CHARLES DARWIN UNIVERSITY

Family Name	
Given Names	
Student Number	
Teaching Period	Semester 1, 2017

FINAL EXAMINATION	**DURATION**
ENG246 – Process Analysis	Reading Time: **10** minutes Writing Time: **180** minutes

INSTRUCTIONS TO CANDIDATES

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	**EXAMINATION MATERIALS TO BE SUPPLIED**
No additional printed material is permitted	1 x 20 Page Book Reference Information

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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The exam should be answered on the Answer Sheet provided. Please ensure that your name and student number have been written on the Answer sheet and place in the completed answer Booklet.

Marks for each question are indicated

Question 1 **(40 marks)**

An ethanol dehydrogenation reaction is carried out with the feed entering at 300 °C. The feed containing 90.0 mole % ethanol (C_2H_5OH) with the balance acetaldehyde(CH_3CHO) enters a reactor at a rate of 150 mol/s. Heat is transferred to the reactor to keep the temperature from dropping too much and thereby decreasing the reaction rate to an unacceptably low level. When the heat addition is 2440 kJ/s, the outlet temperature is 253 °C.

- Develop the block diagram of the process (5 marks)
- Calculate the degree of freedom of the process (5 marks)
- Calculate the fractional conversion of ethanol achieved in the reactor. (30 marks)

$$C_2H_5OH_{(v)} \rightarrow CH_3CHO_{(v)} + H_{2\,(g)}$$

The enthalpies of formation of each component are given below

Component	$\Delta H_{f,298K}$ (kJ/mol)
C_2H_5OH	-235.31
CH_3CHO	-166.20
H_2	0.00

The heat capacity of each component is a function of temperature as shown below:

$$C_{P,(CH_3CHO)} = 0.07196 + \left(20.1 \times 10^{-5}\right)T - \left(12.78 \times 10^{-8}\right)T^2 + \left(34.76 \times 10^{-12}\right)T^3$$

$$C_{P,(C_2H_5OH)} = 0.06134 + \left(15.72 \times 10^{-5}\right)T - \left(8.749 \times 10^{-8}\right)T^2 + \left(19.83 \times 10^{-12}\right)T^3$$

$$C_{P,(H_2)} = 0.02884 + \left(0.00765 \times 10^{-5}\right)T + \left(0.3288 \times 10^{-8}\right)T^2 - \left(0.8698 \times 10^{-12}\right)T^3$$

where Cp is the heat capacity in J/(mol K) and T is the temperature in °C.

Question 2 **(20 marks)**

A 12.5 m^3 tank is being filled with water at the rate of 0.05 m^3/s. At the moment when the tank contains 1.2 m^3 of water, a leak develops at the bottom of the tank and gets progressively worse with time. The rate of the leak can be approximated as 0.005t (m^3/s), where t is the time in seconds from the moment the tank starts leaking.

How long until the tank is empty?

The solution of a quadratic equation

$$Ax^2 + Bx + C = 0$$

Is given by

$$x = \frac{-B \pm \sqrt[2]{B^2 - 4AC}}{2A}$$

Question 3 **(30 marks)**

Calculate the entire material balance for the diagram presented in Figure 1. All compositions are mass percent.

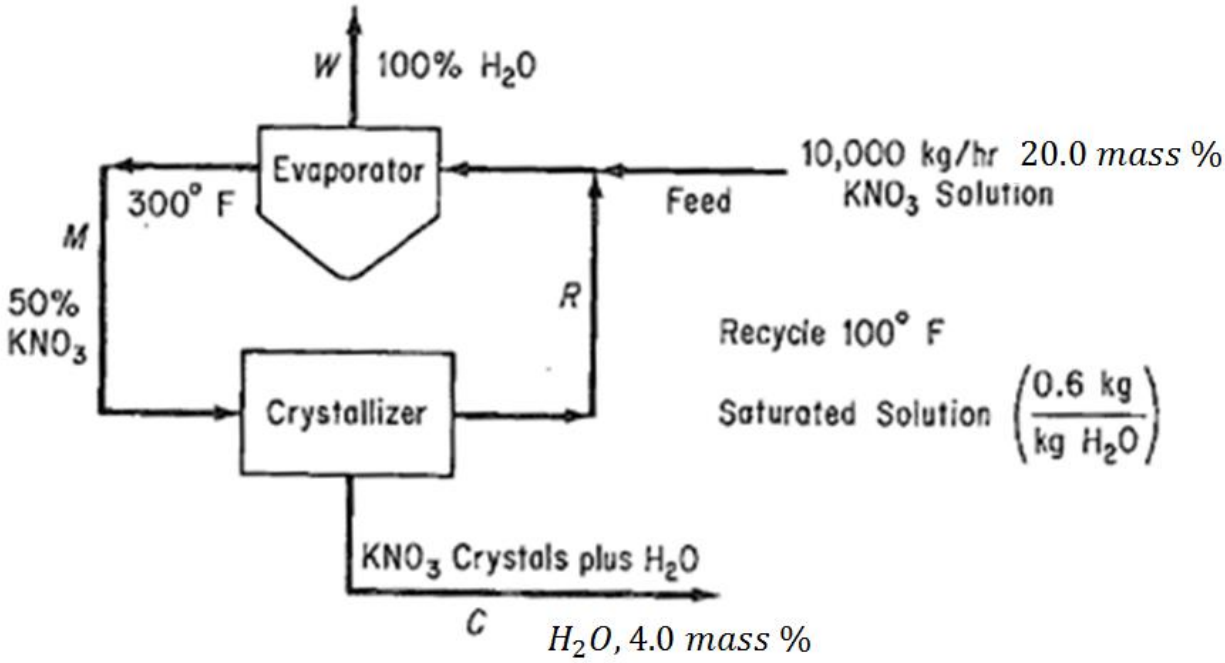

Figure 1.

The figure is taken from

Felder, R., & Rousseau, R. (2005). *Elementary principles of chemical processes* (3rd ed., 2005 ed. with integrated media and study tools.. ed.). Hoboken, NJ: Wiley.

Question 4 **(10 marks)**

500 g of ice at -20°C is mixed with saturated water at 100 °C. How much liquid water is added if the final temperature of the mix is 50°C?. Use the data from tables 1 and 2.