# Charles Darwin University

Final Examination

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| Family Name | | | | | | |
| Given Name/s | | | | | | |
| Student Number | | | | | | |
| Teaching Period | Semester 1, 2019 | | | | | |

| ENG246 – Process Analysis | DURATION | |
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| | | |
| | Reading Time: | 10 minutes |
| | Writing Time: | 120 minutes |
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## INSTRUCTIONS TO CANDIDATES

1. Read all questions carefully.
2. Answer ALL questions in the exam booklet. Only your answers provided in the exam booklet will be marked.
3. Show all working (calculations and sketches).
4. This exam constitutes 50% of the total marks for this Unit.
5. Total marks available on this exam = 100.
6. Use dark blue or black ink.

## EXAM CONDITIONS

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

This is a RESTRICTED OPEN BOOK examination

Any non-programmable calculator is permitted

One A4 sheet of handwritten double-sided notes permitted

No dictionaries are permitted

| ADDITIONAL AUTHORISED MATERIALS | EXAMINATION MATERIALS TO BE SUPPLIED |
|---|---|
| No additional printed material is permitted<br>Formula sheet | 1 x 20 Page Book<br>1 x Scrap Paper<br>Reference Information |

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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## Question 1

A stream containing $180\,{}^{kmol}/_{h}$ of propylene $(C_3H_6)$ is mixed with a stream holding $210\,{}^{kmol}/_{h}$ of CO and $210\,{}^{kmol}/_{h}$ of $H_2$. The two streams are mixed with a recycle stream coming from the overhead of a separator. The recycle stream contains pure propylene. A single pass conversion on $30\%$ propylene is attained. The desired product butanal $(C_4H_8O)$ is removed in a bottom stream; unreacted $H_2$ and CO are removed from the separator on a third output stream and propylene is recovered and recycle.

$$C_3H_6 + CO + H_2 \rightarrow C_4H_8O$$

a) Develop the block diagram of the process ( 5 marks)
b) Calculate the composition and molar flow rate for all streams in the process (25 marks)

**(30 marks)**

## Question 2

Methane $(CH_4)$ and oxygen are fed in stochiometric proportion to a continuous reactor at $25℃$ and $1\ Atm$. The reaction proceeds to completion and the effluent stream is found to be at $200℃$. Calculate the heat transfer rate from the reactor when $300\,{}^{kg}/_{h}$ of methane are fed to the reactor.

Additional information for this question is given below

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$\Delta H_{f,CH_4} = -74.85\,{}^{kJ}/_{mol}$; $\Delta H_{f,CO_2} = -393.5\,{}^{kJ}/_{mol}$; $\Delta H_{f,H_2O} = -241.83\,{}^{kJ}/_{mol}$

$C_{P,CO_2}\left(\frac{J}{molK}\right) = 36.11 + 0.04233T - 2.887 \times 10^{-5}T^2$;

$C_{P,H_2O}\left(\frac{J}{molK}\right) = 36.46 + 0.00688T + 0.7604 \times 10^{-5}T^2$.

**(20 marks)**

## Question 3

A solution containing 10.00% NaCl, 3.00% KCl and the remainder water is fed to the separation process shown below. The feed rate is 18400 kg/hr. The evaporator product (P) stream composition is 16.8% NaCl, 21.6% KCl, and the balance water. The recycle (R) stream contains 18.9% NaCl, some KCl, and the balance water. For simplicity, the bottom products of the evaporator and the crystallizer are presumed to be pure and dry compounds. All compositions are given in weight percentages.

a) Calculate the amount of NaCl produced. (5 marks)
b) Calculate the amount of KCl produced. (5 marks)
c) Calculate the amount of material recycled and its composition. (15 marks)
d) Calculate the total amount of product P and its composition. (15 marks)

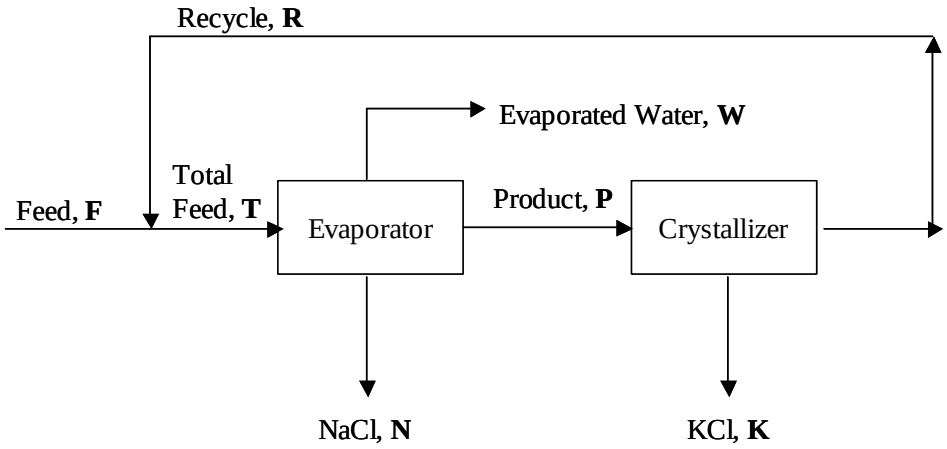


Figure 1: Block diagram for question 3.

(40 marks)

Question 4

A kettle used to boil water containing 10 L of water at $20℃$ is placed on an electric heater $\left(\dot{Q} = 5000 {}^{J}/_{S}\right)$. Find out the time at which water begins to boil. Assume that the heat capacity is constant $C_p = 4.18 \frac{J}{g℃}$ and the density of water is $\rho = 1000 \frac{g}{L}$

(10 marks)