Code No: A109210804 **R09** **Set No. 2**

II B.Tech I Semester Examinations,November 2010
CHEMICAL PROCESS CALCULATIONS
Chemical Engineering

Time: 3 hours Max Marks: 75

Answer any FIVE Questions
All Questions carry equal marks

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1. Calculate the heat evolved, expressed as Btu when the following materials are mixed at 25^0C.
   (a) 50lb H_2SO_4 & 50lb H_2O
   (b) 50 lb H_2SO_4 & 200 lb of a solution of sulfuric acid and water, which contains 50% by weight of H_2SO_4.
   (c) 50 lb H_2O and 200 lb of a solution of sulfuric acid and water, which contains 50% by weight of H_2SO_4
   (d) 60 lb of Na_2SO4 $10H_2O$. [15]

2. (a) Explain about the different types of vapor pressure plots and their applications.
   (b) Explain about liquefaction and liquid state. [15]

3. A solid material with 15% w water under the following conditions . fresh air is mixed with recycled air which is part of the air leaving the dryer containing 0.1 Kg of water/kg dry air. The proportions of fresh and recycled air are adjusted so that the mixture entering the drier contains 0.03 kg water per kg dry air.
   (a) How many kg of water are removed from 100 kg of wet material fed to the drier?
   (b) How many kg of dry air are in the fresh air fed per 100 kg of wet material?
   (c) How many kg of dry air are recycled per 100 kg of wet material? [15]

4. An aqueous solution of acetic acid is 35% conc. (by weight) has density 1.04 gm/cm^3 at 25^0C. Find the mole fraction, molarity, normality and molality of the solution. [15]

5. A flue gas has the following composition by volume:
   $CO_2 = 9.5\%, CO = 0.2\%, O_2 = 9.6\%, N_2 = 80.7\%$
   Using ideal gas law, calculate
   (a) Average molecular weight of the gas
   (b) Volume in m^3 of 10 kg of the gas at 25^0C and 1.02 atm pressure
   (c) Composition of the gas by weight
   (d) Density of the gas in kg/m^3 at the condition in part (b). [15]

6. (a) Helium contains 12% by volume of ethyl acetate .Calculate
   i. The percent relative saturation and
   ii. The percent absolute saturation of the mixture at a temperature of 30^0C and a Pressure of 98 kPa.

   Vapor pressure of Ethyl acetate at 30^0C: 15.9 kPa.

   (b) Define humidity heat and humidity volume. [15]

7. In the Deacon process for the manufacture of chlorine, a dry mixture of hydrochloric acid gas and air is passed over a heated catalyst which promotes oxidation of the acid. Air is used in 30% excess of that theoretically required.
   (a) Calculate the weight of air supplied per pound of acid.
   (b) Calculate the composition , by weight , of the gas entering the reaction chamber.
   (c) Assuming that 60% of the acid is oxidized in the process, calculate the composition, by weight of the gases leaving the chamber. [15]

8. A gas containing 20% CO and 80% N_2 is burnt with 100% excess air, both air and gas initially being at 25^0C. A flame temperature of 942^0C is attained during combustion. Calculate the enthalpy of the products. Given means molar heat capacities between 25^0C and 942^0C as :
   CO_2 - 11.74, O_2 - 7.90 and N_2 - 7.45 cal/gm mol ^{0}K. [15]

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Code No: A109210804 **R09** **Set No. 4**

II B.Tech I Semester Examinations,November 2010
CHEMICAL PROCESS CALCULATIONS
Chemical Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. 100 lb of an oleum solute on containing 15.4 % free SO_3 are to be diluted with water to make a 30.8% solution of H_2SO_4. Calculate the heat evolved. [15]

2. Write short notes on
   (a) Heat capacity of gases with equations
   (b) Effect of pressure on heat capacities. [15]

3. In the manufacture of soda ash by the LeBlance process, sodium sulfate is heated with charcoal and calcium carbonate. The resulting black ash has the following composition.
   Na_2CO_3 42%
   Other water soluble material 6%
   Insoluble material 52%
   The black ash is treated with water to extract the sodium carbonate. The solid residue from this treatment has the following composition.
   Na_2CO_3 4%
   Other water soluble material 0.5%
   Insoluble material 85%
   Water 10.5%
   (a) Calculate the weight of residue remaining from the treatment of 1 ton of black ash.
   (b) Calculate the weight of sodium carbonate extracted per ton of black ash. [15]

4. A fertilizer plant produces ammonia by reforming naphtha with steam, the synthasis gas, obtained from methanator is passed through the converter after mixing the recycle stream. Based on the operating parameters of the converter the conversion per mass is limited to 25%. The composition of the fresh feed is CH_4 - 0.7%, Ar - 0.3%, H_2 - 74.25%, and N_2 - 24.75% on mol basis. The converter outlet gases pass through the heat exchanger where it cools down. Later the gases are passed through a chiller come separator which separates 65% of the ammonia present in the converter outlet gas. Non condensable gases and uncondensed ammonia are recycled back. Inorder to limit the concentration of inert(CH_4+Ar) to 10mols in the mixed feed, a portion of the recycle stream is purged based on a fresh feed rate of 100kmol /s calculate
   (a) The recycle feed rate and recycle ratio.
   (b) The purge gas rate. [15]

5. (a) In the decomposition of $KClO_3 : 2KClO_3 \rightarrow 2KCl + 3O_2$
   i. Calculate the amount of oxygen that evolves on decomposition of 12.9% gm of KClO_3
   ii. Calculate the amount of KClO_3 for evolution of 5 gm of oxygen

   (b) A solution of caustic soda in water contains 20% NaOH by weight. The density of the solution is 1.196 kg/l, find the molarity and molality. [15]

6. (a) The weather bureau reports the local barometric pressure is 29.6 inches of mercury, the temperature in 85.5^{0}F and the relative humidity in 80%.
   i. Calculate the partial pressure of water vapor,
   ii. Mole fraction of water
   iii. Mole ration of water vapor to dry air? Data: At 85^{0}F water pressure: 4.1 kPa.

   (b) Define partial saturation and relative saturation. [15]

7. In the manufacture of HCl, a gas is obtained that contains 25% HCl and 75% air by volume. This gas is passed through an absorption system in which 98% of the HCl is removed. The gas enters the system at a temperature of 49^{0}C and a pressure of 743 mm Hg and leaves at a temperature of 27^{0}C and a pressure of 738 mm Hg.
   (a) Calculate the volume of gas leaving per 100 m^3 entering the absorption apparatus.
   (b) Calculate the percentage composition by volume of the gases leaving the absorption apparatus
   (c) Calculate the weight of HCl removed per 100 m^3 of gas entering the absorption apparatus. [15]

8. The following is the vapor pressure of benzene and chloro-benzene

Temperature (^{0}C)	79.6	90	100	110	120	132.3
Benzene (mmHg)	760	1013	1340	1744	2235	2965
Chloro-benzene (mmHg)	85	208	293	408	542	760

Assuming the Raoult's law is valid use the above data to plot T-x-y and x-y at a total pressure of 760 mmHg. Where T is the temperature, x is the liquid phase mole fraction and y is vapor phase mole fraction. [15]

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Code No: A109210804 **R09** **Set No. 1**

II B.Tech I Semester Examinations,November 2010
CHEMICAL PROCESS CALCULATIONS
Chemical Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. Write short notes on:
   (a) Cox chart and its applications
   (b) Duhrings chart and its applications
   (c) Critical properties
   (d) Reduced conditions. [15]

2. Explain in detail about energy balance with the help of flow sheet and equations. [15]

3. Write short note on
   (a) Heat of reaction
   (b) Heat of formation
   (c) Heat of combustion
   (d) Neutralization. [15]

4. (a) CO_2 is contained in 250 L cylinder at a temperature of 300 K. The gas from the cylinder is allowed to enter an evacuated chamber of 750 L by opening a valve. The flow of gas into the chamber stops when the pressure inside the chamber and the cylinder equal 100 kPa. The temperature of the gas is uniform throughout and it is equal to 310K. What was the original pressure inside the cylinder?
   (b) Natural gas is piped from the well at 300 K and 400 kPa. The gas is found to contain 93% methane, 4.5% ethane and the rest nitrogen. Calculate the following
      i. The partial pressure of nitrogen
      ii. The pure component volume of ethane in 10 m^3 of the gas
      iii. The density at the given conditions . [15]

5. A fertilizer plant produces ammonia by reforming naphtha with steam, the synthesis gas, obtained from methanator is passed through the converter after mixing the recycle stream. Based on the operating parameters of the converter the conversion per mass is limited to 25%. The composition of the fresh feed is CH_4 - 0.7%, Ar - 0.3%, H_2 - 74.25%, and N_2 - 24.75% on mol basis. The converter outlet gases pass through the heat exchanger where it cools down. Later the gases are passed

through a chiller come separator which separates 65% of the ammonia present in the converter outlet gas. Non considerable gases and uncondensed ammonia are recycled back. Inorder to limit the concentration of inert (CH_4+Ar) to 10mols in the mixed feed, a portion of the recycle stream is purged based on a fresh feed rate of 100kmols calculate

(a) The recycle feed rate and recycle ratio.

(b) The purge gas rate. [15]

6. In the LeBlanc soda process the first step is carried out according to the following reaction :

$2NaCl + H_2SO_4 = NaCl + NaHSO_4 + HCl$

The acid contains 80.0% H_2SO_4. It is supplied in 5% excess of that theoretically required for the above reaction.

(a) Calculate the weight of acid supplied per 1000 lb of salt charged.

(b) Assume that the reaction goes to completion, all the acid forming bisulfate, and that in the process 90% of the HCl formed and 25% of the water present are removed. Calculate the weights of HCl and water removed per 1000 lb of salt charged.

(c) Assuming the condition of part b, calculate the percentage composition of the remaining salt mixture. [15]

7. (a) What is the minimum number of cubic meters of dry air at 20^0C and 100 kPa that are necessary to evaporate of 6 kg of ethyl alcohol if the total pressure remains constant at 100 kPa? Assume that the air is blown through the alcohol to evaporate it in such a way that the exit pressure of the air-alcohol mixture is at 100 kPa.

Data: Vapor pressure of alcohol at 20^0C: 5.93 kPa.

(b) A telescopic gas holder contains 250m^3 of gas saturated with water vapor at 80^0C and a pressure of 6.0 in H_2O above atmosphere. The barometer reads 28.46 in Hg. Calculate the weight of water vapor in the gas.

Vapor pressure of water at 80^0F = 1.32 in Hg. [15]

8. A mixture of H_2 and CH_4 is burned with air. The following is the analysis of the waste gas on dry basis: N_2=86.9%, O_2=4.4% and CO_2=8.7%.

(a) What is the composition of the fuel mixture of H_2 and CH_4?

(b) What is the ratio of fuel to air? [15]

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Code No: A109210804 **R09** **Set No. 3**

II B.Tech I Semester Examinations,November 2010
CHEMICAL PROCESS CALCULATIONS
Chemical Engineering

Time: 3 hours **Max Marks: 75**

Answer any FIVE Questions
All Questions carry equal marks

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1. A product gas from a reaction has the composition by weight, chlorine 67%, bromine 28%, oxygen 5%. Using the ideal gas law
   (a) Calculate the composition of gas by volume,
   (b) Calculate the density of the mixture in gms/liter at 25^0C,
   (c) Specific gravity of the mixture and
   (d) average molecular weight. [4+4+4+3]

2. Calculate the specific heat at 20^0C of ZnO, Al_2O_3, SnO_2, FeO, As_2O_3 from Kopp's rule and compare with the experimental values. [15]

3. Refined sugar (sucrose) can be converted to glucose and fructose by the inversion process.
   $C_{12}H_{22}O_{11} \rightarrow C_6H_{12}O_6 + C_6H12O_6$
   The combined quantity glucouse plus fructose is called inversion sugar. If 90% conversion of sucrose occurs on one pass through the reactor, what would be the recycle stream flow per 100 Ib fresh feed of sucrose solution entering the process shown in Figure 1. What is the concentration of inversion sugar in the recyle stream and in the product steam? The concentration of components in the recycle stream and product strem are the same. [15]

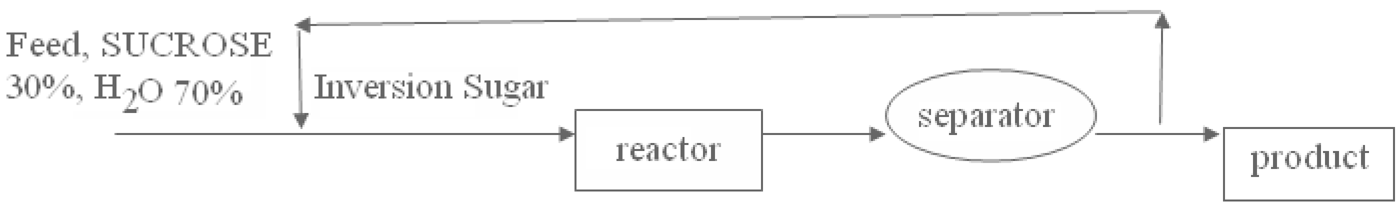

Figure 1:

4. Air at 38^0C and 20% relative humidity is forced through a cooling tower. The air leaves at 29.4^0C and 70% relative humidity Atmospheric pressure is 29.48 inch Hg Calculate the following:
   (a) The kgs of water evaporated per kg of dry air.
   (b) Volume of air leaving per 30m3 of entering air.

Antoine equation for water: $\log_{10}P = 7.2643 - \frac{1767.30}{T-36.85}$ where P is in kPa and T is in ^{0}K. [15]

5. Ethyl alcohol is industrially produced by fermentation of molasses. A sample of molasses contains 45% fermentable sugar. The reaction taken place in the fermenter are as follows.

   $C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6$
   $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

   Calculate theoretical production of refined spirit (density is 0.785 kg/l) in leters per tons of molasses. [15]

6. (a) Calculate the total pressure and the composition of the vapors in contact with a solution at 100^{0}C, containing 30% benzene (C_6H_6), 45% toluene ($C_6H_5CH_3$) and 25% O-Xylene ($C_6H_5CH_3CH_3$) by weight. (Data: Vapor pressure at 100^{0}C is Benzene- 1340 mmHg, toluene -560 mmHg and O-Xylene -210 mmHg).
   (b) Explain briefly why liquid water boils quickly in hills. [15]

7. A sample of coal if found to contain 65% carbon and 12.7% ash by mass. The refuse obtained after burning the fuel is found to have 8.6% carbon. Assume that negligible oxygen is present in the coal. Flue gas analysis showed CO_2 10.6%, O_2 8.7% N_2 80.7 % by volume. Calculate
   (a) the actual mass of dry air used to burn the coal.
   (b) the actual mass of flue gases produced by burning the coal and the amount of combustible hydrogen present in the fuel. [15]

8. Diborane B_2H_6 a possible rocket propellent can be made by using lithium hydride, LiH
   $6LiH + 2BCl_3 \rightarrow B_2H_6 + 6LiCl$
   If you have mixed 90720 gm of LiH, 453600 gm of BCl_3, 20412 gm of B_2H_6 is recovered. Determine
   (a) Limiting reactant,
   (b) Excess reactant,
   (c) Percent excess reactant,
   (d) the percent conversion,
   (e) the degree of completion of the reactant,
   (f) the yield of B_2H_6 based the LiH charged. [15]

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