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# Charles Darwin University

Final Examination

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|---|---|---|---|---|---|---|
| Family Name | | | | | | |
| Given Name/s | | | | | | |
| Student Number | | | | | | |
| Teaching Period | Semester 2, 2018 | | | | | |

| ENG142 – Concepts of Chemical Engineering | DURATION | |
|---|---|---|
| | | |
| | Reading Time: | 10 minutes |
| | Writing Time: | 120 minutes |
| | | |

## INSTRUCTIONS TO CANDIDATES

1. Read all questions carefully.
2. Answer ALL questions.
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 | 1 x 20 Page Book<br>Reference Information |



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## Question 1.

A double-pipe counter-current flow heat exchanger is used to cool ethylene glycol $\left(C_P = 2560\ {}^{J}/_{kg\ ^\circ C}\right)$ flowing at a rate of $3.5\ {}^{kg}/_{s}$ from 85 ℃ to 35 ℃. Cooling water $\left(C_P = 4180\ {}^{J}/_{kg\ ^\circ C}\right)$ enters to the heat exchanger at a mass flow rate of $2.45\frac{kg}{s}$ and 20 ℃. The overall heat transfer coefficient based on the inner surface area of the tube is $\left(U = 800\ {}^{W}/_{m^2}\right)$.

Calculate

a) The heat duty (rate of heat transfer) of the heat exchanger), (5 marks)
b) the output temperature of the water (5 marks)
c) the heat transfer surface area on the inner side of the tube for a counter current heat exchanger (5 marks)

**(15 marks)**

## Question 2.

A fuel cell as the one presented in the figure below uses methane $(CH_4)$ and oxygen from the air $(21mol\ \%\ O_2\ and\ 79mol\%\ N_2)$ to produce electricity and waste products. Calculate the material balance of the cell, based on the data given in Figure 1. You need to show the mass of every component for each of the streams in the fuel cell. The chemical reaction has a 70% conversion for methane.

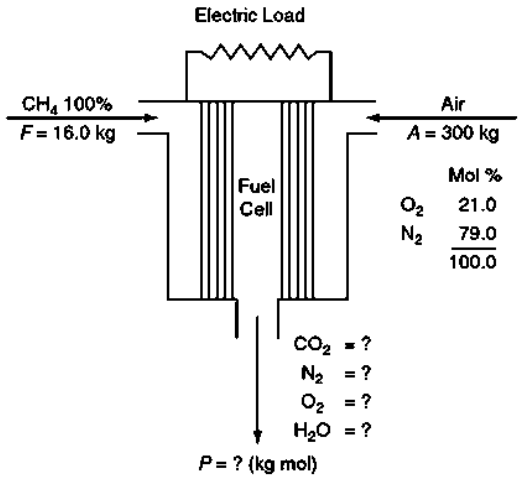


Figure 1. diagram of a fuel cell. Taken from Himmelblau, D., & Riggs, J. (2012). *Basic principles and calculations in chemical engineering.* 8th ed., Prentice Hall

$$CH_{4(g)} + 2O_2 \rightarrow CO_2 + 2H_2O$$

**(20 marks)**

## Question 3.

A liquid of density $1.17 \times 10^3\ {}^{kg}/_{m^3}$ flows steadily through a pipe of varying diameter and height. At location 1 along the pipe the flow speed is $9.4\frac{m}{s}$ and the pipe diameter is 1.11 cm. At location 2 the pipe diameter is 1.77 cm. At location 1 the pipe is 9.45 m higher than it is at location 2. Ignoring viscosity, calculate the difference between the fluid pressure at location 2 and the fluid pressure at location 1.



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(25 marks)

## Question 4.

A sophisticated machine works on a range of pressures between 500 Pa and 4000 Pa (gauge pressure). The machine uses a liquid column manometer to indicate the internal gauge pressure of the machine. The liquid column manometer is built in glass with a tube of 5 mm diameter and 40 cm length. A technician in the lab realises that the liquid column manometer used to measure the pressure has lost 50% of the glycerine (manometer fluid) just before the equipment needs to be used. Since the practical has to be carried on, the technician suggests replacing all the glycerine in the manometer with cooking oil from the kitchen.

a) You need to elaborate an argument that explains if the technician's idea is a good one or not. You must base your argument in some sort of calculation. (10 marks)
b) Can you suggest another idea to solve the problem by using only these two fluids? (10 marks)

Some data that you may require are $\rho_{Oil} = 0.925\ \frac{g}{cm^3}$, $\rho_{glycerine} = 1.26 \frac{g}{cm^3}$
The 50% of the glycerine is based on the maximum pressure achieved by the equipment.

(20 marks)

## Question 5.

Present a brief explanation of the necessary steps required to develop a risk assessment.

(20 marks)



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