4 + S_2Cl_2$$

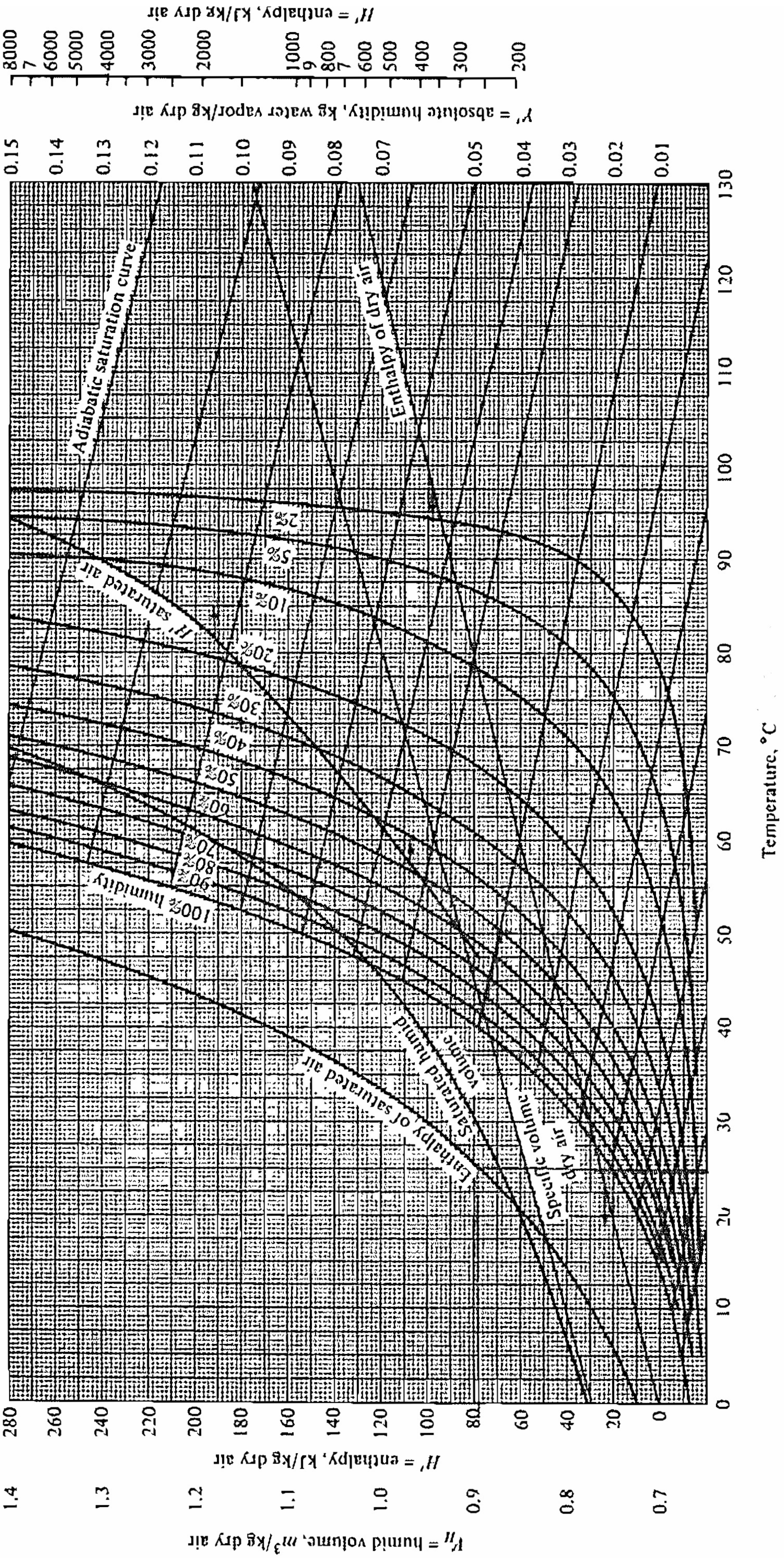
The product gases are found to contain

	CCl_4	S_2Cl_2	CS_2	Cl_2
Mole %	23.3	23.3	1.4	32

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 weight. Calculate (1) the mass flow rates of top and bottom products in kg/h and (2) the percentage loss of alcohol. **07**

(b) Crystals of $MgCl_2.6H_2O$ have a solubility of 190 g per 100 g ethanol at 298^0 K (25^0 C). It is desired to make 1000 kg of saturated solution. Calculate the quantities of the crystals and ethanol required to make the above solution. Also, find the consumption of the saturated solution by weight. **07**


H' = enthalpy, kJ/kg dry air
3000
7
6000
5000
4000
3000
2000
1000
9
800
7
600
500
400
300
200
Y' = absolute humidity, kg water vapor/kg dry air
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.05
0.04
0.03
0.02
0.01
Adiabatic saturation curve
Enthalpy of dry air
H' saturated air
2%
5%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100% humidity
Enthalpy of saturated air
Saturated humid volume
Specific volume dry air
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
H' = enthalpy, kJ/kg dry air
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
v_H = humid volume, m^3/kg dry air
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Temperature, °C