

**TECHNICAL UNIVERSITY OF MOMBASA**  

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**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.

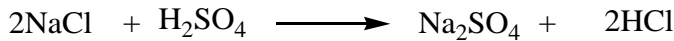
**Do not write on the question paper.**

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**QUESTION ONE**

- a) i) Define a process flow diagram (2 marks)
- ii) State the four key type of information that is obtainable from a process flow diagram (4 marks)
- iii) Give any four main advantages of a process flow diagram (4 marks)
- b) State four main reasons for carrying out a dimensional analysis of a physical process. (4 marks)

- c) The sulphate process for the production of hydrochloric acid is described by the following reaction:



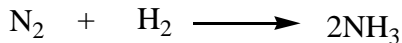
Calculate the heat of reaction for the production of 500kg of HCl. (the heats of formation in MJ/kmol are NaCl = 410.9, H<sub>2</sub>SO<sub>4</sub> = 811.3, Na<sub>2</sub>SO<sub>4</sub> = 1384.0, HCl = 92.3 molar masses H = 1, Cl = 35.5).

(6 marks)

- d) Use the three fundamental dimensions (mass, length and time) to express each of the following:
- i. Acceleration (2 marks)
  - ii. Force (2 marks)
  - iii. Work (2 marks)
  - iv. Density (2 marks)
  - v. Viscosity (2 marks)

## QUESTION TWO

- a) Ammonia is produced as per the following reaction



Calculate the molal flow rate of hydrogen corresponding to nitrogen feed rate of 25kmol/hr if they are at the stoichiometric proportions. The kg of ammonia produced per hour if percent conversion 25 and nitrogen feed rate is 25 kmol/hr. (N=14, H=1)

(10 marks)

- b) Briefly define each of the following:
- i. Unit process (2 marks)
  - ii. Material balance (2 marks)
  - iii. Conversion (2 marks)
  - iv. Steady-state operation (2 marks)
  - v. Law of conservation of mass (2 marks)

### QUESTION THREE

- a) Pure  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  was crystallized from a solution containing 25%  $\text{Na}_2\text{CO}_3$  by evaporating 15% of the water at a temperature of  $25^\circ\text{C}$ . Calculate the amount of crystals produced per 100kg of original solution. (Solubility of  $\text{Na}_2\text{CO}_3$  at  $25^\circ\text{C}$  = 27.5kg per 100kg of water, C=12, H=1, Na=23, O=16). (10 marks)
- b) Calculate the theoretical temperature of combustion of ethane with 25% excess air. The average specific heats in kJ/kg.K are  $\text{CO}_2 = 1.24$ ,  $\text{O}_2 = 1.10$ , steam = 2.41 and  $\text{N}_2 = 1.19$ . (10 marks)

### QUESTION FOUR

- a) Water enters a boiler at 136kPa and  $35^\circ\text{C}$ , through a 102mm pipe at an average velocity of 1.5m/s and steam leaves at  $315^\circ\text{C}$  and a pressure of 2860kPa. At what rate must heat be supplied to the boiler under steady state conditions? (10 marks)
- b) An organic ester of formula  $\text{C}_{19}\text{H}_{36}\text{O}_2$  is to be hydrogenated at a rate of 100kg/hr to yield  $\text{C}_{19}\text{H}_{38}\text{O}_2$ . The hydrogen required for the plant, which runs continuously, is available as 50litre cylinders in which the gas is contained at 70bar and 300K. How many cylinders should the company order per week? (C=12, H=1, O = 16). (10 marks)

### QUESTION FIVE

- a) An autoclave contains 1000 cans of pea soup. It is heated to an overall temperature of  $100^\circ\text{C}$ . If the cans are to be cooled to  $40^\circ\text{C}$  before leaving the autoclave, how much cooling water is required if it enters at  $15^\circ\text{C}$  and leaves at  $35^\circ\text{C}$ ? The specific heats of the can and pea soup are  $0.50\text{kJ.kg.}^\circ\text{C}$  and  $4.1\text{kJ/kg.}^\circ\text{C}$ . The weight of each can is 60g and it contains 0.45kg of pea soup. Assume that the heat content of the autoclave walls above  $40^\circ\text{C}$  is  $1.6 \times 10^4\text{kJ}$  and that there is no heat loss through the walls. (15 marks)
- b) In the production of sulphur trioxide, 100kmol of sulphur dioxide and 200kmol of oxygen are fed to the reactor. The product stream is found to contain 80kmol sulphur dioxide. Find the percent conversion of sulphur dioxide. (5 marks)