# UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, APRIL/MAY 2019

**COURSE NO**: RN 274
**COURSE NAME**: ELECTROCHEIMAL POWER SOURCES
**CLASS**: RN II **TIME:** 3 HOURS

Name**:** _____Index Number: _____

## INSTRUCTIONS

- Answer **only three** questions.
- All questions carry equal marks
- Answer all questions in your answer booklet
- Use a value of F = 96500 C for Faradays Constant, R = 8.314 J/mol. K for gas constant.
- Begin each answer on a **FRESH PAGE.**

**QUESTION 1** **[20 marks]**

a) Briefly explain four technical consideration as a renewable energy engineer, you will take into account when selecting a particular electrical energy storage system for an energy generation system. **(4 marks)**

b) State and explain the advantages supercapacitors have over batteries. **(3 marks)**

c) A direct methanol fuel cell uses methanol as fuel with an alkaline electrolyte. Using data provided in Table 1, Determine

i) $\Delta h^o_{rxn}, \Delta s^o_{rxn}, \Delta g^o_{rxn}$ **(6 marks)**

ii) Standard reversible voltage **(2 marks)**

**Table 1**

| Chemical Species | $\Delta h^o_f (kJ/mol)$ | $\Delta S^o_f (J/mol.K)$ |
|---|---|---|
| $CH_3OH$ | -200.95 | 239.83 |
| $O_2$ | -2.5 | 205.14 |
| $CO_2$ | -393.51 | 213.8 |
| $H_2O$ (liq) | -285.83 | 69.95 |

d) What exactly happens during electrolysis of water, support your answer with the oxidation and reduction as well as overall cell reduction indicating. **(5 marks)**

**QUESTION TWO** **[20 marks]**

a) Briefly explain how a solar power installation system is successfully integrated with a hydrogen fuel cell using a case study of the installation at the Renewable Energy Engineering Department, UMaT Tarkwa. **(3 marks)**

b) Calculate the change of reversible voltage at STP for $H_2$-$O_2$ fuel cell operating at a cell temperature of 25.15°C if air is used instead of pure $O_2$. Take $E^o = 1.229V$, $\rho_{H_2} = 3\ bar$, $\rho_{air} = 5\ bar$, $a_{H_2O} = 1$ and the composition of oxygen in air to be 21 %. **(6 marks)**

c) With the aid of a diagram and reaction half and overall reaction equations, briefly describe how a hydrogen fuel cell works? **(7 marks)**

d) An institution purchased lead acid batteries and stored it in a confined area for three years. When the batteries were finally installed It was discovered that, the batteries discharge within a shorter period after charging contrary to the manufacturer's specification. Within a few months of usage, the batteries conditions got worse and discharged within a much shorter period. Briefly explain what caused this phenomenon to occur. **(4 marks)**

**QUESTION THREE** **[20 marks]**

a) State four grid services Electrical Energy Systems can be employed to do. **(2 marks)**

b) i) write half-cell and full reaction for direct methanol fuel cell in alkali medium. **(3 marks)**

ii) Determine the standard reversible voltage if $\Delta g^o$ values are **(3 marks)**

$CH_3OH = -174\ \text{kJ/Mol}$
$CO_2 = -394\ \text{kJ/Mol}$
$H_2O = -237\ \text{kJ/Mol}$
$O_2 = -205\text{J/Mol}$

c) briefly state and explain four causes of voltage drops in a fuel cell **(4 marks)**

d) State four principal advantages of ECSCs as compared to batteries **(4 marks)**

e) With the aid of a diagram briefly explained the reasons why you will prefer a fuel cell operating at high temperature than those operating at low temperature ranges. **(4 marks)**

**QUESTION FOUR** **[20 marks]**

a) Briefly explain the following terminologies as used in batteries **(5 marks)**

i) C rates

ii) Depth of Discharge

iii) Open-circuit voltage
iv) Capacity
v) Float voltage

b) Indicate the anodic and cathodic half reactions for the charging and discharge of a lead acid battery utilising $H_2SO_4$ as an electrolyte. **(4 marks)**

c) State four advantages of fuel cells. **(4 marks)**

d) What role does the environmental pressure play in the generation of hydrogen? **(2 marks)**

e) i) State the chemical half reactions in the anode and cathode of an alkaline fuel cell **(2 marks)**

iii) State three advantages of alkaline fuel cell **(3 marks)**

***Examiner: Mr I. Osei/*** *Mr D. Yellezuome*