Code No: OR210854 **OR**

II B.Tech I Semester Supplementary Examinations, May 2005
MATERIALS AND ENERGY BALANCE
(Chemical Engineering)

Time: 3 hours **Max Marks: 70**

Answer any FIVE Questions
All Questions carry equal marks

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1. A natural gas has the following composition, all figures being in volumetric percent:
   Methane, $CH_4 = 80\%$
   Ethane, $C_2H_6 = 15\%$
   Nitrogen, $N_2 = 5\%$
   Calculate:
   (a) Composition in mole percent.
   (b) Composition in weight percent.
   (c) Average molecular weight.
   (d) Density at standard conditions, kg/m^3.

2. (a) State and explain:
      i. Daltons law
      ii. Amagat's law.
   (b) Prove that for an ideal gas mixture, the pure component volume of a component of the gaseous mixture is equal to the product of the total volume and the mole fraction of that component.

3. (a) Define
      i. Vapour pressure.
      ii. Normal boiling point.
   (b) Differentiate a gas and a vapour.
   (c) Write about the effect of change in temperature and pressure on vapour pressure of substances.

4. Air at a temperature of 20^0C and pressure of 750 mm Hg has a relative humidity 0f 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 2.4 atm, condensing out some of water.
   (c) The weight of the water condensed from 1000 m^3 of the original wet air in cooling and compressing to the conditions of part (b).
   (d) The final volume of the wet air of part (c).
   Vapour pressure of water:
   17.5 mm Hg at 20^0C.
   9.2 mm Hg at 10^0C.

5. Urea is produced by reacting NH_3 and CO_2 to form ammonium carbamate which then decomposes to urea and water as per the following reactions
   $2NH_3 + CO_2 \rightarrow NH_2COONH_4$
   $NH_2COONH_4 \rightarrow NH_2CONH_2 + H_2O$
   If only 60% of the ammonia takes part in the desired reaction and 1000kg of urea are to be produced Calculate
   (a) The volume of NH_3 to be fed at NTP.
   (b) The quantity of water produced.

6. The dry flue gas from an oil fired furnace has a composition of 11.2% CO_2, 5.8% O_2, and 83% N_2 when analysed by an orsat apparatus. Calculate
   (a) % excess air and
   (b) Weight of combustion air used per Kg of oil fired. Assume fuel to have 82% C, 12% H, 3% S and balance impurities. Molecular weight of dry gas is 30.

7. Flue gases leaving a stack at 300^0C have an overall molar composition of 8.2% CO_2, 2.7% CO, 2.7% H_20, 9.4% O_2 and the rest N_2. Calculate the heat lost in 100 kg moles of this gas basing the gas on a datum temperature of 35^0C. Assume water is in the vapor form. The constants for C_p are as follows:

Gas	a	b x 10^3	c x 10^6
CO_2	7.7	5.30	-0.83
CO	6.6	1.20	—-
H_2O (vapor)	8.2	0.15	1.34
O_2	6.8	0.61	0.13
N_2	6.8	0.61	0.13

   Where C_p is in cal/g mol K and T is in K.

8. (a) State Hess law
   (b) How much heat is absorbed or removed from the following reaction
   $C_2H_2 + 2H_2 = C_2H_6$
      i. use heat of formation data
      ii. use of heat of combustion data

   heat of formation in kcal/mol : C_2H_6 = -20.236, C_2H_2 = -54.194
   heat of combustion data in kcal/mol : C_2H_6 = -372.82
   C_2H_2 = -310.615 ; H_2 = -68.317

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