Code No: NR210803 **NR**

II B.Tech I Semester Supplementary Examinations, November 2006
MATERIALS AND ENERGY BALANCE
(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, all figures being in volumetric per cent: Methane CH_4 83.5, Ethane C_2H_6 12.5, Nitrogen N_2 4.0. Calculate composition in mole percent and weight percent, average molecular weight, density at standard conditions as kg per m_3. [16]

2. (a) The value of ideal gas constant is 8.3144 J/g.mole (^{0}K). How many gram-moles of nitrogen will occupy 1000 m^3 at a pressure of 112000 N/m^2 and a temperature of 400^{0}K.
   (b) Calculate the specific volume of superheated steam at 10 MPa a and 623 K (350^{0}C) using
      i. the ideal gas and
      ii. the Vander Waal equation. If the actual specific volume of steam at the above conditions is 0.02242 m^3/kg, find the percentage error in the above cases. P_c = 22.076 MPa, T_c = 647.11 K for water. [8+4+4]

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. [6+5+5]

4. Nitrogen from a cylinder is bubbled through acetone at 825 mm Hg and 50 ^{0}C at the rate of 2x10^{-4} m^3/min. The nitrogen saturated with acetone vapor, leaves at 760 mm Hg and 35^{0}C at the rate of 3.83x 10^{-4} m^3/min. Calculate
   (a) The vapor pressure of acetone at 35^{0}C.
   (b) The kg acetone/kg dry N_2 at the exit condition. [8+8]

5. A phosphate rock chiefly a mixture of $Ca_3(PO_4)_2$ and inerts contains 32% P_2O_5 and is treated with 95% Sulfuric acid to produce H_3PO_4 as per the reaction $Ca_3(PO_4)_2$ + $3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$. 1.2 tonne of the rock is treated with 752 kg of 95% H_2SO_4. The degree of completion of the reaction is 90% (based on $Ca_3(PO_4)_2$. Calculate :
   (a) the weight and composition of the phosphoric acid produced.
   (b) the weight and composition of the solid residue. [8+8]

6. Methane burns in the reactions:
   $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   $CH_4 + 3/2O_2 \rightarrow CO + 2H_2O$
   One hundred mol/h of methane is fed to a reactor.
   (a) What is the theoretical O_2 flow rate if complete combustion occurs in the reactor?
   (b) What is the theoretical O_2 flow rate assuming that only 70% of the methane reacts?
   (c) What is the theoretical air flow rate?
   (d) If 100% excess air is supplied, what is the flow rate of air entering the reactor?
   (e) If the actual flow rate of air is such that 300 moles O_2/h enter the reactor, what is the percent excess air? [3+4+3+3+3]

7. Write notes on :
   (a) Kopp's rule.
   (b) Kistyakowsky equation.
   (c) Humid heat capacity of air.
   (d) Clapeyron equation. [4×4]

8. (a) Define standard heat of reaction.
   (b) Calculate the standard heat of reaction of:
   $4NH_3$ (g) + $5O_2$ (g) → 4NO (g) + $6H_2O$(g)
   Data: $\triangle H_f$ at 25^0C and 1 atm in kJ/kg mol are as follows:
   NH_3 (g) = -47.7 × 10^3
   NO (g) = +90.3 × 10^3
   H_2O(g) = -241.8 × 10^3
   O_2 (g) = 0
   (c) Estimate the heat of vaporization of isobutyric acid at 200^0C.
   Data: Vapor pressure data for isobutyric acid are:

Pressure, atm	2	5
Temperature, ^{o}C	179.8	217.0

   Write down the assumptions involved in solving this problem. [4+6+6]

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