**Question 1:** Blending is an important unit operation in the chemical and process industries. It is employed in a wide variety of industries including the production of cement and gasoline.

Consider the mixing of 2 acids, nitric acid and concentrated sulphuric acid, to produce a mixed acid. The composition of the acids are as follows:-

Sulphuric Acid: 95% w/w H2SO4, 5% w/w H2O

Nitric Acid: 30% w/w HNO3, 70% w/w H2O

Mixed Acid 75% w/w H2SO4, 6.3% w/w HNO3, 18.7% w/w H2O

a) If it is required to produce 1000kg/day of mixed acid then calculate the daily requirement of nitric and sulphuric acid

b) Due to an upstream processing problem the amount of nitric acid that can be supplied is reduced to 150 kg/day. If the feed rate of sulphuric acid remains the same as before, determine the new composition of the mixed acid product.

**Question 2:** a) Calculate the energy required to heat 1kg of CO2 from 400ºC to 600ºC at a constant pressure of 1atm using:-

i) The mean heat capacity data given below

ii) The heat capacity function:-

Cp = 6.393 + 10.1 x 10-3T – 3.405 x 10-6 T2

Where Cp is in cal/mol K and T is in K.

b) It is desired to calculate the standard hear of the reaction of:-

CH3Cl (g) + KOH (g) → CH3OH (l) + KCl (s) (A)

Standard heats of formation for CH3Cl (g) and CH3OH (l) are not available but the data available does include the standard heats of combustion of CH3Cl (g) and CH3OH (l). What other physical data is required to find the heat of reaction (A)?

**Information:**

Mean Heat Capacity of CO2 (cal/mol ºC)

Reference Temperature: 0ºC; Pressure 1 atm

ºC cal/mol ºC

0 8.595

200 9.590

400 10.360

600 10.965 Basic Principles Page 3

**Question 3:** A mixture of air and methanol vapour is fed to a converter in which the following reactions take place:

O H HCHO O OH CH 2 2 3 21   

2 3 H HCHOOH CH  

In addition, some methanol is completely oxidised to CO2 and water. 25% of the methanol feed leaves the converter unreacted. After condensation of the unreacted methanol, formaldehyde (HCHO) and water vapour, the gas stream contains: 17% H2, 75% N2 and 3% O2 & 5% CO2 by moles.

Calculate a) the ratio of air to methanol in the feed

b) the yield of formaldehyde from methanol (moles HCHO/mole CH3OH feed)

**Question 4:** For the following reaction

C2H4 (g) + H2O (g)  C2H5OH (g)

Calculate

a) The Standard Heat of Reaction at 25 C, HR

b) The Heat of Reaction at 300C, HR 300C

**Information:**

Standard Heats of Formation at 1 atm and 25C:

C2H5OH (g) - 52.230 kcal/ mole

CO2 (g) -94.052 kcal/ mole

H2O (g) -57.798 kcal/ mole

Standard Heats of Combustion at 1 atm and 25C :

C2H4 (g) -337.2 kcal/ gmole

Latent Heat of Vaporization at 25C:

H2O 10.52 kcal/ gmole

Heat capacities within the temperature range 0-300ºC:

C2H4 (g) Cp = 2.830 + (28.601 x 10-3 T) – (8.276 x 10-6 T2)

C2H5OH(g) Cp = 6.990 + (39.741 x 10-3 T) – (11.926 x 10-6 T2)

H2O (g) Cp = 7.256 + (7.256 x 10-3 T) + (0.283 x 10-6 T2)

Cp is in cal/ gmole K and T is in K. Basic Principles Page 4

**Question 5:** For the following reaction

2CH4 (g) → C2H2 (g) + 3H2 (g)

Calculate the Standard Heat of Reaction at 25ºC, ΔHºR

**Information:**

Standard Heats of formation at 1 atm and 25ºC:

HfCH4 (g) = -62.76 kJ mol-1

HfH2O (g) = -241.83 kJ mol-1

HfCO2 (g) = -393.5 kJ mol-1

Standard Heat of Combustion at 1 atm and 25ºC:

HcC2H2 (g) = -1299.6 kJ mol-1

Latent Heat of Vaporization at 25C:

H2O = 40.66 kJmol-1

**Question Six**

Consider the following reaction:

C5H12 (l) + 8O2 (g) → 5CO2 (g) + 6H2O (l)

a) Determine the standard heat of reaction for the combustion of n-pentane (C5H12) using the thermochemical data supplied.

b) Explain the procedure you would use to determine the heat of reaction for the combustion of n-pentane (C5H12) at 300ºC and detail the extra data that would be required.

**Information:**

Standard Heats of Formation (25ºC):-

C5H12 (l) -173.0 kJ/mol

H2O (g) -241.8 kJ/mol

Standard Heats of Combustion (25ºC):-

C (s) -393.5 kJ/mol

Latent Heat of Vaporisation at 25ºC:

H2O (l) 43.99 kJ/mol