TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCES

DEPARTMENT OF PURE & APPLIED SCIENCES

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED CHEMISTRY

ACH 4206 : CHEMICAL PROCESSES

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: AUG 2017

TIME: 2 HOURS

DATE: Pick Date Sep 2017

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, Non-programmable calculator, 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

An experiment on the growth rate of certain organisms (e.g., yeasts, bacteria, or viruses) requires an environment of humid air enriched in oxygen. Three input streams are fed into an evaporation chamber to produce an output stream with the desired composition.

A: Liquid water, fed at a rate of 20.0 cm^3/min

B: Air (21 mole% O_2, the balance N_2)

C: Pure oxygen, with a molar flow rate one-fifth of the molar flow rate of stream B

The output gas is analyzed and is found to contain 1.5 mole % water.

a) Draw and label a flowchart of the process, (5 marks)

b) Perform a degree of freedom analysis, and (10 marks)

c) Calculate all unknown stream variables. (15 marks)

Question TWO

Formaldehyde (CH_2O) is produced industrially by the catalytic oxidation of methanol (CH_3OH) by the following reaction:

$$CH_3OH + 1/2\ O_2 \rightarrow CH_2O + H_2O \quad (i)$$

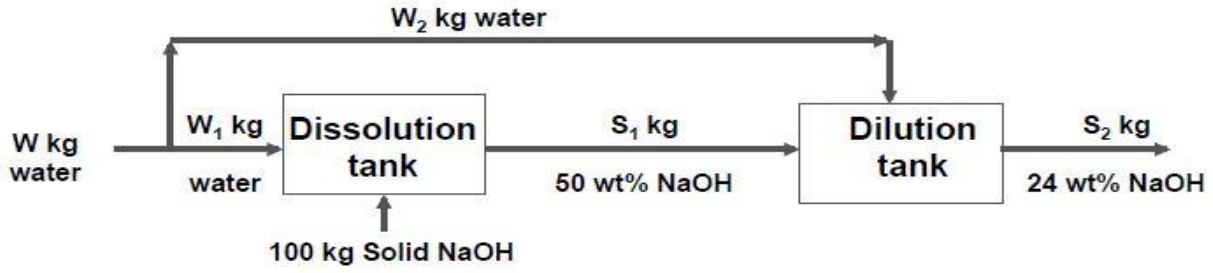
Unfortunately, under the conditions used to produce formaldehyde at a profitable rate, a significant portion of the formaldehyde can react with oxygen to produce CO and H_2O:

$$CH_2O + 1/2\ O_2 \rightarrow CO + H_2O \qquad (ii)$$

Assume that methanol and twice the stoichiometric amount of air needed for complete oxidation of the CH_3OH are fed to the reactor, that 90% conversion of the methanol results, and that a 75% yield of formaldehyde occurs (based on the theoretical production of CH_2O by Reaction (*i*)). Draw and label the process flow diagram. Determine the composition of the product gas leaving the reactor. (20 marks)

Question THREE

In textile industry, it is desired to make caustic soda solution containing 24% NaOH by mass for a mercerization process. Due to the very high heat of dissolution of caustic soda in water, the solution is prepared as follows; first in a dissolution tank caustic soda of 50 wt. % NaOH was prepared by mixing 100 kg of solid NaOH with water. It was then fed to the dilution tank where a fraction of feed water is added to produce the desired solution.



a) Calculate the amount of water required (4 marks)
b) Calculate the amount of desired solution produced. (4 marks)
c) Calculate the amount of 50 wt. % NaOH solution produced. (4 marks)
d) Calculate the amount of feed water that is bypassed to the dilution tank. (4 marks)
e) Calculate the ratio of water that is bypassed to the dilution tank to that is fed to the process. (4 marks)

Question FOUR

a) CH_4 burns in O_2, producing CO_2 and H_2O (g). A 1.22 L CH_4 cylinder, at 15°C, registers a pressure of 328 kPa. What volume of O_2 at STP will be required to react completely with all of the CH_4? (8 marks)
b) Nitroglycerin explodes according to:

$$4\ C_3H_5(NO_3)_3\ (l) \rightarrow 12\ CO_2\ (g) + 6\ N_2\ (g) + 10\ H_2O\ (g) + O_2\ (g)$$

i. Calculate the volume, at STP, of each product formed by the reaction of 100 g of $C_3H_5(NO_3)_3$. (6 marks)
ii. 200 g of $C_3H_5(NO_3)_3$ is ignited (and completely decomposes) in an otherwise empty 50 L gas cylinder. What will the pressure in the cylinder be if temperature stabilizes at 220°C? (6 marks)

Question FIVE

Liquid acetone (C_3H_6O) is fed at a rate of 400 liters/min into a heated chamber, where it evaporates into a nitrogen stream. The gas leaving the heater is diluted by another nitrogen stream flowing at a measured rate of 419 m^3 (STP)/min @ 25 ºC. The combined gases are then compressed to a total pressure P_{gauge} = 6.3 atm at a

temperature of 325 ºC. The partial pressure of acetone in this stream is p_a = 501 mmHg. Atm. pressure is 763 mm Hg. (Acetone: Mol. Weight = 58.1, ρ = 791 g/L)

a) What is the molar composition of the stream leaving the compressor?
b) What is the volumetric flow rate of N_2 entering the evaporator if T = 27 ºC and P_{gauge} = 475 mm Hg