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**Student name**

# CHEMISTRY
# Unit 4
# 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 | 10 | 62 |
| | **Total** | **82** |

- 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.

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# *STAV Publishing*

## 2011

# CHEMISTRY

## Unit 4 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**

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.

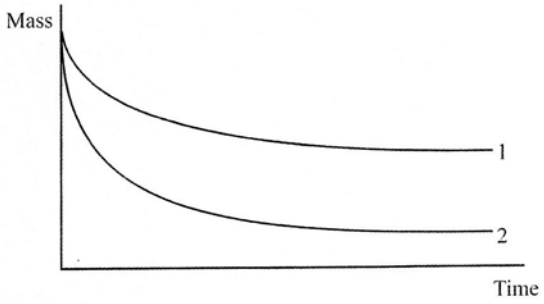
### Question 1

The rate of a reaction between two gases increases when the temperature is increased and a catalyst is added. Which statements are both correct for the effect of these changes on the reaction.

| | Increasing the temperature | Adding a catalyst |
|---|---|---|
| **A.** | Collision frequency increases | Activation energy increases |
| **B.** | Activation energy increases | Activation energy does not change |
| **C.** | Activation energy does not change | Activation energy decreases |
| **D.** | Activation energy increases | Collision frequency increases |

### Question 2

Excess magnesium was added to a beaker of aqueous hydrochloric acid on a balance. A graph of the mass of the beaker and contents was plotted against time (line 1).




What change in the experiment could give line 2?

I. The same mass of magnesium but in smaller pieces

II. The same volume of a more concentrated solution of hydrochloric acid

III. A lower temperature

**A.** I only

**B.** II only

**C.** III only

**D.** None of the above

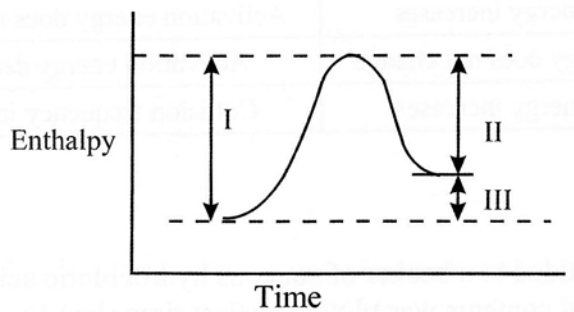
**Question 3**

At 25°C, 100 mL of 1.0 mol $L^{-1}$ hydrochloric acid is added to 3.5 g of magnesium carbonate. If the mass of magnesium carbonate is kept constant, which conditions will **not** increase the initial rate of reaction?

| | Volume of HCl (L) | Concentration of HCl (M) | Temperature (°C) |
|---|---|---|---|
| **A.** | 200 | 1.0 | 25 |
| **B.** | 100 | 2.0 | 25 |
| **C.** | 100 | 1.0 | 35 |
| **D.** | 200 | 2.0 | 25 |

**Question 4**

Which of the quantities in the enthalpy level diagram below is (are) affected by the use of a catalyst?




**A.** I only

**B.** III only

**C.** I and II only

**D.** II and III only

**The next two questions relate to the following information**

Phosphorus (V) chloride $PCl_5$, decomposes to form phosphorus (III) chloride $PCl_3$, and chlorine $Cl_2$, according to the equation

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

**Question 5**

Four different flasks, A, B, C and D, at the same temperature, contain a mixture of $PCl_5$, $PCl_3$, and $Cl_2$. The concentration in mol $L^{-1}$ of these components in each of the flasks is shown below. In three of the four flasks the mixture of gases is at equilibrium. In which one is the mixture of gases **not** at equilibrium?

| Flask | $[PCl_5(g)]$ | $[PCl_3(g)]$ | $[Cl_2(g)]$ |
|---|---|---|---|
| **A.** | 0.15 | 0.20 | 0.30 |
| **B.** | 0.20 | 0.15 | 0.15 |
| **C.** | 0.10 | 0.10 | 0.40 |
| **D.** | 0.30 | 0.80 | 0.15 |

**Question 6**

Some gaseous $PCl_5$ is placed in an empty container at the same temperature as in the previous question. When equilibrium is reached, the mass of the gas mixture, compared to the initial mass of $PCl_5$, is

**A.** halved

**B.** unchanged

**C.** one and a half times greater

**D.** doubled

**Question 7**

Gaseous NOCl decomposes to form the gases NO and $Cl_2$, according to the equation

$$2NOCl\ (g) \rightleftharpoons 2NO\ (g) + Cl_2(g)$$

The equilibrium constant (K) for the given equation is $1.6 \times 10^{-5}$ at 35°C. What is the value of the equilibrium constant ($K_1$), at 35°C, for the following equation?

$$NO\ (g) + \tfrac{1}{2}\ Cl_2(g) \rightleftharpoons NOCl\ (g)$$

**A.** $-1.6 \times 10^{-5}$

**B.** $1.6 \times 10^{-5}$

**C.** $2.5 \times 10^{2}$

**D.** $6.3 \times 10^{4}$

**Question 8**

If an aqueous solution containing 0.10 M $NH_3$ is diluted with an equal volume of distilled water

**A.** the overall pH decreases and the percentage ionisation increases.
**B.** the overall pH decreases and the percentage ionisation decreases.
**C.** the overall pH increases and the percentage ionisation increases.
**D.** the overall pH increases and the percentage ionisation decreases.

**Question 9**

The sodium salt of propanoic acid (sodium propanoate) is used as a preservative in bread and other baked goods. It can be produced by reacting propanoic acid with sodium hydroxide.

In a particular experiment 100 mL of 0.080 M NaOH was added to 100 mL of 0.16 M propanoic acid.

Which of the following statements is/are correct?

I. The pH of the resulting solution will be less than that of the propanoic acid solution.
II. The resulting solution contains equal amounts of propanoic acid and its conjugate base.
III. Before the NaOH was added there were no propanoate ions present.

**A.** II only
**B.** III only
**C.** I and II only
**D.** II and III only

**Question 10**

100 mL of a 0.0100 M solution of barium hydroxide, $Ba(OH)_2$, is diluted by adding 900 mL of water at 25°C. The pH of the resulting solution will be

**A.** 2.00
**B.** 2.70
**C.** 11.0
**D.** 11.3

**Question 11**

In which of the following processes will the $\Delta H$ have the opposite sign to that of the other three?

**A.** $CO_2(s) \rightarrow CO_2(g)$

**B.** $2\,NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$

**C.** $CO_2(g) \rightarrow C(s) + O_2(g)$

**D.** $Na^+ + e^- \rightarrow Na$

**Question 12**

If the specific heat capacity of glass is 0.0840 J $g^{-1}$ $^oC^{-1}$, the amount of energy, in J, needed to raise the temperature of 50.0 g of glass by 10.0 $^oC$ is

**A.** 42

**B.** 50

**C.** 84

**D.** 420

**Question 13**

If 0.500 mol of carbon dioxide is released by the complete combustion of a certain amount of ethanol, the amount of energy, in kJ, that will also be released is closest to

**A.** 171

**B.** 341

**C.** 682

**D.** 1364

**Question 14**

In which of the following combinations of half-cells, will $Fe^{2+}$ act as the reductant?

**A.** $Fe^{3+}(aq)/Fe^{2+}(aq)$ and $Cl_2(g)/Cl^-(aq)$

**B.** $Fe^{2+}(aq)/Fe(s)$ and $I_2(s)/I^-(aq)$

**C.** $Fe^{2+}(aq)/Fe(s)$ and $Zn^{2+}(aq)/Zn(s)$

**D.** $Fe^{3+}(aq)/Fe^{2+}(aq)$ and $Cu^{2+}(aq)/Cu(s)$

**Question 15**

A galvanic cell can be constructed by combining a standard hydrogen half-cell to a standard $Ni^{2+}/Ni$ half-cell. In this galvanic cell

**A.** the concentration of nickel(II) ions would decrease.

**B.** reduction would occur at the nickel electrode.

**C.** the pH of the solution in the standard hydrogen half-cell would increase.

**D.** hydrogen gas would be consumed at the anode.

**Question 16**

When a freshly cleaned piece of magnesium is placed in **de-oxygenated** water

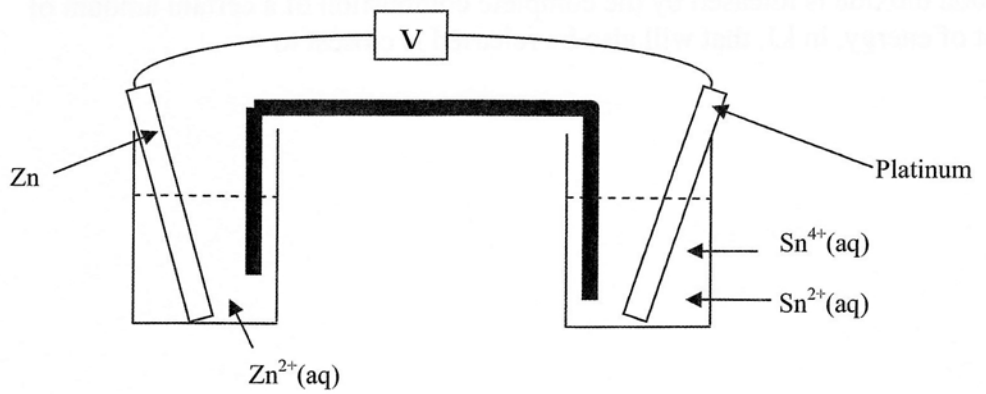
**A.** no reaction is predicted.

**B.** hydrogen bubbles only would be formed.

**C.** hydroxide ions only would be formed.

**D.** both hydrogen gas and hydroxide ions are formed.

**The next two questions refer to the galvanic cell shown below.**




**Question 17**

In the galvanic cell

**A.** the Zn electrode is the anode and has a negative polarity.

**B.** the Zn electrode is the cathode and has a positive polarity.

**C.** the Pt electrode is the anode and has a negative polarity.

**D.** the Pt electrode is the cathode and has a negative polarity.

**Question 18**

If the salt bridge was soaked in a saturated solution of $KNO_3$, then as the cell discharges

**A.** $K^+$ ions will migrate towards the half-cell containing the anode.

**B.** $K^+$ ions will migrate towards the half-cell containing the cathode.

**C.** $NO_3^-$ ions will migrate towards the half-cell containing the cathode.

**D.** $Sn^{4+}$ ions will migrate towards the half-cell containing the anode.

**Question 19**

The cell reaction occurring in a particular button cell as current is drawn is

$$Ag_2O(s) + Zn(s) + H_2O(l) \rightarrow 2Ag(s) + Zn(OH)_2(s) \quad \text{The cell potential is 1.50 V}$$

Given that the electrolyte in a button cell is 1 M KOH (aq) and the $Ag_2O/Ag$ half cell has $E^o = +0.34$ V, then the $E^o$ of the $Zn(OH)_2/Zn$ half cell is

**A.** −1.16 V

**B.** −1.84 V

**C.** +1.16 V

**D.** +1.84 V

**Question 20**

The number of Faraday(F) needed to deposit all the Co from 0.500 mol of $Co_2(SO_4)_3$ dissolved in 100 mL of distilled water.

**A.** 0.5

**B.** 1.0

**C.** 1.5

**D.** 3.0

**END OF SECTION A**

## SECTION B – Short answer questions

**Instructions for Section B**

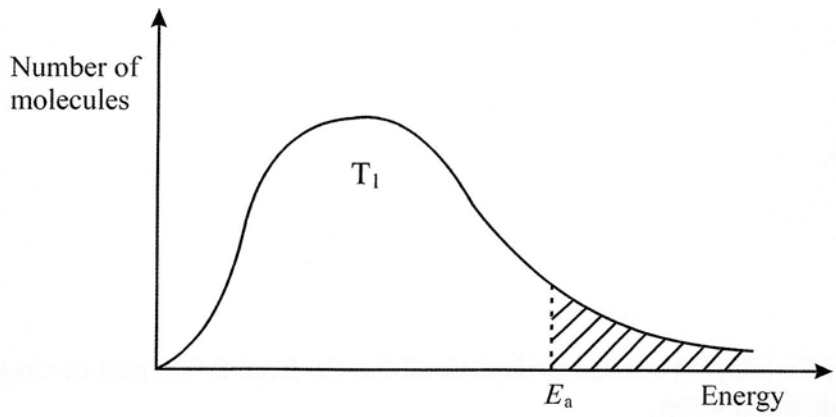
Answer **all** questions in the spaces provided.

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 the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s)

### Question 1

The diagram shows the distribution of energy for the molecules in a sample of gas at a given temperature, $T_1$.




**a.** In the diagram above, $E_a$ represents the *activation energy* for a reaction. Define this term.

_____

_____

_____

_____

1 mark

**b.** On the diagram above, carefully draw another curve to show the energy distribution for the same gas at a higher temperature. Label the curve $T_2$.

1 mark

**c.** What can be said about the area under the original curve and under your curve? Explain your answer.

_____

_____

_____

_____

1 mark

**d.** With reference to your diagram, state and explain what happens to the rate of a reaction when the temperature is increased.

_____

_____

_____

2 marks

Total 5 marks

**Question 2**

Butanoic acid is a natural product and a component of human sweat.

**a.** Write an equation for the ionisation of butanoic acid in water.

_____

1 mark

**b.** Write an expression for the acid dissociation constant, $K_a$, of butanoic acid.

_____

_____

_____

1 mark

**c.** Calculate the value of $K_a$ for butanoic acid if a 0.10 mol $L^{-1}$ solution has a pH of 2.9 at 298 K.

_____

_____

_____

3 marks

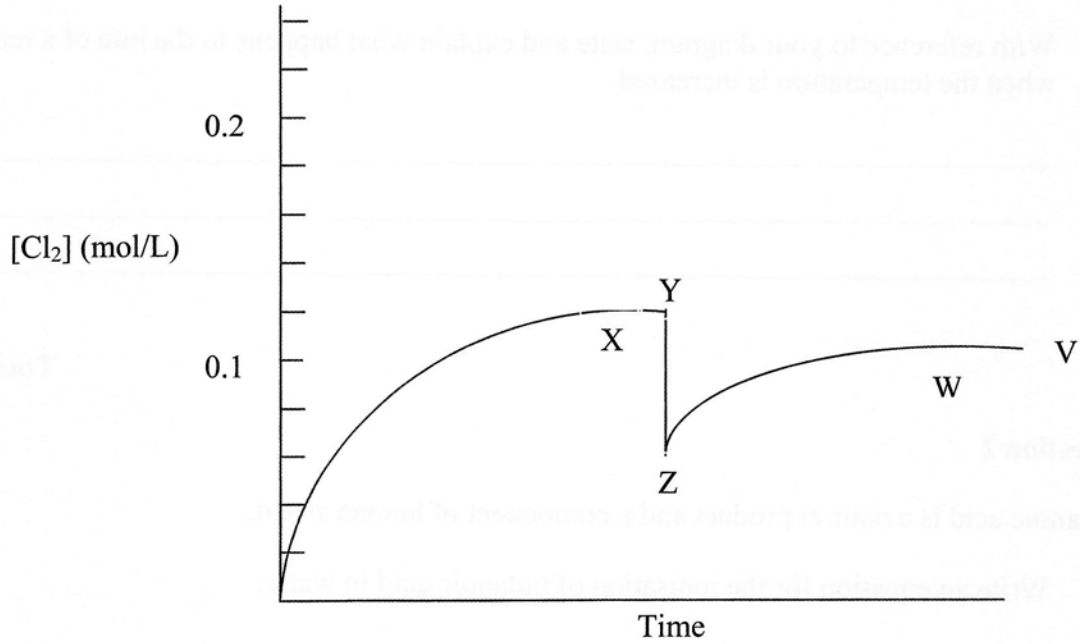
Total 5 marks

**Question 3**

At a fixed temperature, 0.020 mol of $PCl_5$ was placed in a large syringe with the volume adjusted to 0.100 L.

The reaction occurring is $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

The concentration of chlorine as a function of time is shown in the graph below. At time, t, the volume available to the gas mixture was suddenly increased to 0.200 L. The graph shows the variation in chlorine concentration at and also after that time.




**a.** Explain why the $[Cl_2]$ remained constant from X to Y and why it did not get to 0.020 mol/L.

_____

_____

_____

2 marks

**b.** Why did the concentration of $[Cl_2]$ decrease suddenly to Z (at time t)?

_____

_____

_____

1 mark

**c.** Why did the $[Cl_2]$ increase from Z to W and why did it remain constant from W to V?

_____

_____

_____

_____

2 marks

**d.** Suppose that the volume had decreased to 0.050 L at time t (instead of being increased). On the graph, sketch the curve you would expect for the $[Cl_2]$ after point Y.

1 mark

**e.** On the graph, draw a dotted curve for the $[Cl_2]$ that you would have expected if a catalyst had been used for the first part of the experiment.

1 mark

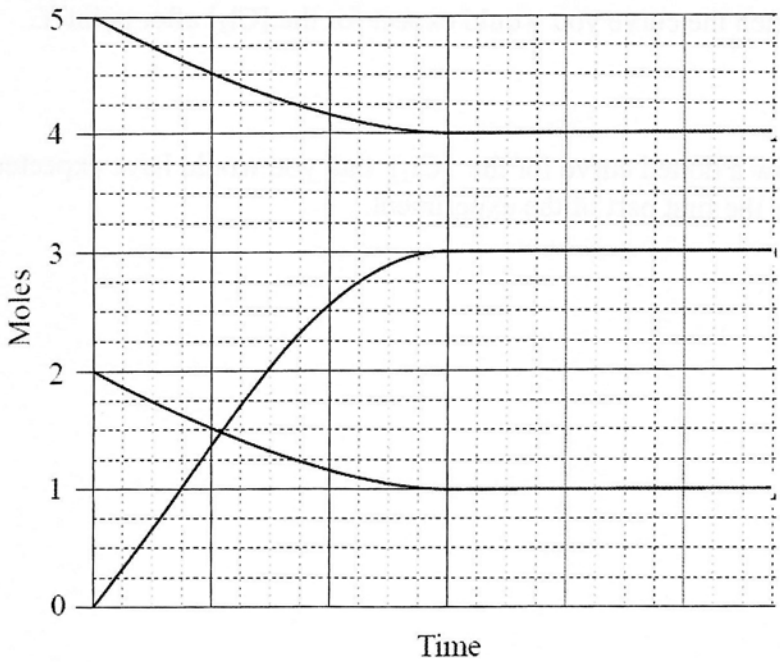
Total 7 marks

**Question 4**

Two substances *A* and *B* react according to the equation:

$$A + B \rightleftharpoons 3C$$

5 moles of *A* and 2 moles of *B* are mixed in a 2 L closed container. The reaction is allowed to come to equilibrium at temperature *T*. The graph below shows the variation in moles of *A*, *B*, and *C* over time.




Calculate the value of the equilibrium constant, $K_c$, including units, for the reaction at temperature *T*. Show all of your working.

Total 4 marks

**Question 5**

A stage show requiring a frothing 'blood-like' liquid used dry ice, $CO_2$ (s) and iron complexes to produce this effect. One such iron complex consists of an alkaline solution containing iron(III) chloride and sodium thiocyanate. This produces the following equilibrium reaction:

$$\underset{\text{(yellow)}}{Fe(OH)^{2+}(aq)} + SCN^-(aq) \rightleftharpoons \underset{\text{(bright red)}}{Fe(SCN)^{2+}(aq)} + OH^-(aq)$$

The numerical value of $K$ at 25°C for this reaction was found to be $2.3 \times 10^{-4}$

**a.** What does the value of $K$ tell us about the equilibrium concentrations of the $Fe(SCN)^{2+}$ and $OH^-$ ions?

_____

1 mark

**b.** Predict the colour of the solution at 25 °C. Justify your prediction.

_____

_____

1 mark

**c.** Explain how the addition of dry ice, $CO_2(s)$ achieves the effect of the blood-like liquid.

_____

_____

_____

3 marks

Total 5 marks

**Question 6**

A quantity of 60.0 mL of 0.862 M HCl at 20.5°C is mixed with 40.0 mL of 0.431 M $Ba(OH)_2$ at 20.5°C in a constant-pressure calorimeter that has a calibration factor of 453 J $°C^{-1}$.

For the process $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ the heat of neutralisation is -56.2 kJ $mol^{-1}$.

What is the final temperature of the mixed solution?

_____

_____

_____

_____

_____

_____

6 marks

**Question 7**

**a.** The energy stored in biomass, such as wood, can be released in several ways. Two of these are direct combustion or conversion to ethanol. For **each** of these **two methods**, give **one** advantage and **one** disadvantage.

**i** Direct combustion

*Advantage*

_____

_____

*Disadvantage*

_____

_____

**ii** Conversion to ethanol

*Advantage*

_____

_____

*Disadvantage*

_____

_____

4 marks

**b.** Given the density of ethanol is 0.79 g $mL^{-1}$ at 25°C, calculate the energy that can be obtained through the complete combustion of 1.00 L of ethanol.

_____

_____

_____

_____

_____

_____

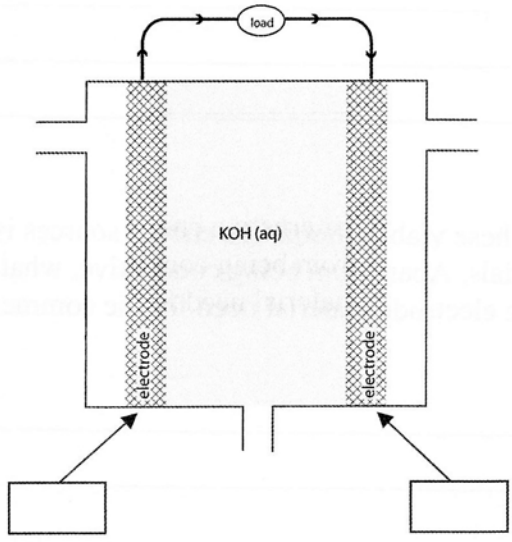
_____

3 marks

Total 7 marks

**Question 8**

The diagram below shows a prototype version of an alkaline methane-oxygen fuel cell. The arrows show the direction of electron flow in the external circuit.




**a.** Label the electrodes (+) and (-) in the brackets provided.

1 mark

**b.** Add labels to the diagram to show where the methane gas and oxygen gas are introduced.

1 mark

**c.** Explain why this is referred to as a ***fuel cell***.

_____

_____

_____

1 mark

The equations for the half-reactions occurring are

$$CH_4(g) + 8OH^-(aq) \rightarrow CO_2(g) + 6H_2O(l) + 8e^-$$

$$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$

**d.** Write the simplest possible overall equation for this cell.

_____

1 mark

**e.** When set up, the electrolyte contained 0.50 mol of dissolved $OH^-$. The cell operates for a period of time during which 0.10 mol of $CH_4$ gas is consumed. What amount of $OH^-$, in mol, is now dissolved in the electrolyte? Explain how you arrived at your answer.

_____

_____

_____

2 marks

**f.** A key to making cells like these viable alternative energy sources is the development of appropriate electrode materials. Apart from being conductive, what other properties/qualities does the electrode material need for the commercial viability of a fuel cell?

_____

_____

2 marks

**g.** On the diagram, clearly label the direction of the migration of hydroxide ions in the electrolyte.

1 mark

Total 9 marks

**Question 9**

When 1.00 A is passed through an electrolytic cell with a copper anode for 70.0 min, the anode decreases in mass by 1.34 g.

**a.** Use the information above to determine an experimental value for the Avogadro constant.

5 marks

**b.** Suggest and explain a specific reason why your answer in part **a.** might differ from the accepted value.

2 marks

Total 7 marks

**Question 10**

During this unit, you have studied the specific production of one of four major industrial chemicals: ammonia, ethene, nitric acid or sulfuric acid. Record the chemical you have studied below.

Chemical Studied: _____

**a.** Write down the equation for the main equilibrium step in the production of this chemical and the sign of the ΔH.

_____

2 marks

**b.** Identify the formula of a **chemical** from the main equilibrium step that can be recycled.

_____

1 mark

**c.** Identify **two** recognised Australian Hazard warnings relating to this chemical

_____

2 marks

**d.** Give the major use of the chemical **and** write a balanced equation to show how the selected chemical is used for this specific use. States are not required.

_____

_____

2 marks

Total 7 marks

**END OF EXAMINATION**