KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SCH 317: MASS AND ENERGY BALANCE

DATE: TUESDAY, 27TH MARCH 2012 **TIME: 2.00 P.M. – 4.00 P.M.**

INSTRUCTIONS: Answer all questions.

1. (a) Distinguish between
   (i) Limiting reactant and Tie component.
   (ii) Degree of completion and actual yield.
   (iii) Material balance and heat balance.
   (iv) Heat of combustion and standard heat of combustion.

   (8 marks)

   (b) (i) Briefly describe a flow sheet.
   (ii) State and explain the types of flow sheets.
   (iii) Draw and name any two flow sheet symbols.

   (7 marks)

   (c) How much battery acid would be produced having H_2SO_4 conc 20% from weak battery acid of H_2SO_4 conc. 14% by adding 500 kg H_2SO_4 of 80%? (5 marks)

   (Total 20 marks)

2. Nitrogen and hydrogen react under certain conditions to form ammonia according to the equation

$$N_2 + 3\,H_2 \rightleftharpoons 2NH_3$$

If 280 kg of nitrogen and 64.5 kg of hydrogen are brought together and allowed to react At 515^oC and 3000 atm pressure and it is found that there are 38 kg moles of gases present at equilibrium.

(a) How many kg moles of nitrogen, hydrogen and ammonia are present at equilibrium?

(b) Which is the limiting reactant and which is excess reactant?

(c) What is the amount of theoretically required hydrogen and what is the percentage excess hydrogen?

(d) What is the degree of completion of the reaction?

(e) What is the percentage conversion of hydrogen to Ammonia?

(10 marks)

3. (a) 10N HCl is heated to raise its temperature from 25^oC to 98^oC. How much heat must be added to it?

The specific heats of 10N HCl at 25^oC and 98^oC are 0.90 kcal/kg and 0.98kcal/kg respectively.

Basis 100 Kg of 10N HCl.

(5 marks)

(b) After a crystallization process, a solution of calcium chloride in water contains 62 parts of $CaCl_2$ per 100 parts of water.

Calculate the weight of this solution necessary to dissolve 250 kg of $CaCl_2.6H_2O$ at 25^oC temperature.

Solubility of $CaCl_2$ at 25^oC is 7.38 kg mol of $CaCl_2$ per 1000 kg of water. (5 marks)

4. The flue gas from an industrial furnace has the following composition;

$CO_2 \longrightarrow$ 11.73%, CO $\longrightarrow$ 0.2%, $O_2 \longrightarrow$ 6.81%, H_2 = 0.09 and N_2 = 81.17%.

Calculate

(a) amount of O_2 required for complete combustion in Kg mols,

(b) the oxygen demand from air,

(c) the percentage excess air employed in the combustion,

If the loss of carbon in clinker and ash is 1% of the fuel used and the fuel has the following composition by weight;

C – 74%, H_2 – 5%, O – 5%, N_2 – 1%, S_2 – 1%, H_2O – 9% and Ash – 5%

(10 marks)

5. The exhaust gas from a hydrocarbon fuel oil fired furnace, show by analysis 10.2% CO_2, 7.9% O_2 and 81.9% N_2.

Calculate

(a) % excess air used.

(b) Kg of dry air supplied per Kg of oil burnt in the engine.

Let Basis be 100 kg mols of dry flue gas.

6. In the production of metallic manganese, 10 kg of manganese oxide Mn_3O_4 are heated in an electric furnace with 3.0 kg of amorphous carbon (coke), the resulting products are found to contain 4.8 kg of manganese metal and 2.6 kg of manganous oxide Mno, as slag. The remainder of the products consist of unconverted charge and carbon monoxide gas. Calculate the standard heat of reaction of this process for the entire furnace charge.

Heats of formation at 25^oC are as follows.

Mn_3O_4 = -331.4 Kcal/gm mole

Mno = -92.0 Kcal/gm mole

Mn = 0 Kcal/gm mole

CO = -26.416 Kcal/gm mole

Coke = +2.6 Kcal/gm mole

Atomic weight of manganese = 55

(10 marks)

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