

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

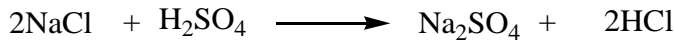
This paper consists of **FIVE** questions. Attempt question ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

QUESTION ONE

- a) 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:



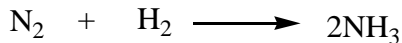
Calculate the heat of reaction for the production of 500kg of HCl. (the heats of formation in MJ/kmol are NaCl = 410.9, H₂SO₄ = 811.3, Na₂SO₄ = 1384.0, HCl = 92.3 molar masses H = 1, Cl = 35.5).

(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% Na_2CO_3 by evaporating 15% of the water at a temperature of 25°C . Calculate the amount of crystals produced per 100kg of original solution. (Solubility of Na_2CO_3 at 25°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°C , through a 102mm pipe at an average velocity of 1.5m/s and steam leaves at 315°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°C . If the cans are to be cooled to 40°C before leaving the autoclave, how much cooling water is required if it enters at 15°C and leaves at 35°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°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)