Code No: R050210803 **Set No. 1**

II B.Tech I Semester Regular Examinations, November 2006
CHEMICAL PROCESS CALCULATIONS
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) The analysis of magnesite ore obtained from chalk hill area, Salem district yields 81% MgCO3, 14% SiO_2 and 5% H_2O (by weight). Convert the analysis into moleAtomic weights: Mg : 24.3, Si: 28.08, H: 1.007, O: 16, C: 12
   (b) Write short notes on the following: Normality, molality, limiting reactant and excess reactant [8+8]

2. (a) A gas mixture contains 0.274 gm-mole of HCl, 0.337 gm-mole of N_2 and 0.089 gm-mole of O_2. Calculate the volume occupied by the mixture, density and partial pressure of each component at a pressure of 2.7 atm and a temperature of 30^oC.
   (b) Explain any equation of state [12+4]

3. (a) What is the main principle involved to derive Clausius Clapeyron equation and what are the assumptions made. [8+8]
   (b) Why the equilibrium vapor pressure of component effected in case of miscible liquid and not in immiscible liquids.

4. Air at a temperature of 20^0C and 750 mm Hg has a relative humidity of 80% Calculate:
   (a) The molal humidity of the air.
   (b) The molal humidity of this air if its temperature is reduced to 10^0C and pressure increased to 2000 mm Hg condensing out some of the water and
   (c) Weight of water condensed from 1000 litre of the original wet air. [5+5+6]

5. In the common process for the production of nitric acid sodium nitrate is treated with 95% H_2SO_4. In order that the resulting ?niter cake? may be fluid, it is desirable to use excess acid, so that final cake contains 34% sulfuric acid. It may be assumed that the cake will contain 1.5% water and that the reaction will go to completion. 2% of HNO_3 formed will remain in the cake.
   (a) Calculate the composition of niter cake by weight %, formed per 100 kg of sodium nitrate charged.
   (b) Calculate the weight of sulfuric acid to be used.
   (c) Calculate the weight of HNO_3 and water vapor distilled from the niter cake. [16]

6. (a) A crystallizer is charged with 7,500 kg of aqueous solution at 104^0C containing 29.6% by weight of anhydrous Na_2SO_4. The solution is then cooled to 20^0C. During this operation 5% of water is lost by evaporation. Glauber salt crystallizes out. Find the yield of crystals. Solubility at 20^0C = 194 g Na_2SO_4/100 g water Molecular weight of Glauber?s salt ($Na_2SO_4.10H_2O$) = 142+180 = 322.

   (b) What are the different ways of crystallizing a solute from a solution? Explain. [8+8]

7. Air is being compressed from 100 Kpa and 225 ^{0}K (the enthalpy is 489 KJ/Kg) to 1000 Kpa and 278 ^{0}K (where it has an enthalpy of 509 KJ/kg). The exit velocity of the air from the compressor is 60 m/s. What is the power required for the compressor if the load is 100 kg/hr of air. [16]

8. (a) A sample of dry flue gas has the following composition by volume CO_2 = 13.4%; N_2 = 80.5%; O_2 = 6.1%. Calculate the excess air supplied

   (b) Calculate the change in enthalpy for the reaction
   CH_4 (g) + $2O_2$(g) = CO_2(g) + $2H_2O$(g) ; The enthalpies of formation of CH_4 (g) , CO_2(g) , H_2O(g) are -74.9, -393.5, -241.8KJ/Kmol respectively
   . [16]

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Code No: R050210803 **Set No. 2**

II B.Tech I Semester Regular Examinations, November 2006
CHEMICAL PROCESS CALCULATIONS
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) NaCl weighing 600 kg is mixed with 200 kg KCl. Find the composition in weight % and mole %.
   (b) What will be the % Na_2O content of lye containing 73% caustic soda
   (c) Explain briefly various concentration units used for liquid solutions when one of the substance is solid [6+6+4]

2. 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 [16]

3. (a) Derive the Clausius-Claperyon equation State necessary assumptions to solve the problem. [10+6]
   (b) Calculate the vapor pressure at 25^oC of a substance (mol.wt. 58) when its vapor pressure at 0^oC is 180 mmHg and latent hate of vaporization is 90 cal per gram at 0^0C.

4. (a) Leather containing 100% of its own weight of water is dried by means of air. The dew point of entering air is 4^0C while that of leaving air is 13^0C. If 1000 kg of wet air is forced through the drier per hour, how many kg of water is removed per hour. Total pressure is 750 mm Hg. Vapor pressure of water at 4^0C = 6.3 mm Hg and at 18^0C = 11 mm Hg.
   (b) By adsorption in silica gel you are able to remove all the water (0.93 kg) of water from moist air at 15^0C and 98.6 kPa. The same air measures $1000m^3$ at 20^0C and 108 kPa when dry. What was the relative humidity of the air? [16]

5. (a) Soyabean seeds are extracted with hexane in batch extractors. The seeds contain 18.6% oil, 69% solids and 12.4% moisture. At the end of the extraction process, the residual cake is separated from hexane. The analysis of cake reveals 0.8% oil, 87.7% solids and 11.5% moisture. Find the % recovery of oil.
   (b) A multiple effect evaporator handles 100 ton/day of pure cane sugar. The feed to the evaporator contains 30% solids. While the concentrate is leaving with

75% solids concentration, calculate the amount of water evaporated per day. [8+8]

6. (a) A solution of sodium chloride in water is saturated at a temperature of 15^0C. Calculate the weight of NaCl that can be dissolved by 100 kg of this solution if it is heated to 65^0C.

   (b) Define the following terms: [16]

   Solute
   Dissolution
   Solubility
   Crystallisation

7. Air is being compressed from 100 Kpa and 225 ^{0}K (the enthalpy is 489 KJ/Kg) to 1000 Kpa and 278 ^{0}K (where it has an enthalpy of 509 KJ/kg). The exit velocity of the air from the compressor is 60 m/s. What is the power required for the compressor if the load is 100 kg/hr of air. [16]

8. In the production of sulphuric acid from anhydrite, the gypsum is roasted with clay to obtain sulphur dioxide and cement clinker. The reaction proceeds as follows: $3CaSO_4$ (s) + SiO_2 (s) - $\rightarrow$ 3 $CaO.SiO_2$(s) + $3SO_2$(s) + $3/2O_2$(g).
   Calculate the heat of reaction at 291.15 ^{0}K. The heats of formation of $CaSO_4$ = -1432.7
   kJ/mol; SiO_2 =-903.5 kJ/mol $CaO.SiO_2$ =-2879.0 kJ/mol
   SO_2 = -296.81 kJ/mol O_2= 0.0
   . [16]

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Code No: R050210803 **Set No. 3**

II B.Tech I Semester Regular Examinations, November 2006
CHEMICAL PROCESS CALCULATIONS
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. A natural gas has the following composition on volume basis CH4-83.5%,C2H2 -9% and N2-7.5%. Calculate: [16]
   (a) composition in mole %.
   (b) the composition in weight %,
   (c) average molecular weight of the gas and
   (d) specific gravity of the mixture.

2. (a) A gas mixture contains 0.274 gm-mole of HCl, 0.337 gm-mole of N_2 and 0.089 gm-mole of O_2. Calculate the volume occupied by the mixture, density and partial pressure of each component at a pressure of 2.7 atm and a temperature of 30^oC.
   (b) Explain any equation of state [12+4]

3. (a) Write short notes on Lennard ? Jones potential
   (b) Explain corresponding states
   (c) Write short notes on polarity of molecules [6+5+5]

4. 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 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 28 m^3 of gases entering.
   (d) Calculate the volume of gases leaving the evaporator per 28m^3 of gases entering. [16]

5. (a) A water soaked fabric is dried from 44% moisture to final moisture of 9%. Calculate the weight of water removed per 200 kg of dried fabric.
   (b) A tank of weak H_2SO_4 contains 12.43% acid. If 200 kg of 77.7% H_2SO_4 are added to the tank and the final acid is 18.63%, how many kg of weak acid have been made-up? [8+8]

6. Methanol is produced by the reaction of CO with H_2 according to the equation . $CO + 2H_2 \rightarrow CH_3OH$

   Only 15% of the CO entering the reactor is converted to methanol. The methanol product is condensed and separated from the un-reacted gases, which are recycled. The feed to the reactor contains 2 mole of H_2 for every mole of CO. The fresh feed enters at 35^0C and 300 atm. To produce 6,600 kg/hr of methanol calculate

   (a) Volume of fresh feed gas and

   (b) The recycle ratio. [16]

7. (a) Explain heat of fusion and heat of vaporization

   (b) Explain heat of transition and internal energy [8+8]

8. (a) Calculate the standard heat of reaction of the following reaction at 25 ^{0}C:
   $CaC_2(s) + 2\ H_2O(l) \rightarrow Ca(OH)_2\ (s) + C_2H_2(g)$

   Standard heat of formation of $CaC_2(s)$ ΔH_f = -15000 cal
   Standard heat of formation of $H_2O(l)$ ΔH_f = -68317.4 cal
   Standard heat of formation of $Ca(OH)_2$ (s) ΔH_f = -235,800 cal
   Standard heat of formation of $C_2H_2(g)$ ΔH_f = 54,194 cal

   (b) Define heat of combustion and heat of sublimation

   (c) Calculate the standard heat of reaction of the following reaction at 25 ^{0}C:
   $2Fes_2(s)+11/2\ O_2(g)$ Fe_2O_3 (s)+ 4 $SO_2(g)$
   Standard heat of formation of Fes_2s ΔH_f = -42,520 cal
   Standard heat of formation of Fe_2O_3 (s)) ΔH_f = -196,500 cal
   Standard heat of formation of $SO_2(g)$ ΔH_f = -70,960 cal [5+6+5]

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Code No: R050210803 **Set No. 4**

II B.Tech I Semester Regular Examinations, November 2006
CHEMICAL PROCESS CALCULATIONS
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) The flue gas analysis CO: 7.26%, CO2: 4.2%, O2: 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_2O_3 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 [8+8]

2. (a) Butane (C_4H_{10}) at 360^0C and 3 atm absolute flows into a reactor at a rate of 1100 kg/h. Calculate the volumetric flow rate of this stream using conversion from standard state.
   (b) State and prove the Daltons and Amagat Law [8+8]

3. (a) The vapor pressure of ethyl ether (molecular weight = 74) is 185 mmHg at 0^0C. The latent heat of vaporization is 92.5 cal/gm at 0^0C. Calculate the vapor pressure at 20^0C and 35^oC.
   (b) Explain the phenomena of vaporization. [8+8]

4. Define the following terms and give their respective equations explaining the symbols used in the equations
   (a) Humidity
   (b) Saturated gas
   (c) Relative humidity
   (d) Percentage humidity [16]

5. (a) Soyabean seeds are extracted with hexane in batch extractors. The seeds contain 18.6% oil, 69% solids and 12.4% moisture. At the end of the extraction process, the residual cake is separated from hexane. The analysis of cake reveals 0.8% oil, 87.7% solids and 11.5% moisture. Find the % recovery of oil.
   (b) A multiple effect evaporator handles 100 ton/day of pure cane sugar. The feed to the evaporator contains 30% solids. While the concentrate is leaving with 75% solids concentration, calculate the amount of water evaporated per day. [8+8]

6. Methanol is produced by the reaction of CO with H_2 according to the equation . $CO + 2H_2 \rightarrow CH_3OH$

   Only 15% of the CO entering the reactor is converted to methanol. The methanol product is condensed and separated from the un-reacted gases, which are recycled. The feed to the reactor contains 2 mole of H_2 for every mole of CO. The fresh feed enters at 35^0C and 300 atm. To produce 6,600 kg/hr of methanol calculate

   (a) Volume of fresh feed gas and

   (b) The recycle ratio. [16]

7. Chlorinated diphenyl is heated from 313 ^{0}K to 553 ^{0}K at the rate of 4000 Kg/hr. in an indirectly fired heater. In this particular temperature range the heat capacity of the fluid is given by the equation Cp = 0.7511 + 1.465 * 10^{-3} T KJ /KMol The Cp at of diphenyl at 313 ^{0}K is 1.1807 KJ /Kg ^{0}K and Cp at of diphenyl at 553 ^{0}K is 1.5198 KJ /Kg ^{0}K. Calculate the heat to be supplied in the fluid in the heater using the heat capacity equation. Also, calculate the % error involved in using the mean heat capacity data for the heat change calculations. [16]

8. (a) What is heat of hydration. [5+5+6]

   (b) Differentiate between heat of solution and heat of salvation.

   (c) Calculate the standard heat of reaction of the following:
   HCl (g) + NH_3(g) = NH_4Cl (s)
   Standard heat of formation of HCl(g) ΔH_f = -22,063cal
   Standard heat of formation of NH_3(g), ΔH_f = -11,040cal
   Standard heat of formation of NH4 Cl (s), ΔH_f = -75,380cal
   [16]

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