TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCES

DEPARTMENT OF PURE & APPLIED SCIENCES

UNIVERSITY EXAMINATION FOR THE BACHELOR OF TECHNOLOGY IN APPLIED CHEMISTRY

(BTAC 14S & BTAC 15S2)

ACH 4206 : CHEMICAL PROCESSES

END OF SEMESTER EXAMINATION

SERIES: APRIL 2016

TIME: 2 HOURS

DATE: Pick Date Apr 2016

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attempt question ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

QUESTION ONE

a) Briefly define each of the following:

i. Block flow diagram (2 marks)

ii. Flow sheet (2 marks)

b) In the manufacture of cement, limestone is first crushed before being heated at 1000^{o}C to give CO_2 and CaO. Based on this description draw a block flow diagram (4 marks)

c) Highlight four reasons for undertaking mass balance calculations

(4 marks)

d) Three raw materials are mixed in a tank to make a final product in the ration 1:0.4:1.5 respectively. The first raw material contain A and B with 50% C. The second raw material contain C while the third raw material contain A and B with 75% A. assuming a continuous process at steady, find the flow and composition of the product.

(6 marks)

e) Skim milk is prepared by the removal of some fat from the whole milk. The skim milk is found to contain 90.5% water, 3.5% protein, 5.1% carbohydrates, 0.1% fat and 0.8% ash. If the original milk 4.5% fat, calculate its composition assuming fat only was removed to make the skim milk and that there were no losses in processing. (6 marks)

f) When 16g of $CuSO_4$ were dissolved in 384g of water, the temperature rose by 3.95^oC. Determine the enthalpy of formation of $CuSO_4.5H_2O$ from the anhydrous salt and water, if the enthalpy of solution of the crystal hydrate is 11.7kJ/mol, and the specific heat of the solution is 4.18kJ/kg.K. ($CuSO_4$ = 159.6g/mol) (6 marks)

QUESTION TWO

a) In the production of chlorine gas by oxidation of hydrochloric acid gas, air is used 30% in excess of that theoretically required. The reaction is:

$$\underset{(g)}{4HCl} + \underset{(g)}{O_2} \longrightarrow \underset{(g)}{2Cl_2} + \underset{(g)}{2H_2O}$$

Based on 4 kmol HCl:

i. Calculate the weight ratio of air to hydrochloric acid gas in feed (Molar masses H=1, Cl=35.5, O = 16, N= 14) (8 marks)

ii. If the oxidation is 80% complete, find the composition of the product stream on mole basis (5 marks)

b) A solution of potassium dichromate in water contains 15% $K_2Cr_2O_7$ by weight. 1000kg of this solution is evaporated to remove some amount of water. The remaining solution is cooled to 20^oC. If the yield of $K_2Cr_2O_7$ crystals is 80%, calculate the amount of water evaporated. (Given solubility of $K_2Cr_2O_7$ at 20^oC is 114.7kg per 1000kg of water).

(7 marks)

QUESTION THREE

a) If 36,000kg of whole milk containing 4% fat is to be separated in a 6 hour period into skim milk with 0.45% fat and cream with 45% fat. Determine the hourly flow rates of the output streams from a continuous centrifuge which accomplishes this separation?

(10 marks)

b) A textile dryer is found to consume $4m^3$/hr of natural gas with a calorific value of 800kJ/mol. If the throughput of the dryer is 60kg of wet cloth per hour, drying it from 55% moisture to 10% moisture, estimate the overall efficiency of the dryer taking into account the latent heat of vaporization only. (Latent heat of vaporization of water is 2257kJ/K, 1 mole gas at STP = 22.4L). (10 marks)

QUESTION FOUR

a) Ethylene oxide is produced by oxidation of ethylene. 100kmol of ethylene are fed to a reactor and the product is found to 80kmol ethylene oxide and 10kmol CO_2. The reactions are:

$$C_2H_4 + 1/2\ O_2 \longrightarrow C_2H_4O$$

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

Calculate:

i. The % conversion of ethylene (8 marks)

ii. The % yield to ethylene oxide (3 marks)

b) Potatoes are dried from 14% total solids to 93% total solids. What is the product yield from each 1000kg of raw potatoes assuming that 8% by weight of the original potatoes is lost in peeling? (9 marks)

QUESTION FIVE

a) Gaseous benzene ($C_6H_{6)}$ reacts with hydrogen gas in the presence of Ni catalyst as per the reaction below

$$C_6H_6 + 3H_2 \longrightarrow C_6H_{12}$$

The hydrogen gas fed is 30% excess above that required by the above reaction. If the conversion is 50% and yield is 90%. Calculate the requirement of benzene and hydrogen gas for production of 100 moles cyclohexane

(10 marks)

b) Find an expression for the drag force R on a smooth sphere of diameter D, moving with uniform velocity u, in a fluid of density ρ, and dynamic viscosity, μ.

(10 marks)