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

II B.Tech I Semester Examinations,MAY 2011
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) A gas mixture contains 0.1234 kg-mole of HCl ,0.153Kg-mole of nitrogen, and 0.04037 Kg-mole of oxygen .Calculate its density in kg/m^3 at a pressure of 1.72 atm and a temperature of 40^0C
   (b) State and prove law of Amagat. [7+8]
2. (a) By titration, it was found that a sample of water contains alkalinity equivalent to 800 mg/lit $CaCO_3$. Assuming that the water contains temporary hardness due to $Mg(HCO_3)$, find the $Mg(HCO_3)$ content of water.
   (b) Explain Baume and API. [15]
3. Pure sulfur is burnet in a burner at the rate of 0.3 kg/s. fresh air is supplied at 303K and 100 kpa. The gasess from the burner contain 16.5% SO_2 3% O_2 and rest N_2 on SO_3 free volume basis. The gasess leave the burner at 1073k and 101.325 kpa. Calculate
   (a) The fraction of sulfur burnet in SO_3
   (b) The % excess air over the amount required to oxidize the sulfur to SO_2
   (c) The volume of dry air in m^3 /s(d). The volume burner gas in m^3 /s. [15]
4. (a) Discuss in detail what is heat of formation and how to calculate heat of formation.
   (b) Calculate heat of reaction of the following
   $HCl(g)+NH_3(g) \rightarrow NH_4Cl(s)$
   HCl(g) of change of enthalpy is -22,063 cal
   NH_3(g) of change of enthalpy is -11040 cal
   NH_4Cl(s) of change of enthalpy is -75,380 cal. [15]
5. (a) What do you mean by crystallization? Explain how it is used in industries.
   (b) What do you mean by dissolution. [15]
6. Calculate the number of kilocalories required to heat , from 500 to 1500^0 C, 1 Cubic meter (standard conditions) of a gas having the following composition by volume : [15]

CO_2	70%
N_2	27%
O_2	2%
H_2	1%
	100%

7. It is proposed to recover acetone which is used as a solvent in an extraction process by evaporation into a stream of nitrogen. The nitrogen enters the evaporator at 30^0C containing acetone such that its dew point is 10^0C. It leaves at a temp of 25^0C with a dew point of 20^0C. The atmospheric pressure is 750 mm Hg.

   (a) Calculate the vapor concentration of the gases entering and leaving the evaporator expressed in moles of vapor/mole of vapor/mole of vapor free gas.

   (b) Calculate the moles of acetone evaporated per mole of the vapor free gas passing through the evaporator.

   (c) Calculate the weight of acetone evaporated per $28m^3$ of gases entering.

   (d) Calculate the volume of gases leaving the evaporator per $28m^3$ of gases entering.

   Antoine equation for Acetone is: $\log_{10} P = 6.2834 - \frac{1231.2}{T-41.35}$ where P is in kPa and T is in ^{0}K. [15]

8. Construct Durhing plots for aqueous 10% by weight of NaOH solution. The vapor pressure of water is given by Antoine equation ln P = A - B/(T+C) Where p is in mm Hg, T is in ^{0}K and A,B,C are constants. The values of A, B, C for water are given by 18.3036, 3816.44, -46.13 respectively. [15]

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

II B.Tech I Semester Examinations,MAY 2011
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. On the basis of data and the chemical reaction given below, find the heat of formation of $ZnSO_4$ from elements.
   (a) Zn + S(rambho) → ZnS, ΔH = - 44 kcal / kg. mol
   (b) 2 ZnS + $3O_2$ → 2 ZnO + 2 SO_2, ΔH = - 221.88 kcal / kg. mol
   (c) $2SO_2$ + O_2 → 2 SO_3, ΔH = - 46.88 kcal / kg. mol
   (d) ZnO+ SO_3 → 2 $ZnSO_4$, ΔH = - 55.10 kcal / kg. mol. [15]

2. (a) The flue gas analysis CO: 7.26%, CO_2: 4.2%, O_2: 7.5%, N_2: 81.04% on mole basis. Express the composition in weight basis and also find the average molecular weight.
   (b) The analysis of a sample of glass yields 7.8% Na_2O, 7% MgO, 9.7% ZnO, 2% Al_2O_3, 8.5% B_2O3 and 65% SiO_2 (by weight). Convert the composition into mole%.
   Atomic weights: Na: 22.98, Mg : 24.3, Zn: 65.37, Al: 26.98, B: 10.81, Si: 28.086. [15]

3. (a) Calculate the volume occupied by 13.6 kg of chlorine at a pressure 743 mmHg and 21.1^0C.
   (b) Calculate the weight of 3 m^3 of water vapor, measured at a pressure of 15.5 mmHg and 23^0C.
   (c) What is the ideal gas equation of state? At what conditions does the ideal gas equation provide the most accurate estimates? [5+5+5]

4. (a) Explain the orsat analysis.
   (b) A hydro carbon fuel is burnet with excess air, the orsat analysis of the flue gas shows 10.2% CO_2, 1% CO, 8.4% O_2, and 80.4% N_2. What is the atomic ratio of H to C in the fuel? [15]

5. (a) Write short notes on Lennard - Jones potential.
   (b) Explain corresponding states.
   (c) Write short notes on polarity of molecules. [15]

6. (a) A solution of potassium dichromate in water contains 13% $K_2Cr_2O_7$ by weight. From 1000 lb of this solution are evaporated 640 lb of water. The remaining solution is cooled to 20^0C. calculate the amount and % yield of $K_2Cr_2O_7$ crystals produced. Solubility of $K_2Cr_2O_7$ at 20^0C is 0.390 lb-mol per 1000 lb H_2O

(b) A solution of Sodium nitrate in water contains 100 grms of $NaNO_3$ per 1000 grams of water. Calculate the amount of ice formed in cooling 1000 grams of this solution to a temperature of - 15^0C. [15]

7. Utilizing the thermal data for diphenyl, $(C_6H_5.C_6H_5)$ tabulated below and vapor pressure data from a handbook, estimate the following :

   (a) Critical Temperature.

   (b) Boiling Point at 25psi.

   (c) Heat of vaporization at 25psi, as Btu per pound.

   (d) Enthalpy of 1lb of saturated diphenyl vapor at 25psi relative to solid diphenyl at 32^0F. [15]

   Data of diphenyl :

Normal Boiling Point	255^0C
Melting Point	71^0C
Specific heat of solid diphenyl	0.385 Btu per lb per^0 F
Heat of fusion	46.9 Btu per lb.
Specific heat of liquid diphenyl	$C_P = 0.300 + 0.00120t^0$ C

8. Acetone is used as a solvent in a certain process. Recovery of the acetone is accomplished by evaporation in to a stream of N_2 followed by cooling and compression of the final gas mixture. In the solvent recovery unit 5000 kg of acetone are removed per hour. The N_2 is admitted at 38^0C and 750 mm Hg. Partial pressure of acetone in incoming nitrogen is 10 mm Hg. The nitrogen leaves at 29.4^0C, 740 mm Hg and 85% saturation.

   (a) How many m^3 of incoming gas must be admitted per hour to obtain the required rate of evaporation of the acetone?

   (b) How many m^3 of gases leave the unit per hour? (Molecular weight of Acetone $(CH_3)_2CO$ is 58. Vapor pressure of acetone at 29.4^0C is 287 mm Hg). [15]

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

II B.Tech I Semester Examinations,MAY 2011
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. Stock containing 1.562gm of water per gm of dry stock is to be dried to 0.099gm as shown in figure 1. For each gm of stock (dry basis) 52.5gm of dry air pass through the drier, leaving at a humidity of 0.0525. The fresh air is supplied at a humidity 0.0152. Calculated the fraction of air recirculated. [15]

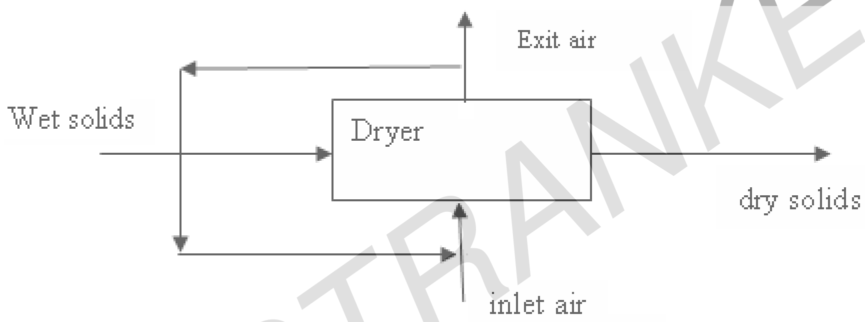

Figure 1:

2. Calculate the theoretical flame temperature of a gas containing 20% CO and 80% N_2 when burned with 150% excess air, both air and gas being at 25^0 C. Heat of formation, ΔH kcal / kg. mol. [15]

3. (a) The vapor pressure of chloroform is given by the Antoine equation.
   In $P^S = 13.9582 - \frac{2696.79}{(T-46.16)}$
   Where pressure is in kPa and temperature in K. Determine
   i. The boiling of chloroform at 50 kPa and
   ii. The vapor pressure at 300 K.
   (b) Explain briefly critical properties. [15]

4. Calculate the number of calories required to heat 1000 grams of each of the following aqueous solutions from 0 - 100^0C.
   (a) 5% NaCl by weight.
   (b) 20% NaCl by weight.
   (c) 20% H_2SO_4 by weight.
   (d) 20% KOH by weight.
   (e) 20% NH_4OH by weight

(f) 20% Pb $(NO_3)_2$ by weight. [15]

5. (a) 200 kg of pure sulfur is burnt with 25 % excess of dry air to convert S completely into SO_3. 4.45% of S is oxidized to SO_3 and 95.5 % to SO_2. Calculate the composition (mole %) of the exit gas.

   (b) 10 kg of liquid A of specific gravity 1.17 is mixed with 5 kg of liquid B of specific gravity 0.83. Assuming that there is no volume change on mixing what is the specific gravity of the mixture? (take density of water is 1000 kg/m^3). [15]

6. (a) Write the difference between flue gas analysis and orsat analysis on dry and wet basis.

   (b) pure carbon is burned in a oxygen. The flue gas analysis is CO_2 75 mole %, CO 14 mol %, O_2 11 mol %. What was the present excess oxygen used? [15]

7. A volume of moist air of 0.792 cubic meters at a total pressure of 740 mmHg and a temperature of 30^0C contains water vapor in such proportions that its partial pressure is 22 mmHg. Without the total pressure being changed, the temperature is reduced to 15^0C and some of the water vapor removed by condensation. After cooling it is found that the partial pressure of water vapor is 12.7 mmHg. Using partial pressure method, calculate:

   (a) The volume of gas after cooling and

   (b) The weight of water removed [15]

8. Air at 38^0C, 70% saturated with water vapour is heated to 82.4^0C and passed through a dryer where it gets adiabatically cooled to 54.4^0C and humidified to 40% saturation. The air leaving the dryer is cooled in a cooler to 26.6^0C and reheated to 38^0C. Determine:

   (a) Molar humidity of air entering the first heater

   (b) Molar humidity and % saturation of air leaving the first heater

   (c) Molar humidity of air leaving the dryer

   (d) Water evaporated in the dryer per kg mole of air entering.

   The vapour pressure of water is as follows: [15]

Temperature ^{0}C	26.6	38	54.4	82.4
Vapor pressure, mmHg	26.2	49	115	388.4

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

II B.Tech I Semester Examinations,MAY 2011
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 equivalent in Btu of the external work of vaporization of 1 lb of water at a temperature of 80^0F, assuming that water vapor follows the ideal-gas law. [15]

2. A natural gas has the following composition on volume basis CH_4-83.5%,C_2H_2 -9% and N_2-7.5%. Calculate
   (a) composition in mole %
   (b) the composition in weight %,
   (c) average molecular weight of the gas and
   (d) specific gravity of the mixture. [15]

3. (a) Discuss about material balance involving chemical reaction.
   (b) Write difference between conversion, selectivity and yield? [15]

4. (a) A mixture of benzene vapour and nitrogen has a relative humidity of 60% at 297 K; the total pressure being 102.4 kN/m^2. If the mixture is cooled to 283 K, to what pressure must the mixture to be compressed in order to recover 75% of the benzene? The vapour pressure of benzene is 12.2 kN/m^2 and 6.05 kN/m^2 at 297 K and 283 K, respectively.
   (b) Define dry and wet bulb temperature. [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. (a) When heated to 100^0C and 720 mmHg pressure 17.2 grams of N_2O_4 gas occupy a volume of 11450 cc. Assuming the ideal gas law applies calculate the percentage dissociation of N_2O_4 to NO_2.

   (b) Calculate the density in kg/m^3 at 736.6 mm.Hg and 30^0C of a mixture of hydrogen and oxygen that contains 11.1% H_2 by weight . [15]

7. (a) An approximate Equation for C_P(cal/gm mol K) of gaseous HCl is $C_P = 6.6 + 0.96 \times 10^{-3}$ T.Calculate the heat required to raise the temperature of 1gm mole of Gas from 100 - 200^0C.

   (b) The following enthalpy changes are known from experiments from the reactions below at 25C in Standard State. Calculate the standard heat of formation of Propylene gas. [15]

Reactions	Δ H kcal / kg. mol
$C_3H_6(g) + H_2(g) \rightarrow C_3H_8(g)$	-29.60
$C_3H_8(g) + 5O_5 \rightarrow 3CO_2(g) + 4H_2O(l)$	-530.60
$H_2(g) + 0.5O_2(g) \rightarrow H_2(l)$	-68.30
$C(graphite) + O_2(g) \rightarrow CO_2(g)$	-94.05

8. The following data in the vapour pressure data for water vapour. Determine the latent heat of vaporization at normal boiling point. [15]

Temperature (^{0}F)	10	40	80	120	160	210	212
Pressure (inches of Hg):	0.07091	0.2478	1.0321	3.4458	9.652	28.755	29.922

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