**2024 Unit 3 Chemistry trial exam**

**Name**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Total: \_\_\_\_\_\_/83

**Section A: Multiple Choice section**

**Question 1**

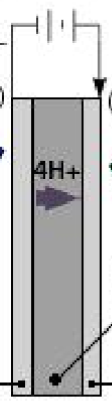
One of the stages in the production of bioethanol is distillation. This step is required

**A**. to separate ethanol from other alcohols present in the fermented solution.

**B**. to increase the concentration of the ethanol in the fermented solution.

**C**. to break the bonds in the glucose molecules enabling the yeast to form ethanol from glucose.

**D**. to increase the rate of the fermentation reaction.



*Use the following information to answer Questions 2 and 3.*

Hydrogen gas can be produced in a PEM electrolyser cell. The diagram provided

Is an outline of a PEM cell with the labels removed

**Question 2**

In this cell, the reaction at

**A**. the cathode is 2H2O(l) 🡪 O2(g) + 2H2(g) + 4e

**B**. the anode is 2H2(g) + O2(g) 🡪 2H2O(l)

**C**. the anode is 2H2O(l) 🡪 O2(g) + 4H+(aq) + 4e

**D**. the cathode is 4OH-(aq) + 4e 🡪 H2(g) + H2O(l)

**Question 3**

Select the alternative that is a correct description of the hydrogen gas produced.

**A**. This cell produces green hydrogen if it is powered by a wind turbine.

**B**. The hydrogen gas produced in a PEM is considered green hydrogen as the only raw material is water.

**C**. The use of electrodes that act as catalysts makes the energy required for this cell negligible.

**D**. The salt bridge in this cell should be a solution of KNO3.

**Question 4**

Which of the following will release the most energy?

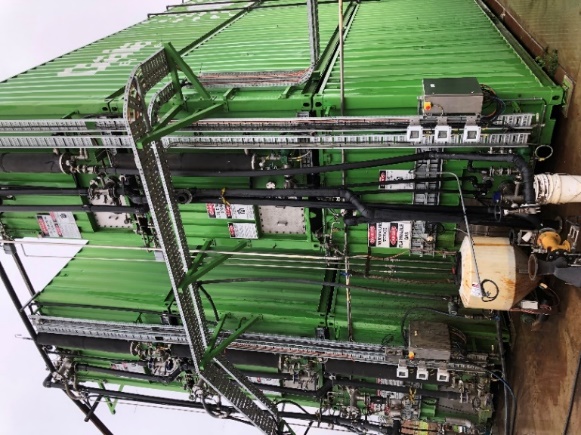
**A**. 49.6 L of methane at SLC.

**B**. 30 g of methane.

**C**. 50 L of ethane at SLC.

**D**. 20 g of hydrogen gas.

*Use the following information to answer Questions 5 and 6*

The effluent from the barn below is connected to the biodigestor

shown. The biodigestor in turn is connected to a gas generator.

****

**Question 5**

Select the alternative that describes the processes occurring.

**A**. The biodigestor will convert the carbohydrates in effluent to bioethanol that can then form electricity.

**B**. The effluent is burnt to produce electrical energy.

**C**. The biodigestor will produce a gas mixture that is burnt to produce electrical energy.

**D**. The biodigestor will produce bioethanol which can be used with triglycerides to form biodiesel.

**Question 6**

The best description of the sustainability of this process is:

**A**. The process is non-renewable as the volume of fuel is limited by the small number of cows.

**B**. This process is renewable and it does not produce any greenhouse emissions.

**C**. This process is renewable but it releases significant amounts of methane to the atmosphere.

**D**. This process is renewable but it will still produce greenhouse emissions.

**Question 7**

Which statement about energy changes in combustion is correct?

**A**. Incomplete combustion of a fuel will release more energy than complete combustion.

**B**. The molar enthalpy of combustion is represented as a negative value while the heat of combustion is positive.

**C**. Less energy is released when water is formed as a liquid rather than as a gas.

**D**. The energy required to break the bonds in the fuel is greater than the energy released when new bonds form.

**Question 8**

The reaction at the anode in a methane fuel cell operating in acid conditions is:

**A**. O(g) + 4H+(aq) + 4e- 🡪 2H2O(l)

**B**. CH4(g) + 4H+(aq) 🡪 CO2(g) + 4H2O(l) + 4e-

**C**. CH4(g) + H2O(l) 🡪 CO2(g) + 4H+(aq) + 4e-

**D**. CH4(g) + 2H2O(l) 🡪 CO2(g) + 8H+(aq) + 8e-

**Question 9**

An energy profile diagram is shown below.

A graph of a function

Description automatically generated

Which alternative correctly shows the activation energy and enthalpy change of the reverse reaction?

**A**. -75 kJ and -100 kJ

**B**. +175 kJ and -100 kJ

**C**. +75 kJ and -100 kJ

**D**. +175 kJ and +100 kJ

*Use the galvanic cell drawn below to answer Questions 10 and 11*

Diagram

Description automatically generated

**Question 10**

The overall equation in the cell will be

**A**. Al(s) + Ni2+(aq) 🡪 Al3+(aq) + Ni(s)

**B**. 2Al(s) + Ni2+(aq) 🡪 2Al3+(aq) + 3Ni(s)

**C**. 2Al3+(aq) + 3Ni(s) 🡪2Al(s) + 3Ni2+(aq)

**D**. 2Al(s) + 3Ni2+(aq) 🡪 2Al3+(aq) + 3Ni(s)

**Question 11**

In this cell,

**A**. aluminium will be the negative electrode and the potential will be around 1.41 V

**B**. the electrons will flow from the nickel electrode to the aluminium electrode.

**C**. nickel metal is oxidised and aluminium ions are reduced.

**D**. nickel will be the positive electrode and electrons will flow to the aluminium electrode.

**Question 12**

A copper half-cell is connected to a half-cell that has hydrogen gas pumped into a graphite electrode. In this cell

**A**. the copper electrode will gradually dissolve and water will be produced at the anode.

**B**. oxygen gas will be formed at the cathode and water at the anode.

**C**. copper metal will be deposited at the cathode and water at the anode.

**D**. copper metal will be deposited at the cathode and the pH will drop at the anode.

**Question 13**

When hydrochloric acid is added to sodium thiosulfate, the following reaction occurs gradually.

Na2S2O3(aq) + 2HCl(aq) 🡪 2S(s) + SO2(g) + 2NaCl(aq) + H2O(l)

The rate of this reaction can be monitored by placing the beaker the reaction is taking place in on top of a cross. As the reaction proceeds, the solution becomes cloudier and the cross obscured.

Which of the following lists contains only changes that will lower the reaction time of the reaction?

**A**. Decreased temperature, decreased HCl concentration and addition of a catalyst.

**B**. Decreased temperature, increased HCl concentration and addition of a catalyst.

**C**. Increased temperature, decreased HCl concentration and addition of further water.

**D**. Increased temperature, addition of a catalyst and increasing of the HCl concentration.

**Question 14**

The reaction between nitrogen monoxide and chlorine gas is

2NO(g) + Cl2(g) ⇄ 2NOCl(g)

2.0 mole of NOCl is added to an empty reactor. At equilibrium 1.4 mole remains. The number of mole of gas in the reactor is

**A**. 1.5

**B**. 2.3

**C**. 3.5

**D**. unable to be determined.

*Use the following diagram to answer Questions 15 and 16*

The equation for the formation of ammonia is:

N2(g) + 3H2(g) ⇄ 2NH3(g) ∆*H* = -92 kJ mol-1 *K*= 729 M-2 at 100 ºC.

**Question 15**

The magnitude of *K* for the equation

N2(g) + H2(g) ⇄ NH3(g) at 100 ºC will be:

**A**. 0.0014

**B**. 9

**C**. 27

**D**. 729

**Question 16**

The volume of an equilibrium mixture of the above gases is halved. When equilibrium is re-established, compared to the first point of equilibrium, the

**A**. concentration of hydrogen will be lower and the amount will be lower.

**B**. concentrations of nitrogen and hydrogen gases will be lower.

**C**. position of equilibrium is unchanged because the temperature is unchanged.

**D**. concentration of hydrogen will be higher but the amount will be lower.

**Question 17**

A current is passed through a 0.1 M solution of Fe(NO3)2 using iron electrodes. The products at the anode and cathode respectively will be

**A**. oxygen gas and hydrogen gas.

**B**. iron ions and iron metal.

**C**. oxygen gas and iron metal.

**D**. iron ions and hydrogen gas.

**Question 18**

2000 C of charge is passed through each of the following cells. Which cell will see the deposition of the highest mass of metal?

**A**. 0.1 M Sn(NO3)4

**B**. 0.1 M Sn(NO3)2

**C**. 0.1 M AgNO3

**D**. 0.1 M Ca(NO3)2

**Question 19**

A beaker contains a mixture of 0.1 M Pb(NO3)2, 0.1 M Al(NO3)3 and 0.1 M Ca(NO3)2. Graphite electrodes are added to the circuit and a current is passed through it until metals stop depositing on the cathode. The order in which the metals deposit will be

**A**. lead only.

**B**. lead then aluminium only.

**C**. lead then calcium only.

**D**. lead, then aluminium, then calcium.

**Question 20**

A student constructs a galvanic cell from standard zinc and copper half-cells. She sets the room temperature at 25 0C. The voltage obtained is 0.72 Volts. She repeats the arrangement for four more cells and obtains further voltages of 0.71 V, 0.73 V and 0.72 V. The student’s results are an example of data that is

**A**. precise but the accuracy cannot be determined.

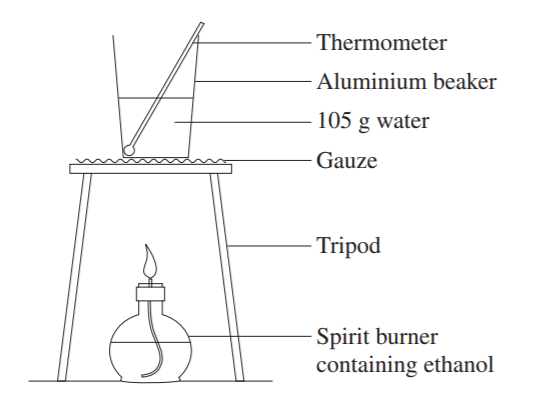
**B**. accurate but not precise.

**C**. precise but not accurate.

**D**. accurate and precise.

**Section B: Short answer questions**

**Question 1** (9 marks)



A student’s apparatus used to measure the enthalpy of combustion

of ethanol is drawn on the right.

**a**. Write a balanced equation for the reaction occurring. 1 mark

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**b**. If the mass change of ethanol is 0.740 g, what is the theoretical

temperature change? 2 marks

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**c. i**. Are the student’s results likely to be higher or lower than theoretical predictions? Explain your answer.

2 marks

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**ii**. Suggest two modifications that could be made to this procedure to improve the results obtained. 2 marks

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**d**. Olive oil is used to replace the water in the beaker. Discuss the likely impact of this change and whether valid

results could still be obtained for the heat of combustion of ethanol. 2 marks

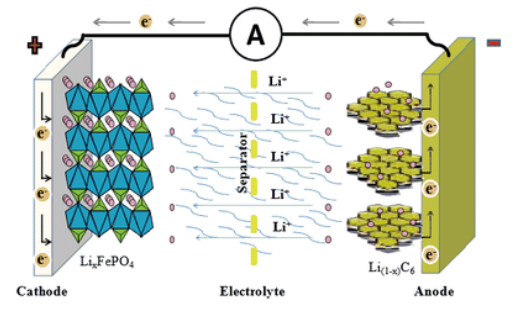
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**Question 2** (8 marks)

One form of lithium cell being trialled uses a grid of lithium in graphite and a grid of lithium in iron (III) phosphate.

The cell is rechargeable and the diagram below shows the cell being **discharged**.



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The half-equations occurring in the discharging cell are:

LiC6 🡪 Li+ + C6 + e-

FePO4 + Li+ + e- 🡪 LiFePO4

**a. i**. Use the boxes and lines provided to show the polarity of the electrodes during discharge. 1 mark

**ii**. Use the solid lines to indicate the anode and cathode during discharge. 1 mark

**iii**. Use the dashed lines to indicate the anode and cathode during recharge. 1 mark

**b**. Use the headings below to write overall equations for

**i**. Discharge: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 1 mark

**ii**. Recharge: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 1 mark

**c**. What is the oxidation number change occurring in the half-equation FePO4 + Li+ + e- 🡪 LiFePO4? 1 mark

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**d**. Give two reasons why lithium is so popular in newer technology cells. 2 marks

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**Question 3** (10 marks)

The diagram below shows a potential CO2 capture system based on the action of a CO2 electrolytic cell. The cell reacts CO2 with water to produce carbon monoxide, CO, and hydrogen gas.

**A picture containing application

Description automatically generated**

**a. i**. One of the components of petrol is octane. Write a balanced equation to show how petrol

produces CO2. 1 mark

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**ii**. Write a balanced equation to show how a coal-fired power station might produce CO2. 1 mark

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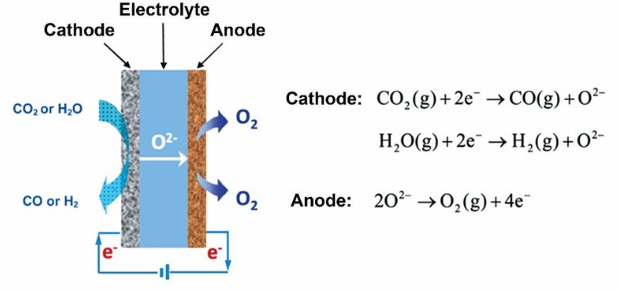
**iii**. Discuss the sustainability benefits offered by this cell. 3 marks

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**b**. A simple sketch of the CO2 electrolytic cell is shown below:

(The electrolyte is non-aqueous, therefore states not shown)

Use the information on the diagram to

**i**. write a balanced half-equation for the reaction occurring at the anode. 1 mark

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**ii**. write balanced half-equations for the two separate reactions occurring at the cathode. 2 marks

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**c. i**. State one use for the hydrogen gas produced in this cell. 1 mark

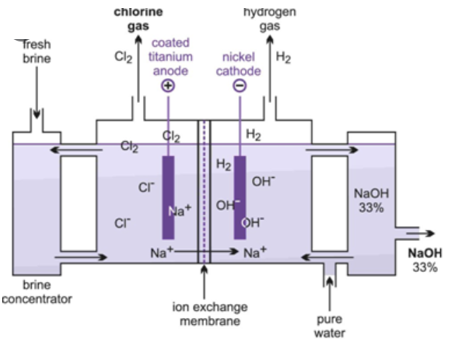
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**ii**. Write a thermochemical equation for the complete combustion of hydrogen gas. 1 mark

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**Question 4** (11 marks)

The diagram below is of an electrolytic cell where the electrolyte is brine, concentrated NaCl solution.



**a. i**. Sodium metal is not formed in this cell. Explain why? 1 mark

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**ii**. Oxygen gas is not formed in this cell. Explain why. 2 marks

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**b**. Use the headings below to write the half-equations and overall equations for the reactions in this cell. 3 marks

Anode: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cathode: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Overall: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**c**. Why is this cell useful? 2 marks

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**d**. Calculate the volume of gas produced at SLC when a current of 240 amps runs

for 1.00 hour. 3 marks

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**Question 5** (5 marks)

a. Write a thermochemical equation for

**i**. the complete combustion of glucose. 1 mark

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**ii**. respiration in body cells. 1 mark

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**b**. **i**. Use the axes provided to draw an energy profile diagram for the combustion of glucose. 2 marks

A grid of white paper

Description automatically generated with medium confidence

kJ

**ii**. Mitochondria in cells contain enzymes that catalyse the combustion of glucose. Show on your graph the

action of the catalyst. 1 mark

**Question 6** (8 marks)

The following reaction can be used to produce nitrosyl bromide:

2NO(g) + Br2(g) ⇄ 2NOBr(g) ∆*H* = - 16.1 kJ mol *K* = 1.3 × 10-2 M-1 at 1000 K

**a**. What are the values of ∆*H* and *K*c for the reaction 2 marks

NO(g) + ½ Br2(g) ⇄ NOBr(g)?

∆*H* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and *K* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**b**. What are the values of ∆*H* and *K* for the reaction 2 marks

NOBr(g) ⇄ NO(g) + ½ Br2(g)?

∆*H* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and *K* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**c**. The temperature of an equilibrium mixture of the above gases is increased. Explain the impact of this change on

**i**. the concentration of NOBr. 1 mark

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**ii**. the rate of the forward reaction. 1 mark

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**d**. 0.50 mol of NO and 0.50 mol of Br2 are both added to an empty 2.0 L container at 1000 K. Calculate the

concentration of the NOBr at equilibrium. 2 marks

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**Question 7** (12 marks)

Hydrogen peroxide, H2O2, decomposes to form water and oxygen gas. Manganese dioxide can be used as a catalyst for this reaction.

A student uses the equipment shown below to investigate the impact of temperature upon the rate of this reaction.

A picture containing text, line, diagram, parallel

Description automatically generated

**a**. **i**. Write a balanced equation for the reaction occurring. 1 mark

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**ii**. Identify the reason for the use of string in this reaction. 1 mark

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**b**. i. Write a procedure the student could follow to investigate the impact of temperature on rate of

this reaction. 3 marks

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**ii**. identify the independent and dependent variables in your procedure. 2 marks

Independent variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Dependent variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**c. i**. Explain why the rate changes with temperature? 2 marks

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**ii**. Will the final volume of gas increase with temperature? Justify your answer. 2 marks

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**iii**. Circle the one of the following that manganese dioxide impacts? 1 mark

enthalpy of the reaction the position of equilibrium the activation energy of the reaction

**End of exam**

Section A: 20 marks

Section B: 63 marks