S T A V

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Student name	

CHEMISTRY
Unit 3
Trial Examination

QUESTION AND ANSWER BOOK

Total writing time: 1 hour 30 minutes

Structure of book

Section	Number of questions	Number of marks
A	20	20
B	11	70
	Total	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape, mobile phones and/or any other unauthorised electronic devices.
- A copy of the official VCAA Data Book (printed or photocopied) can be brought into the trial examination.

Materials supplied
- Question and answer book of 18 pages, with a detachable answer sheet for multiple-choice questions inside the front cover.

Instructions
- Detach the answer sheet for multiple-choice questions during reading time.
- Write your **name** in the space provided above on this page and on the answer sheet for multiple-choice questions.
- All written responses should be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep your copy of the VCAA Data Book.

STAV Publishing
2022

CHEMISTRY
Unit 3 Trial Examination
MULTIPLE CHOICE ANSWER SHEET

STUDENT NAME:

INSTRUCTIONS: USE PENCIL ONLY
- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries.
- If you make a mistake, **ERASE** it – **DO NOT** cross it out.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- Mark your answer by **SHADING** the letter of your choice.

	ONE ANSWER PER LINE				ONE ANSWER PER LINE		
1	A B C D	11	A B C D
2	A B C D	12	A B C D
3	A B C D	13	A B C D
4	A B C D	14	A B C D
5	A B C D	15	A B C D
6	A B C D	16	A B C D
7	A B C D	17	A B C D
8	A B C D	18	A B C D
9	A B C D	19	A B C D
10	A B C D	20	A B C D

SECTION A – Multiple-choice questions

Instructions for Section A
Instructions for Section A Answer all questions in pencil on the answer sheet provided for multiple-choice questions. Choose the response that is **correct** or that **best answers** the question. A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No mark will be given if more than one answer is completed for any question.

Question 1

Which of the following statements about renewable energy sources is **most correct**?

A.   Renewable energy sources are cheaper than non-renewable energy sources.

B.   Renewable energy sources are all plant based.

C.   Renewable energy sources are produced at a similar rate to which they are used.

D.   Renewable energy sources always produce less carbon dioxide emissions than non-renewable energy sources.

Question 2

Which of the following fuels has the highest cloud point?

A.   petrol

B.   petrodiesel

C.   jet fuel

D.   biodiesel

Question 3

In the complete combustion of octane, the total chemical energy of the products when compared with that of the reactants is

A.   greater and the bonds in the products are stronger.

B.   lower and the bonds in the products are stronger.

C.   greater and the bonds in the products are weaker.

D.   lower and the bonds in the products are weaker.

Question 4

Consider the balanced equation for the incomplete combustion of ethanol to produce carbon monoxide. The lowest whole number coefficient for oxygen gas would be

A.   2

B.   3

C.   4

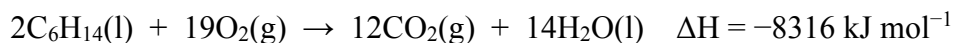D.   5

Question 5

Which of the following reactions would release the greatest amount of energy, in kJ?

A. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

B. $4H_2(g) + 2O_2(g) \rightarrow 4H_2O(g)$

C. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

D. $4H_2(g) + 2O_2(g) \rightarrow 4H_2O(l)$

Question 6

The thermochemical equation for the complete combustion of hexane is

$$2C_6H_{14}(l) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(l) \quad \Delta H = -8316 \text{ kJ mol}^{-1}$$

The mass of hexane that would be required to generate 600 kJ of energy is closest to

A.   6.20 g

B.   7.95 g

C.   12.4 g

D.   18.6 g

Question 7

When limestone, impure $CaCO_3$, reacts with hydrochloric acid, the following reaction occurs

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

Which one of the following would **not** increase the rate of reaction?

A.   increasing the volume of the conical flask

B.   using finely divided limestone

C.   changing the temperature from 15°C to 25°C.

D.   using 2.0 M hydrochloric acid instead of 1.0 M hydrochloric acid

Question 8

Reaction rates usually increase with an increase in temperature. This increase is **mainly** due to an increase in the

A. frequency of collisions between particles.

B. number of particles with the energy required to react.

C. activation energy of the reaction.

D. average energy of the reaction.

Question 9

Copper metal can be oxidized by nitric acid according to the following half-equations

$$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$$

$$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$$
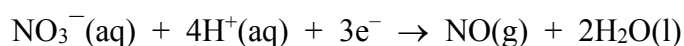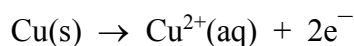
The number of moles of nitrate ions reduced by one mole of copper is closest to

A. 0.33

B. 0.67

C. 1.5

D. 2.0

Question 10

What happens to the manganese in MnO_2 when it is converted to MnO_4^{2-} ?

A. Its oxidation number increases and it undergoes reduction.

B. Its oxidation number increases and it undergoes oxidation.

C. Its oxidation number decreases and it undergoes reduction.

D. Its oxidation number decreases and it undergoes oxidation.

Question 11

A transition metal alloy catalyst is used to catalyse the following reaction

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The purpose of the catalyst is to

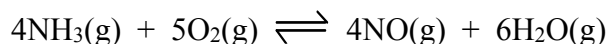**A.** increase the equilibrium constant, K, of the reaction.

B. increase the activation energy of the reaction

C. decrease the equilibrium constant, K, of the reaction.

D. decrease the activation energy of the reaction

Question 12

The table below gives the chemical equations and equilibrium constants for two related reactions at 25°C.

Reaction	Equation	Equilibrium constant
W	$NO(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO_2(g)$	$K_1 = 6.60$
X	$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$	K_2

Calculate the numerical value for the equilibrium constant of reaction X, K_2

A. 0.0230

B. 0.152

C. 0.389

D. 43.3

Question 13

Heat is released when sulfur trioxide, SO_3, is formed in the following equilibrium process:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H \text{ has a negative value}$$
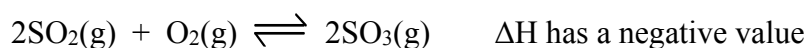
Which change will increase the quantity of SO_3 at equilibrium?

A. adding a catalyst

B. decreasing the pressure

C. decreasing the temperature

D. removing O_2

Question 14

A student placed four metals, W, X, Y and Z in separate solutions containing the cations W^{2+}, X^{2+}, Y^{2+} and Z^{2+}. If any reaction occurred, the student placed a tick ($\checkmark$) in the appropriate column of the results table shown below.

	W	X	Y	Z
W^{2+}	–	–	–	–
X^{2+}	$\checkmark$	–	$\checkmark$	$\checkmark$
Y^{2+}	$\checkmark$	–	–	$\checkmark$
Z^{2+}	$\checkmark$	–	–	–

Based on these observations, which cation is the strongest oxidising agent?

A. W^{2+}

B. X^{2+}

C. Y^{2+}

D. Z^{2+}

Question 15

A feature of the standard hydrogen electrode is

A. hydrogen gas at 1 atm pressure

B. 1.0 mol L^{-1} sulfuric acid

C. a temperature of 273 K

D. an inert graphite electrode

Question 16

The diagram below represents the electrochemical cell: Fe(s) | Fe^{2+}(aq) || Cu^{2+}(aq) | Cu(s)
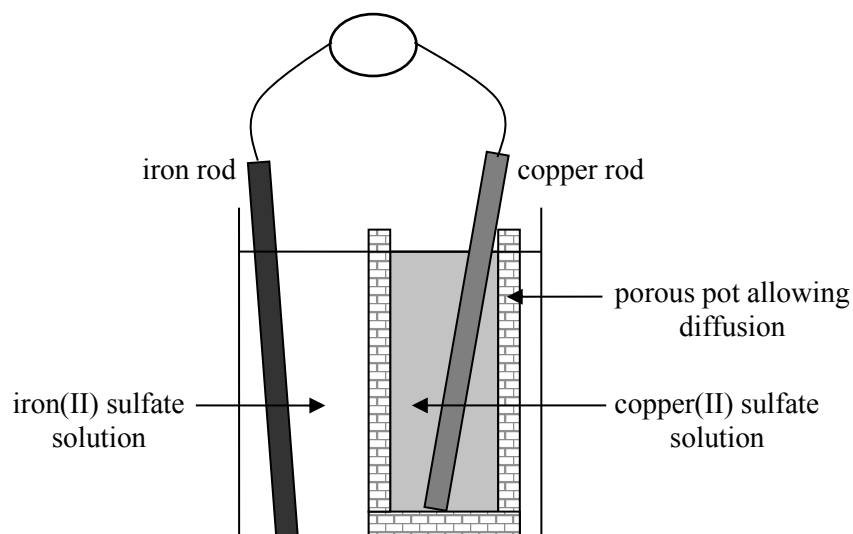
The particles, I, II, III, and IV, involved in this electrochemical cell are:

I	copper atoms	
II	iron atoms	
III	copper(II) ions	
IV	iron(II) ions	

The particles that move towards the site of reduction are

A.   I only

B.   II only

C.   I and III

D.   III and IV

Question 17

A solution of tin(II) chloride was electrolysed using the circuit shown below.
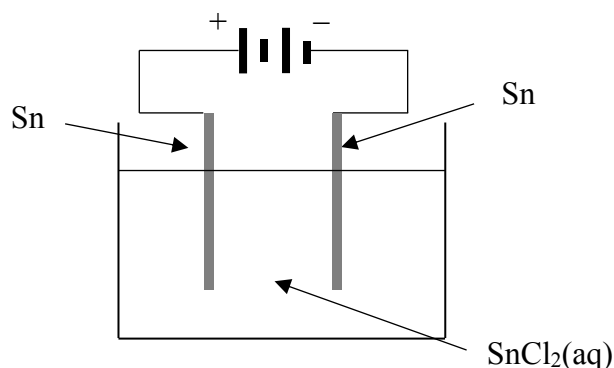
The reaction that is most likely to occur at the positive electrode under standard conditions is

A. $Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$

B. $Sn(s) \rightarrow Sn^{2+}(aq) + 2e^-$

C. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

D. $2H_2O(l) \rightarrow O_2(g) + 4H^+ + 2e^-$

Question 18

Which of the following arrangements of an electrolytic cell would electroplate a silver coin with copper?

	cathode	anode	electrolyte
A.	copper	silver coin	copper(II) sulfate
B.	silver coin	copper	copper(II) sulfate
C.	copper	silver coin	silver nitrate
D.	silver coin	copper	silver nitrate

Question 19

A student passed 1500 C of electricity through an aqueous solution of an ionic salt MCl_n.
1.62 g of metal, M, was deposited at the cathode. The metal and the value of 'n' are likely to be

A.   silver, n = 1

B.   chromium, n = 2

C.   palladium, n = 2

D.   lead, n = 2

Question 20

The following data was recorded for determining the density of three samples of a pure element.

mass (g) ± 0.01 g	volume (cm³) ± 0.1 cm³
5.61	2.8
4.32	2.1
6.37	3.1

Which one of the following average density values, in g cm^{-3}, has been calculated from this data to the correct number of significant figures?

A.   2

B.   2.0

C.   2.04

D.   2.039

END OF SECTION A

SECTION B – Short answer questions

| **Instructions for Section B** |
| --- |
| Answer **all** questions in the spaces provided |
| To obtain full marks for your responses you should |
| • Give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not be given full marks. |
| • Show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working. |
| • Make sure chemical equations are balanced and that formulas for individual substances include an indication of state; for example, $H_2(g)$; $NaCl(s)$ |

Question 1

The structures of a biodiesel component and a petrodiesel component are shown below.
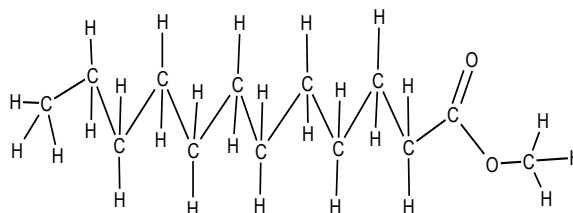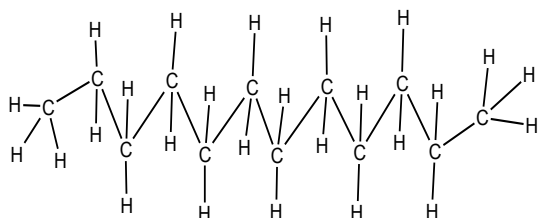
a.   i. Explain why biodiesel is more viscous than petrodiesel.

_____

_____

_____

_____

ii. Why does this pose a possible problem for use in car engines?

_____

_____

_____

3 + 2 = 5 marks

b.   Explain why biodiesel is considered to have less impact on global warming and climate change than petrodiesel.

_____

_____

2 marks

Total 7 marks

Question 2

Use the energy profile diagram shown below to answer the following questions.
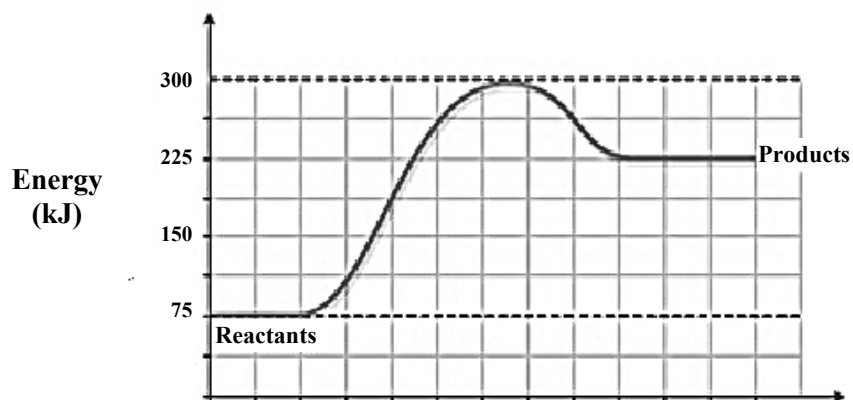
a.   What is the energy **change** for the forward reaction?

_____
<div align="right">1 mark</div>

b.   **i.** Is this reaction endothermic or exothermic? Explain why.

_____

_____

           ii. Would the temperature of the surroundings increase or decrease?

_____
<div align="right">2 + 1 = 3 marks
Total 4 marks</div>

Question 3

A pig farm in Victoria captures the methane produced by the waste the pigs produce to save money on their own electricity and to sell as carbon credits. The pig farm claims to produce 4.126×10^6 kg of methane, CH_4, per year (365 days).

a. Calculate the volume, in ML, of methane produced at SLC each day.

_____

_____

_____

_____

_____

_____

_____

4 marks

b. The average minimum winter temperature at the pig farm is 3.2°C. Calculate the pressure, in kPa, the same volume of methane would exert at this lower temperature.

_____

_____

_____

2 marks

Total 6 marks

Question 4

Two systems, **A** and **B**, at 100°C containing N_2O_4 and NO_2 were analysed.

The equation for the reaction is: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

The reaction has an equilibrium constant, K_c, of 0.213 mol L^{-1} at 100°C.

Data obtained in the analysis is shown in the table below.

system	$[N_2O_4]$ (mol L^{-1})	$[NO_2]$ (mol L^{-1})
A	0.0049	0.0385
B	0.0042	0.0299

a.   Determine whether each of the systems **A** and **B** is at equilibrium.

_____

_____

_____

_____

_____

_____

_____
                                                                    5 marks
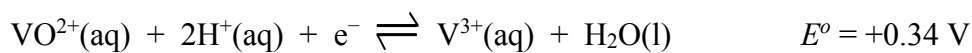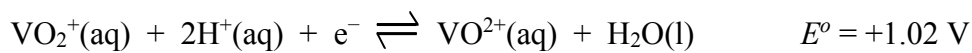
b.   If one of the systems is not at equilibrium, will more reactants or products be formed before equilibrium is established? Explain your response.

_____

_____

_____

_____
                                                                    2 marks
                                                              Total 7 marks

Question 5

Consider the following data:

$$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l) \qquad E^o = +1.02 \text{ V}$$

$$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq) \qquad E^o = +0.54 \text{ V}$$

$$VO^{2+}(aq) + 2H^+(aq) + e^- \rightleftharpoons V^{3+}(aq) + H_2O(l) \qquad E^o = +0.34 \text{ V}$$

$$V^{3+}(aq) + e^- \rightleftharpoons V^{2+} \qquad E^o = -0.25 \text{ V}$$

a. Of the ions listed, give the species containing the element V in its highest oxidation state. Show all working.

_____

_____

_____

3 marks

b. Which, if any, of the four species, $V^{2+}(aq)$, $V^{3+}(aq)$, $VO^{2+}(aq)$ and $VO_2^+(aq)$ should be chosen to convert iodide ions to iodine in an aqueous solution? Explain your answer.

_____

_____

_____

2 marks
Total 5 marks

Question 6

Collision theory is an important part of understanding why chemical reactions occur.

a. Complete the following table using **arrows** for increase or decrease or a **dash** for no change to show how collision frequency, collision energy and activation energy can be changed in a chemical system.

	increase in concentration	increase in volume	increase in temperature	addition of suitable catalyst
collision frequency				
collision energy				
activation energy barrier				

4 marks

b. Explain why not all collisions lead to a chemical reaction.

_____
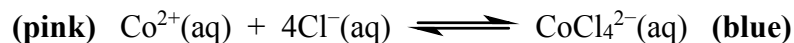
_____

_____

2 marks

c. Use collision theory to explain your answer in the table above to the increase in volume.

_____

_____

1 mark
Total 7 marks

Question 7

In a practical activity in preparation for a SAC, you may have carried out the reaction represented by the following equation:

$$\textbf{(pink)} \quad Co^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CoCl_4{}^{2-}(aq) \quad \textbf{(blue)}$$

a. Describe the method that you would use to determine if the reaction was endothermic or exothermic. Include the expected **results** if it is <u>endothermic</u>.

Method:

_____

_____

Results:

_____

_____

_____

_____
<div align="right">2 marks</div>

b. After 4 minutes at equilibrium, the system was heated. Complete the graph below to show the effect of heating the system. Equilibrium was re-established at 6 minutes. You may assume this reaction is endothermic.
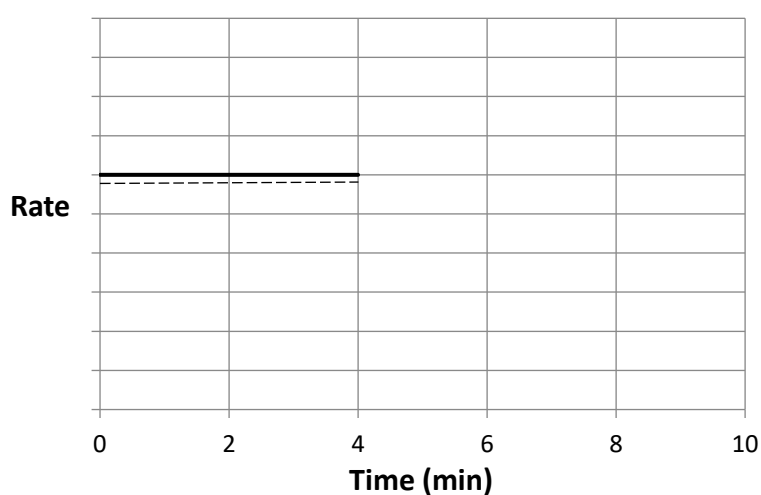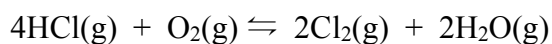

- - - - - - - reverse reaction

———— forward reaction

<div align="right">3 marks
Total 5 marks</div>

Question 8

Hydrogen chloride can be oxidised to chlorine in the Deacon process as shown below:

$$4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$$

0.800 mol of hydrogen chloride was mixed with 0.200 mol of oxygen in a vessel of volume 10 L. At equilibrium it was found that the mixture contained 0.200 mol of hydrogen chloride.

a. Write the expression for the equilibrium constant for this reaction.

_____
1 mark

b. Determine the equilibrium concentrations of oxygen, chlorine and steam.

_____

_____

_____

_____

_____
3 marks

c. Determine the value of the equilibrium constant at this temperature (including its unit).
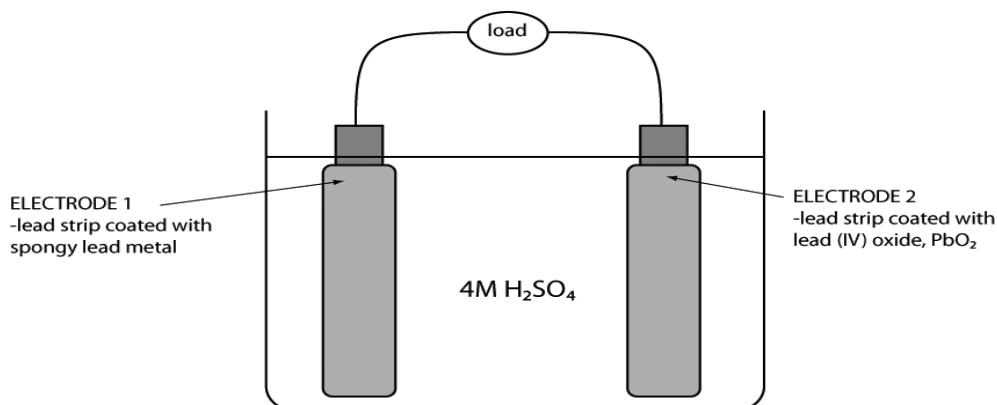
_____
2 marks

d. What change would the addition of more steam have on the equilibrium constant?
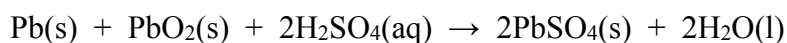
_____

_____
1 mark
Total 7 marks

Question 9

The diagram below shows a simple version of a **fully charged** lead-acid cell.

a. During **discharge**, when the cell is delivering energy, the overall equation occurring is:

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

Write a half-equation for the half-reaction occurring at electrode 2 during **discharging**.

_____

1 mark

b. Explain how the cell can be recharged when it is flat.

_____

_____

2 marks

c. Write a half-equation for the half-reaction occurring at electrode 1 during **recharging**.

_____

1 mark

d. Tick **one** box only for each of the following to indicate in which of the discharge and recharge cycles it occurs.

	discharge only	recharge only	during both	during neither
Electrons flow from electrode 1 to electrode 2.				
Electrode 2 is the negative (−) electrode.				
Electrical energy is converted into chemical energy.				
The cathode is the electrode at which oxidation occurs.				
Electrode 1 is the anode.				
Anions in the acid solution migrate towards electrode 1.				
The mass of electrode 2 increases.				
Reduction occurs at electrode 1.				
The pH of the electrolyte solution decreases.				

9 marks

Total 13 marks

Question 10

LPG cylinders are filled essentially with propane (C_3H_8). It might be possible to use the propane from such a cylinder instead of hydrogen in a fuel cell to generate electricity in the home.

The overall cell reaction would be the same as the direct combustion of propane in oxygen, forming carbon dioxide and liquid water.

a. Write the overall equation for the reaction.

_____
<div align="right">2 marks</div>

b. Write the half-equation for the oxidation of propane in a fuel cell with an acidic electrolyte.

_____
<div align="right">1 mark</div>

c. Write the half-equation for the reduction of oxygen in a fuel cell with an acidic electrolyte.

_____
<div align="right">1 mark</div>
<div align="right">Total 4 marks</div>

Question 11

The electrolysis of a solution of chromium ions using a current of 2.2 A for 25 minutes produced 0.59 g of chromium. Determine the charge on the chromium ion.

_____

_____

_____

_____

_____

_____
<div align="right">Total 5 marks</div>

END OF TRIAL EXAMINATION