Z/K/TX

Reg. No: 23BCH0058

VIT
Vellore Institute of Technology

Final Assessment Test – November 2024

Course: **BCHE203L - Chemical Process Calculations**

Class NBR(s): **3079** Slot: **A2+TA2+TA**

Time: **Three Hours** Max. Marks: **10**

- **KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE**
- **DON'T WRITE ANYTHING ON THE QUESTION PAPER**

Answer ALL Questions

(10 X 10 = 100 Marks)

1. Pure water and alcohol are mixed to get a 60% (weight) alcohol solution. The densities (kg/m^3) of water, alcohol and the solution may be taken to be 998, 798 and 895 respectively at 293 K. Calculate the following:

   (a) The volume percent of ethanol in the solution at 293K

   (b) The molarity

   (c) The molality

2. Natural gas has the following composition by weight CH_4 = 94.1%, C_2H_6 = 3% and N_2 = 2.9%.The gas is piped from the well at a temperature of 27°C, and an absolute pressure of 4 bar it may be assumed that the ideal gas law is applicable. Calculate

   a) the partial pressure of each component.

   b) pure component volume of each component.

   c) density of the mixture at the given conditions.

3. A solution contains 55% benzene, 28% toluene and 17% xylene by weight at 100°C; the vapours are in contact with the solution. Calculate the total pressure and the molar percentage composition of the liquid and vapour. The vapour pressures and molecular weights are as follows:

Component	Vapour pressure at 100°C (kPa)	Molecular Weight
Benzene	178.60	78
Toluene	74.60	92
Xylene	28	106

4. The dry-bulb temperature and dew point of ambient air were found to be 302K (29°C) and 291K (18°C), respectively. The barometer reads 100 kPa. Calculate:

   a) The absolute molal humidity,
   b) The absolute humidity,
   c) The % RH,
   d) The % saturation,
   e) The humid heat,
   f) The humid volume,

Data:
Vapour pressure of water at 291 K (18°C) = 2.0624 kPa.
Vapour pressure of water at 302 K (29°C) = 4.004 kPa.

separated in to vapour and liquid streams. The analysis of the vapour streams in weights percentage is given below.

Stream component	Feed weight %	Vapour weight %	Liquid weight %
C_4H_{10}	20	71.4	?
C_5H_{12}	30	23.8	31.6
C_6H_{14}	50	4.8	?
Total	100	100	100

Calculate

a) Weight of vapour product per unit weight of feed.

b) Full composition of liquid product.

c) Average molecular weight of product.

6. A limestone analysis is shown as $CaCO_3$= 92.89%, $MgCO_3$=5.41%, insoluble = 1.70 %: (All percentage is by weight). Calculate

(a) How many kg of CaO can be made from 6 tonnes of this limestone?

(b) How many kg of CO_2 can be recovered per kg of limestone?

(c) How many kg of limestone are needed to make 2 tonnes of lime?

7. A dryer system handles 1000 kg/day of wet solids. The wet solids containing 50% solid and 50% water are fed to the first dryer. From the first dryer the product that comes out has 20% moisture. This is admitted to the second dryer from which the product coming out has 2% moisture. Calculate the percentage of original water that is removed in each dryer and the final weight of the product.

8. Carbon monoxide combines with chlorine in the presence of a suitable catalyst to form phosgene according to the reaction

$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$.

After reaction, the products contained 12 moles of phosgene, 3 moles of chlorine and 8 moles of carbon monoxide. Assuming that the original reactant mixture is free of phosgene, calculate the following:

(a) The percent excess reactant used

(b) The percent conversion of the limiting reactant

(c) The moles of the total product per mole of the reactant mixture fed to the reactor

9.a) In a textile industry, it is desired to make 24% caustic soda solution by weight for a mercerization process. Due to very high heat of dissolution of caustic soda in water, the above solution is prepared by a two-step process. First, in a dissolution tank, caustic soda is dissolved in the correct quantity of water to prepare 50% (by weight) solution. After complete dissolution and cooling, this solution is taken to a dilution tank where some water is added to produce 24% caustic soda solution. Assuming no evaporation loss of water in the dissolution tank, calculate the weight ratio of water fed to the dissolution tank to bypass water to the dilution tank.

OR

9.b) A distillation column separates 10,000 kg/hr of a mixture containing an equal mass of benzene and toluene. 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 vapour V entering the condenser from the top of the column is at 8000 kg/hr. A portion from of the condenser is returned to the column as reflux R and the rest is withdrawn as a final product D. Assume that V, R and D are identical in composition since V is condensed completely. Find the ratio of the amount refluxed R to the product withdrawn D.

10.a) Octane is burnt with 10% excess air Calculate

(i) air/fuel ratio by weight .
(ii) air/fuel ratio by volume.
(iii) Weight of dry exhaust gas formed per unit weight of fuel.
(iv) Moles of O_2 in the exhaust per unit weight of fuel.
(v) Moles of water vapour in exhaust per unit weight of fuel.
(vi) Volume of exhaust gas at 1atm and 260°C per unit weight of fuel. Specific gravity of octane is 0.7.

OR

10.b) A gas having the following composition is at a temperature of 875K, SO_2 = 7.09%, O_2 = 10.55%, SO_3 = 0.45% and N_2 = 81.91%. Calculate the heat content of 10 kmol gas mixture over 298K (25°C) using the heat capacity data given below:

$Cp = a+bT+cT^2+dT^3$, kJ/(kmol.K)

Gas	a	$bx10^3$	$cx10^6$	$dx10^9$
SO_2	24.77	62.94	-44.25	11.12
O_2	26.02	11.75	-2.34	-0.56
SO_3	22.03	121.62	-91.86	24.36
N_2	29.59	-5.41	13.18	-4.96

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