Code No: RR210803 **Set No.1**

II B.Tech. I Semester Supplementary Examinations, May -2005
MATERIAL & ENERGY BALANCE
(Chemical Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks

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1. Make the following conversions:
   (a) 294 g/1 H_2SO_4 to normality.
   (b) 5N H_3PO_4 to g/1.
   (c) 54.75 g/1 HCl to molarity.
   (d) 3M K_2SO_4 to g/1.
2. (a) Calculate the volume occupied by 13.6 kg of chlorine at a pressure 743 mm Hg and 21.1^0C.
   (b) Calculate the weight of 3 cu.m of water vapor, measured at a pressure of 15.5 mm Hg and 23^0C.
3. (a) Determine the boiling temperature of the benzene-water mixture using the following data given in table. The pressure maintained above the liquid surface is 0.9803 bar. Benzene and water may be treated essentially as immiscible.

Temperature ^{0}C	V.P. Benzene bar	V.P. Water bar
60	0.5133	0.1975
65	0.6053	0.2500
68	0.6711	0.2830
70	0.7238	0.3092

   (b) Write short notes on
      i. Dalton's law
      ii. Amagat's law.
4. Air at a temperature of 20^0C and a pressure of 0.987xl0^5 N/m^2 has a relative humidity of 80%.
   Calculate the following:
   (a) The molal humidity of the air.
   (b) The molal humidity of the air if its temperature is reduced to 10^0C and its pressure is increased to 2.38xl0^5 N/m^2 condensing out some of the water.
   (c) The weight of water condensed from 28.3 m^3 of the original wet air in cooling and compressing to the conditions of part (ii).

(d) Calculate the final volume of the wet air of part (iii).
Vapour pressure of water:
0.023xl0^5 N/m^2 at 20^{0}C
0.012xl0^5 N/m^2 at 10^{0}C

5. 1000 kg /hr of a mixture containing equal parts by mass of benzene and toluene is distilled to get an overhead product containing 95% benzene (by weight). The flow rate of the bottom stream being 512 kg/hr calculate

   (a) the percentage of toluene in the bottom product (by weight).

   (b) flow rate of the overhead product and its molar composition.

   (c) molar percentage of benzene in the feed.

6. What will be the yield of Glauber salt ($Na_2SO_4.10H_2O$) if a pure 32% solution is cooled to 293K without any loss due to evaporation. Solubility of Na_2SO_4 in water at 293K is 19.4 kg per 100kg water.

7. 1000 kg of producer gas, analyzing 35% carbon monoxide and 65% hydrogen is burnt in 25% excess air in a combustion chamber. The feed to the combustion chamber is at 25 ^{0}C and the product gases leave at 1200 ^{0}C. Calculate the heat loss from the chamber.
   Standard Heat of formation : CO = -26.42 kcal/ gmol
   CO_2 = -94.05 kcal/ gmol
   H_2O = -57.80 kcal/gmol
   mean specific heats of gases in cal/gmol C : H_2O = 9.524
   CO = 7.114; O_2 = 8.068; N_2 = 7.635; CO_2 = 12.25

8. Write notes on

   (a) enthalpy-concentration charts

   (b) Partial molar enthalpy

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Code No: RR210803 **Set No.2**

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

Answer any FIVE Questions
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1. (a) Aqueous solution of triethanolamine (TEA) i.e $N(CH_2CH_2OH)_3$, contains 50% TEA by weight. Find the molarity of the solution if the densiy of the solution is 1.05 kg/L.

   (b) The concentration of CO_2 is measured to be 0.206 kmol per kmol monoethanolamine (MEA) in a 20% (by weight) aqueous MEA solution. Assuming the density of the solution to be nearly 1.0 kg/L, find the concentration of CO_2as weight % and mole % in the solution. The chemical formula of MEA is $NH_2CH_2CH_2OH$.

2. Combustion gases having the following molal composition are passed into an evaporator at a temperature of 200^0C and a pressure of 743mm Hg. Nitrogen 79.2%, Oxygen 7.2%, Carbon dioxide 13.6%. Water is evaporated, the gases leaving at a temperature of 85^0C and a pressure of 740 mm Hg with the following molal composition. Nitrogen 48.3%, Oxygen 4.4%, Carbon dioxide 8.3%, Water 39.0%. Calculate:

   (a) Volume of gases leaving the evaporator per 100 cu m entering.

   (b) Weight of water evaporated per 100 cu m of gas entering.

3. (a) A solution contains 50% benzene, 30% toluene and 20% xylene by weight at a temperature of 100^0C. The vapors are in contact with the solution. Calculate the total pressure and the molar percentage compositions of the liquid and vapor.

Components	VP in mm Hg at 100^0C	Molecular weight
Benzene	1340	78
Toluene	560	92
Xylene	210	106

   (b) Explain Clausius-Clapeyron equation. Ether boils at 35^0C at one atmosphere pressure. Calculate its boiling point at 750 mm Hg of pressure, given that latent heat of vaporization is 88.4 cal/g. (R = 1.987 cal/gmol.K ; Mol.wt. of ether = 74)

4. Air at atmospheric pressure has a wet bulb temperature of 20^0C and a dry bulb temperature of 30^0C. Using the humidity chart.

   (a) Estimate the percentage saturation, molal humidity and the dew point.

   (b) Calculate the weight of water contained in $100m^3$ of the air.

5. (a) Define:
   i. Overall fractional conversion.
   ii. Once through (single pass) conversion.
   (b) Write short notes on purging of inerts in recycle stock quoting industrial examples.

6. What will be the yield of Glauber salt ($Na_2SO_4.10H_2O$) if a pure 32% solution is cooled to 293K without any loss due to evaporation. Solubility of Na_2SO_4 in water at 293K is 19.4 kg per 100kg water.

7. Sulfurdioxide is oxidized in 100% excess air with 80% conversion to sulfur trioxide. The gases enter the converter at 400 ^{0}C and leave at 450 ^{0}C. What is the magnitude of heat absorbed, in kcal, in the heat exchanger of the converter if 500 kmol of dioxide are introduced into the converter
   SO_2 (g) + 1/2 O_2 (g) = SO_3 (g) -23490 cal/g mol
   Mean molal heat capacity values in cal/gmol C
   SO_2 = 11.0; O_2 = 7.4; N_2 =7.1; SO_3 = 15.5

8. (a) What is the principle formulated by Lavoisier and Laplace regarding the energy required to decompose a chemical compound into its elements?
   (b) State the law of Hess. Explain its use.
   (c) Calculate the heat of formation of methane from the following:
   CH_4 (g) + $2O_2$ (g) $\rightarrow$ CO_2 (g) + $2H_2O$ (l) $\triangle$H = -8,90,346.832 J
   C (s) + O_2(g) $\rightarrow$ CO_2 (g) $\triangle$H = -3,93,512.73 J
   $2H_2$ (g) + O_2 (g) $\rightarrow$ $2H_2O$ (l) $\triangle$ H = -5,71,676.65 J

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MATERIAL & ENERGY BALANCE
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Time: 3 hours **Max Marks: 80**

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1. (a) The analysis of magnesite ore obtained from chalk hill area, Salem district yields 81% $MgCO_3$, 14% SiO_2 and 5% H_2O (by weight). Convert the analysis into mole%. Atomic Weights: Mg-24.3 Si-28.08 H-1.007 O-16 C-12.0
   (b) The analysis of a sample of glass yields 7.8% Na_2O; 7.0% MgO; 9.7% ZnO; 2.0% Al_2O3; 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
2. (a) One hundred grams of nitrogen is stored in a container at 23^0C and 3 psig. Assuming ideal gas behavior, calculate the container volume in liters.
   (b) What is an equation of state? What is the ideal gas equation of state? At what conditions does the ideal gas equation provide the most accurate estimates?
   (c) Calculate the volume occupied by 15 kg of chlorine at a pressure of 0.9 Bar and 293^0K.
3. Write short notes on:
   (a) Cox chart and its applications.
   (b) Duhrings chart and its application.
   (c) Critical properties.
   (d) Reduced conditions.
4. One thousand cubic meters of moist air at 101 kPa and 22^0C and with a dew point of 11^0C enters a process. The air leaves the process at 98 kPa with a dew point of 58^0C. How many kilo grams of water vapour are added to each kilogram of wet air entering the process. The partial pressures of water vapor at 11^0C and 58^0C are 1.31 kPa and 18.14 kPa, respectively.
5. CO and H_2 react to give CH_3OH according to the reaction
   $CO + 2\ H_2 \longrightarrow CH_3OH$. 18%CO is converted to final product 100kg moles of CO and H_2 mixture in the stoichmetric proportions enter the reactor. CO and H_2 mixture is available with CH4 as impurity which is 0.2 parts per 100parts of CO + H_2 mixture. The tolerable limit in the reactor for CH_4 is 3.2 parts/ 100 parts of CO + H_2 mixture. Find
   (a) Recycle rate and ratio.

(b) Purge ratio.

6. 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 a temperature of 65^0C.
Solution of NaCl at 15^0C = 0.358 kg per kg of H_2O.
Solution of NaCl at 65^0C = 0.372 kg per kg of H_2O.

7. (a) Write about the following:
   i. Kopp's rule.
   ii. Trouton's rule.
   iii. Kistyakowsky equation for non-polar liquids.
   (b) Calculate the heat of vaporization in cal/g of carbon tetrachloride at its normal boiling temperature (76.7^0C) by the following methods:
   (c) From the equation of Kistyakowsky (b) Trouton's rule

8. Calculate the standard heats of reaction of the following reactions, expressed in J/g mol:
C_2H_2 (g) + $2H_2$ (g) $\rightarrow$ C_2H_6 (g)
C_2H_2 (g) + H_2O (l) $\rightarrow$ CH_3CHO (g)
CaC_2 (s) + H_2O (l) $\rightarrow$ CaO (s) + C_2H_2 (g)
Standard heats of formation, J/g mol are:
CaC_2 (s) = -62,760
CaO (s) = -6,35,549.6
Standard heats of combustion, J/g mol are:
C_2H_2 (g) = -12,99,613.16
CH_3CHO (g) = -11,92,356.32
C_2H_6 (g) = -15,59,878.88

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Code No: RR210803 **Set No.4**

II B.Tech. I Semester Supplementary Examinations, May -2005
MATERIAL & ENERGY BALANCE
(Chemical Engineering)

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

Answer any FIVE Questions
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1. (a) A mixture of gases contains 0.5% CO_2, 13% Cl_2, 12.7% N_2 and balance H_2. Compute the average molecular weight of the gas. Calculate the gas composition as weight fractions.
   (b) Given a water solution that contains 1.704 kg HNO_3 per kg H_2O and has a specific gravity of 1.382 at 20^0C, express the composition in the following ways: weight percent HNO_3 and molarity at 20^0C.

2. (a) What are equations of state? State ideal gas law and Vander Waal's equation of state. Differentiate an ideal gas from a real gas.
   (b) A gas has the following composition by volume: CO_2 12% CH_4 40% C_2H_4 48%. It is desired to distribute 15 kg of this gas per cylinder. Cylinders are to be designed so that maximum pressure will not exceed 150kg/cm^2 gauge when the temperature is 80^0C. Calculate the volume of the cylinder required.

3. (a) What is steam distillation? Write about the applications of steam distillation in process industry.
   (b) Explain how the steam distillation temperature is computed for any system.

4. It is proposed to recover acetone, which is used as a solvent in an extraction process, by evaporation in to a stream of nitrogen. The nitrogen enters the evaporator at a temperature of 30^0C containing acetone such that its dew point is 10^0C. It leaves at a temperature of 25^0C with a dew point of 20^0C. The barometric pressure is constant at 750 mm Hg. Calculate
   (a) The vapor concentrations of the gases entering and leaving the evaporator, expressed in moles of vapor per mole of vapor free gas.
   (b) The moles of acetone evaporated per mole of vapor free gas passing through the evaporator.
   (c) The weight of acetone evaporated per 1000 m^3 of gases entering the evaporator.
   (d) The volume of gases leaving the evaporator per 1000 m^3 entering.
   Vapor pressure of acetone:
   116 mm Hg at 10^0C.
   185 mm Hg at 20 ^{0}C.

5. Fresh air with a dew point of 17^0C is used in an adiabatic dryer which recirculates a portion of waste by humid air. The heated air enters the dryer at 87^0C with a wet bulb temperature of 40^0C. and leaves with a percentage saturation of 95 at 760mm Hg. Calculate

(a) Fraction of waste humid air recirculated on dry basis, and

(b) Mass of water evaporated per 100 m^3 of heated air.

6. What will be the yield of Glauber salt ($Na_2SO_4.10H_2O$) if a pure 32% solution is cooled to 293K without any loss due to evaporation. Solubility of Na_2SO_4 in water at 293K is 19.4 kg per 100kg water.

7. What is the final temperature when 800 kJ of heat are added to 10 mol of ethylene initially at 200 ^{0}C in a steady flow heat exchanger operated atatmospheric pressure. Cp = 2.83 + 28.6 x 10-3 T - 8.727 x 10-6 T^2

8. (a) How is the standard heat of reaction obtained from

   i. heats of formation and

   ii. heats of combustion

   (b) Calculate the standard heat of reaction of the following:
   CH_3Cl (g) + KOH (s) $\rightarrow$ CH_3OH (l) + KCl (s)
   The heats of formation of the inorganic compounds are:
   KOH (s), ΔH_f = -4,25,847.52 J
   KCl (s), ΔH_f = -4,35,868.2 J
   The heats of formation of the organic compounds are:
   CH_3Cl (g): ΔH_f = -81,931.1 J
   CH_3OH (l): ΔH_f = -2,38,642.8 J

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