CODE NO: OR 210854 OR

2005 JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY

II B.TECH. I SEMESTER REGULAR EXAMINATIONS
MATERIAL AND ENERGY BALANCE
(CHEMICAL ENGINEERING)

MAY 2005

TIME: 3 HOURS
MARKS: 80

Answer any FIVE Questions
All Questions carry equal marks

1. A natural gas has the following composition, all figures being in volumetric percent:

Methane, CH4 = 80%
Ethane, C2H6 = 15%
Nitrogen, N2 = 5%

Calculate:

(a) Composition in mole percent.

(b) Composition in weight percent.

(c) Average molecular weight.

(d) Density at standard conditions, kg/m3.

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 andthe 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 200C 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 100C and its pressure is increased to 2.4 atm, condensing out some of water.

(c) The weight of the water condensed from 1000 m3 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 200C.
9.2 mm Hg at 100C.

5. Urea is produced by reacting NH3 and CO2 to form ammonium carbamate which then decomposes to urea and water as per the following reactions
2NH3 + CO2 ! NH2COONH4
NH2COONH4 ! NH2CONH2 + H2O 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 NH3 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% CO2, 5.8% O2, and 83% N2 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 3000C have an overall molar composition of 8.2% CO2, 2.7% CO, 2.7% H20, 9.4% O2 and the rest N2. Calculate the heat lost in 100 kg moles of this gas basing the gas on a datum temperature of 350C. Assume water is in the vapor form. The constants for Cp are as follows:

Gas a b x 103 c x 106
CO2 7.7 5.30 -0.83
CO 6.6 1.20 —-
H2O (vapor) 8.2 0.15 1.34
O2 6.8 0.61 0.13
N2 6.8 0.61 0.13
Where Cp 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 C2H2 + 2H2 = C2H6
i. use heat of formation data

ii. use of heat of combustion data

heat of formation in kcal/mol : C2H6 = -20.236, C2H2 = -54.194 heat of combustion data in kcal/mol : C2H6 = -372.82 C2H2 = -310.615 ; H2 = -68.317