Neap

Trial Examination 2023

VCE Chemistry Unit 3

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	6	6	55
			Total 75

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials supplied

Question and answer booklet of 20 pages

Data booklet

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet.

You may keep the data booklet.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2023 VCE Chemistry Units 3&4 Written Examination.

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 marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1

In a chemical reaction, a catalyst alters the

A. rate of the forward reaction but not the activation energy, E_a.

B. enthalpy change, ΔH, but not the rate of the forward reaction.

C. enthalpies of the reactants and products but not the E_a.

D. rate of the reverse reaction but not the ΔH.

Question 2

Which one of the following correctly matches the reaction to its equation or half-equation?

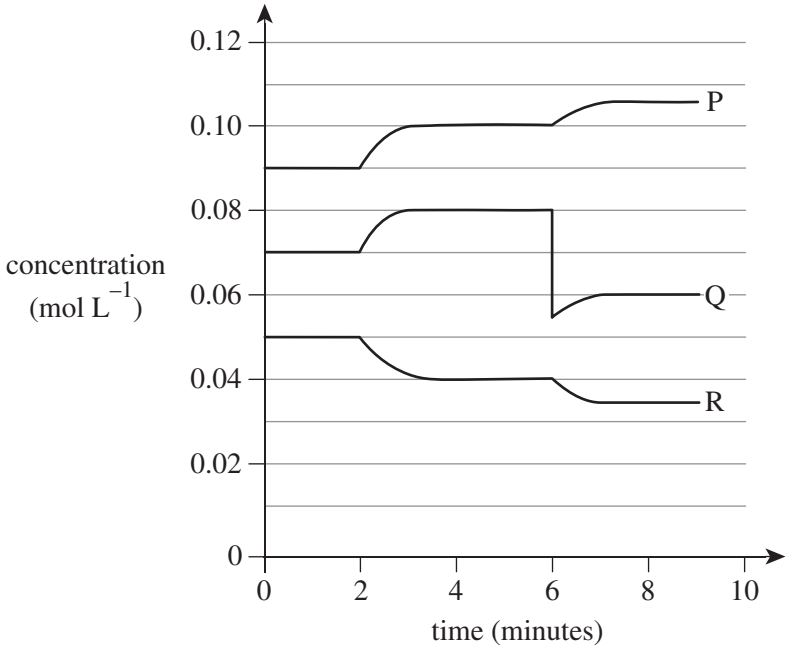
	Reaction	Equation or half-equation
A.	oxidation of methanol in acidic conditions	$CH_3OH(aq) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e^-$
B.	incomplete combustion of methanol	$2CH_3OH(l) \rightarrow 2CO(g) + 4H_2(g)$
C.	cathode reaction in an alkaline methanol–oxygen fuel cell	$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$
D.	combustion of methanol under standard laboratory conditions (SLC)	$CH_3OH(l) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Use the following information to answer Questions 3–5.

The gases P and Q react to form gas R, according to the following equation.

$$P(g) + Q(g) \rightleftharpoons R(g)$$

An equilibrium mixture of the three gases was contained in a sealed vessel. Various changes were made to the equilibrium mixture over time, as shown in the graph below.



Question 3

The values of the equilibrium constant, K_c, at different times during the experiment are shown in the following table.

1 minute	5 minutes	8 minutes
K_{c1}	K_{c2}	K_{c3}

Which one of the following is correct?

A. $K_{c1} = K_{c2}$ only

B. $K_{c2} = K_{c3}$ only

C. $K_{c1} = K_{c3}$ only

D. $K_{c1} = K_{c2} = K_{c3}$

Question 4

Which one of the following statements is correct?

A. The results of the experiment indicate that the formation of gas R is exothermic.

B. At 6 minutes, the volume of the vessel was increased at constant temperature.

C. There was no reaction between gases P and Q or decomposition of gas R at 5 minutes.

D. At 3 minutes, the rate of formation of gas R was lower than the rate of its decomposition.

Question 5

At 9 minutes, a catalyst was added to the equilibrium mixture.

How would the concentration of the gases have been affected immediately after the addition of the catalyst?

A. The concentrations of gases P and Q would have decreased, and the concentration of gas R would have increased.

B. The concentration of gas R would have decreased, and the concentrations of gases P and Q would have increased.

C. The concentrations of all three gases would not have been affected.

D. The concentrations of all three gases would have increased.

Question 6

Bioethanol is a form of ethanol derived from organic matter. It can be used as the fuel in a fuel cell.

Which one of the following statements about bioethanol is correct?

A. Greenhouse gases are not released when bioethanol is used in a fuel cell.

B. Ethanol derived from crude oil has more stored energy per gram than bioethanol.

C. The production of bioethanol and its use in a fuel cell is 100% carbon neutral.

D. The products of a bioethanol fuel cell contain less stored energy than the reactants.

Question 7

Galvanic cells and electrolytic cells are both electrochemical cells. A student wrote the following list of features relating to electrochemical cells.

I The cell heats up because of the inefficiency of the desired energy transformation.

II Negative ions (anions) move towards the negative electrode.

III The weakest oxidising agent loses one or more electrons preferentially.

IV A non-spontaneous redox reaction occurs.

Which of these features apply to galvanic cells but not electrolytic cells?

A. I only

B. II only

C. I and III only

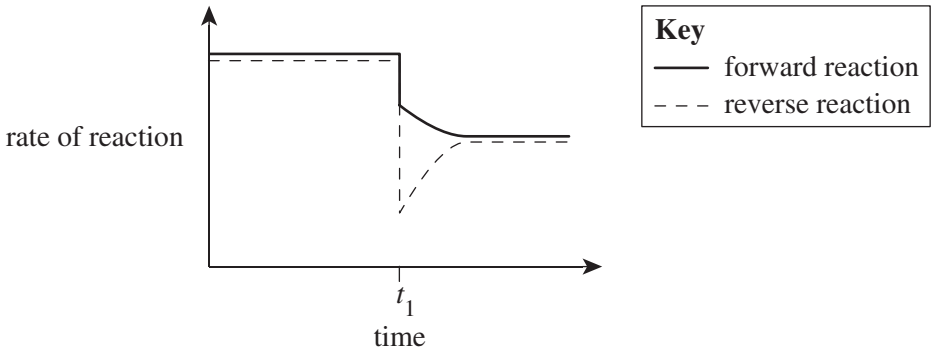
D. II and IV only

Question 8

An equilibrium reaction involving gases occurred according to the following equation.

$$W(g) + 2X(g) \rightleftharpoons 2Y(g) + Z(g) \qquad \Delta H < 0$$

The rates of the forward and reverse reactions in this equilibrium system are shown in the graph below. At time t_1, a change was made to the system.



Which one of the following changes would have produced the graph shown above?

A. removing gas W

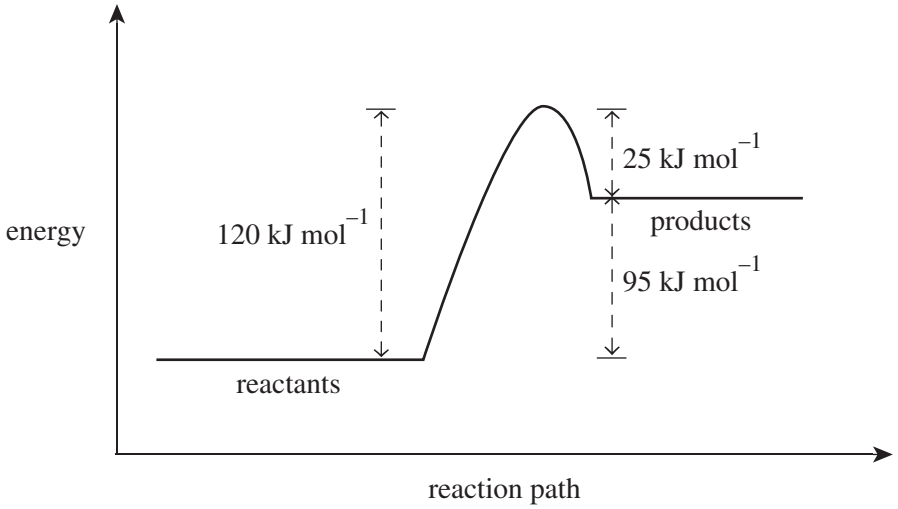
B. decreasing the temperature

C. removing gas Z

D. decreasing the volume of the reaction vessel

Question 9

The energy profile diagram of a particular forward reaction is shown below.



The activation energy, E_a, of the reverse reaction is

A. –120 kJ mol^{-1}

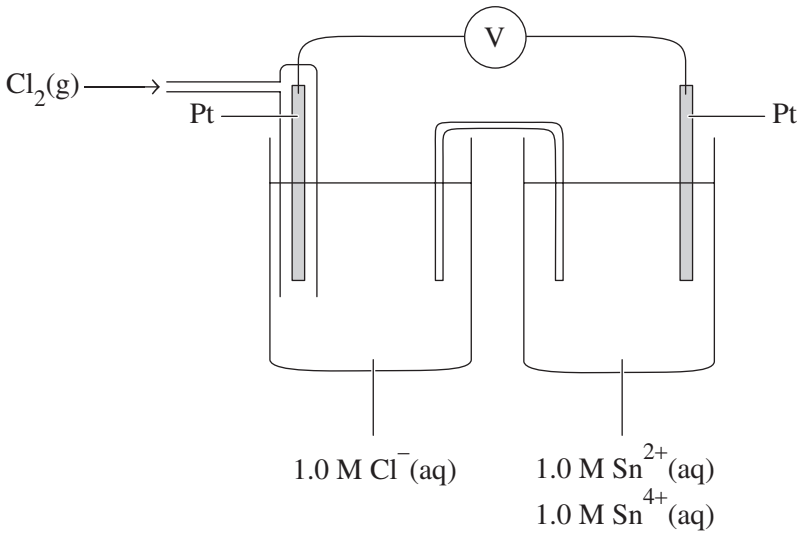
B. 25 kJ mol^{-1}

C. 70 kJ mol^{-1}

D. 95 kJ mol^{-1}

Use the following information to answer Questions 10 and 11.

A galvanic cell is set up as shown in the following diagram.



Question 10

What is the reducing agent in the cell reaction?

A. $Cl_2(g)$

B. $Cl^-(aq)$

C. $Sn^{2+}(aq)$

D. $Sn^{4+}(aq)$

Question 11

The cell is best classified as

A. non-rechargeable because two separate half-cells are used for the cell reaction.

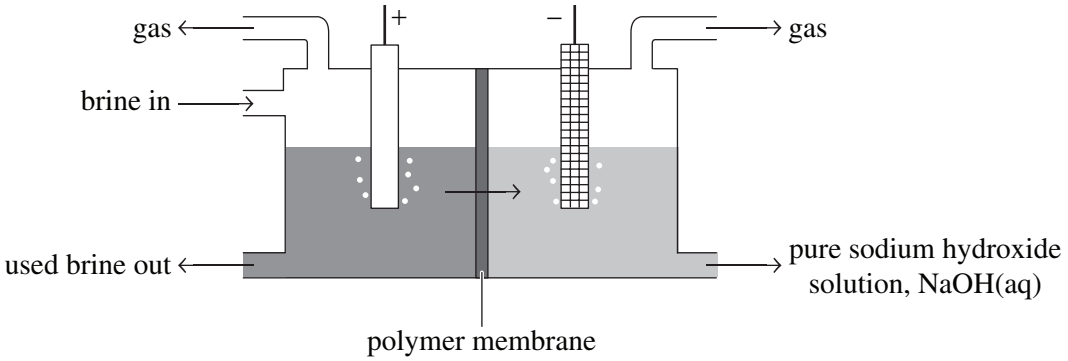
B. non-rechargeable because inert platinum, Pt, electrodes are used in both half-cells.

C. rechargeable because all galvanic cell reactions can be reversed if sufficient energy is used.

D. rechargeable because the products of the cell reaction are in contact with the electrodes.

Use the following information to answer Questions 12 and 13.

Chlorine gas, Cl_2, is manufactured industrially using the electrolysis of concentrated sodium chloride solution, NaCl(aq), which is known as brine. The following simplified diagram illustrates the design of the type of electrolytic cell used.



The polymer membrane prevents the passage of negatively charged ions.

Question 12

The main product formed at the anode is most likely

A. chlorine gas, Cl_2.

B. hydrogen gas, H_2.

C. oxygen gas, O_2.

D. solid sodium, Na.

Question 13

Which one of the following is the primary reason for the use of the selective polymer membrane?

A. The membrane allows Cl_2, rather than O_2, to form at the positive electrode.

B. The membrane allows H_2, rather than Na, to form at the negative electrode.

C. The membrane allows a pure product of NaOH to be collected from the cell.

D. The membrane allows used brine to be reclaimed from the cell.

Question 14

Which of the following factors directly affect the likelihood of reactant molecules successfully interacting to form products?

A. the molar masses and number of bonds in the reactant molecules

B. the kinetic energies and molar masses of the reactant molecules

C. the number of bonds and orientations of the reactant molecules

D. the orientations and kinetic energies of the reactant molecules

Question 15

In an electroplating experiment, 0.25 A was used for 2.0 hours and 0.0185 mol of a metal was deposited.

The charge on the metal ions in the electrolyte was

A. 1+

B. 2+

C. 3+

D. 4+

Use the following information to answer Questions 16 and 17.

At SLC, a series of experiments was undertaken. Metals J, Q and L were each mixed separately with solutions of their ions as well as with hydrochloric acid, HCl. The results of some of the experiments are shown in the following table.

Metal L and J^{2+}(aq)	**Metal J and Q^{2+}(aq)**	**Metal Q and H^{+}(aq)**	**Metal L and H^{+}(aq)**
Metal J forms.	Metal Q forms.	No reaction occurs.	Metal L loses mass.

Question 16

Which one of the following conclusions is correct?

A. Of the three metals, metal L is the weakest reducing agent.

B. H^{+} ions are stronger oxidising agents than Q^{2+}(aq) ions but weaker oxidising agents than L^{2+}(aq) ions.

C. Metal Q is a stronger reducing agent than metal L but a weaker reducing agent than metal J.

D. J^{2+}(aq) ions are stronger oxidising agents than L^{2+}(aq) ions but weaker oxidising agents than Q^{2+}(aq) ions.

Question 17

The results shown in the table above allow for three oxidising agents to be placed in order of oxidising strength.

Which one of the following experiments would need to be undertaken to enable all four oxidising agents to be placed in order of oxidising strength?

A. metal J and H^{+}(aq)

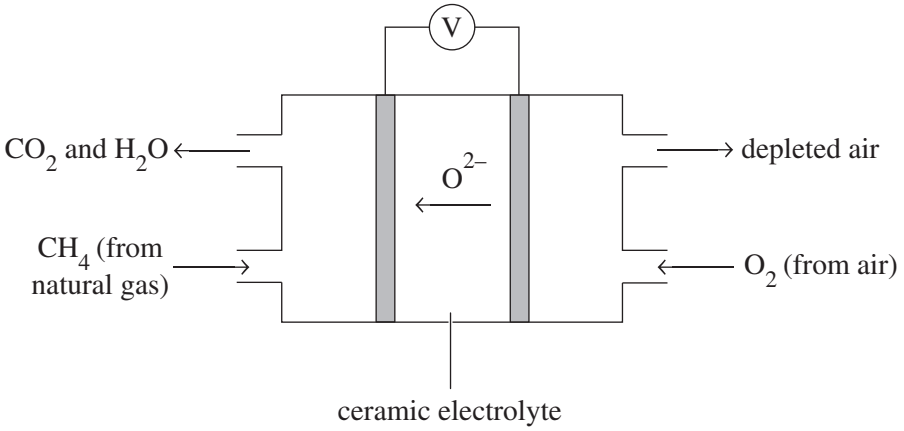
B. metal J and L^{2+}(aq)

C. metal Q and J^{2+}(aq)

D. metal L and Q^{2+}(aq)

Question 18

Methane, CH_4, can be used as the fuel in a fuel cell with a special ceramic electrolyte that allows the passage of the oxide ion, O^{2-}, from one electrode to the other. The design of the cell is shown below.



Which one of the following statements relating to the operation of the cell is correct?

A. The oxidation number of carbon changes from +4 to –4 as the cell operates.

B. O_2 is oxidised at the positively charged anode.

C. O^{2-} ions move through the electrolyte from the cathode to the anode.

D. Electrons flow through the external circuit from the cathode to the anode.

Use the following information to answer Questions 19 and 20.

When a secondary cell needs to be recharged, it is often described as a 'flat' battery.

Question 19

Which one of the following statements best explains why a battery becomes flat?

A. At least one of the reactants of the spontaneous redox reaction is depleted.

B. At least one of the products of the cell reaction has escaped from the cell.

C. The electrolyte has degraded and no longer allows electrons to flow through it.

D. One of the electrodes has been consumed by the cell reaction and must be replaced.

Question 20

One step in the recharging of a secondary cell is to connect a power source to the cell.

Which of the following identifies the cell electrode that is connected to the negative terminal of the power source during recharging and the type of reaction that occurs at this electrode?

	Electrode connected to the negative terminal of the power source during recharging	Type of reaction that occurs at this electrode during recharging
A.	positive	oxidation
B.	positive	reduction
C.	negative	reduction
D.	negative	oxidation

END OF SECTION A

SECTION B

Instructions for Section B

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

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_2(g)$, NaCl(s).

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1 (13 marks)

Propane, C_3H_8, and kerosene are important fuels in common use.

a. i. Write a balanced thermochemical equation for the complete combustion of C_3H_8. 2 marks

ii. What mass of carbon dioxide, CO_2, is produced per litre of C_3H_8 burnt completely at SLC? 3 marks

iii. By burning 0.461 mol of C_3H_8, 15.0 kg of water at 17.8°C is heated. Only 65.0% of the energy produced was transferred to the water.

Calculate the final temperature of the water. 3 marks

b. Like petrodiesel, kerosene is derived from crude oil and is classified as a blended fuel. The constituent elements, basic chemical structure and combustion products of kerosene are similar to those of petrodiesel, but the molecules in kerosene have smaller molar masses than the molecules in petrodiesel.

i. Why is it not possible to write a thermochemical equation for the complete combustion of kerosene? 1 mark

ii. Explain whether the viscosity of kerosene is likely to be higher, lower or the same as the viscosity of petrodiesel at a set temperature. 2 marks

iii. A particular sample of kerosene has a heat of combustion of 43.7 kJ g^{-1}.

Calculate the mass of kerosene that would produce 10.5 MJ of energy when burnt completely at SLC. 2 marks

Question 2 (12 marks)
Sulfur dioxide gas reacts with chlorine gas, according to the following equation.

$$SO_2(g) + Cl_2(g) \rightleftharpoons SO_2Cl_2(g) \qquad \Delta H = -67 \text{ kJ mol}^{-1}$$

At temperature T_1, the equilibrium constant, K_c, for the reaction is 3.8 M^{-1}.

a. An experiment was conducted using this equilibrium reaction at temperature T_1. 2.0 mol of SO_2 and 1.0 mol of Cl_2 were placed in a sealed, empty 2.0 L vessel. Later in the experiment, 1.3 mol of SO_2 was present.

i. Calculate the concentration of all the gases at the later time. 3 marks

ii. Using appropriate calculations, explain whether or not the system had reached equilibrium at the later time. 3 marks

b. At another temperature, T_2, the K_c for the reaction is 4.7 M^{-1}.
Explain whether T_2 is higher or lower than T_1. 2 marks

c. In a different series of experiments, various changes were made separately to equilibrium mixtures of SO_2, Cl_2 and SO_2Cl_2 gases.

For each change in the table below, tick **one** box to indicate how the position of equilibrium was initially affected by the change and explain why each result occurred. 4 marks

Change made to the equilibrium mixture	Position of equilibrium			Explanation
	Moved towards products	Moved towards reactants	Did not move	
Volume was decreased at constant temperature.				
Pressure was increased by the addition of argon gas at constant volume.				

Question 3 (11 marks)

At SLC, a galvanic cell was constructed using solutions of the conjugate redox pairs $Cr^{3+}(aq)/Cr^{2+}(aq)$ and $Fe^{3+}(aq)/Fe^{2+}(aq)$ as the electrolytes in separate beakers. Other components of the cell were an electrode in each beaker connected by a wire and a salt bridge between the beakers.

a. i. Given that the E^0 value for the $Cr^{3+}(aq)/Cr^{2+}(aq)$ half-cell is –0.50 V, calculate the maximum voltage of the galvanic cell. 1 mark

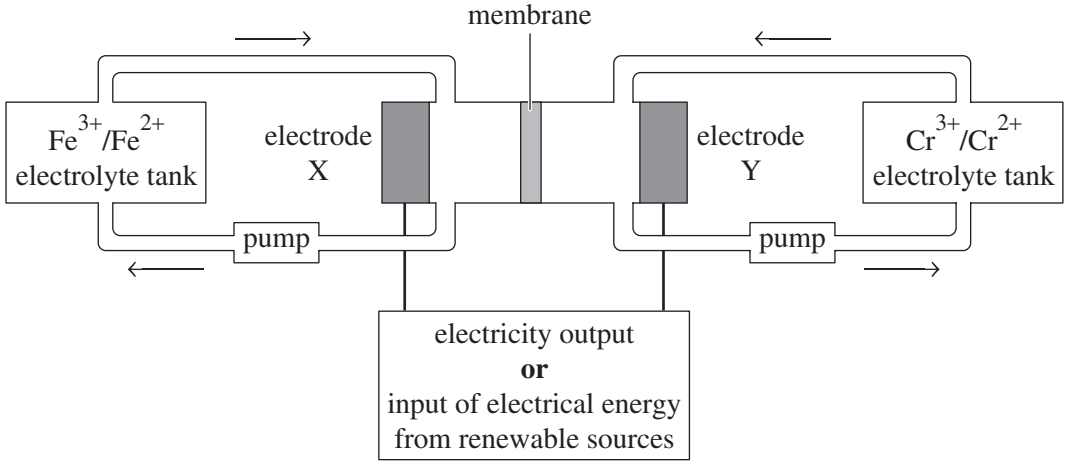
ii. Write the balanced half-equation for the reaction that occurs at the positive electrode. 1 mark

iii. Outline the function of the salt bridge in the galvanic cell. 1 mark

iv. Complete the table below by stating whether each statement is correct or incorrect and explaining why they are correct or incorrect. 3 marks

Statement	Correct or incorrect	Explanation for why the statement is correct or incorrect
As ethanol, C_2H_5OH, is completely soluble in water, it can be used to wet the salt bridge to enable the galvanic cell to operate.		
A chromium electrode must be used in the $Cr^{3+}(aq)/Cr^{2+}(aq)$ half-cell and an iron electrode must be used in the $Fe^{3+}(aq)/Fe^{2+}(aq)$ half-cell.		

b. The same electrolyte components were used in an experimental rechargeable battery as shown in the following diagram.



i. State a feature of the membrane that is necessary for its function. 1 mark

ii. Write the balanced half-equation for the reaction at electrode X when the cell is operating as a galvanic cell. 1 mark

iii. Write the balanced half-equation for the reaction at electrode Y when the cell is operating as an electrolytic cell. 1 mark

iv. Electrodes in many fuel cells are porous and catalytic. The electrodes in the rechargeable battery are not porous but could be catalytic.

Explain why this is. 2 marks

Question 4 (6 marks)

Hydrogen gas, H_2, is used widely in industrial manufacturing and has been promoted as a future fuel with many important benefits. At present, methane gas, CH_4, derived from crude oil is used to produce most of the H_2 industrially through a steam-reforming process. H_2 can also be produced from biogas. The composition of a batch of biogas is shown in the following table.

Component gas	methane	carbon dioxide	nitrogen	hydrogen	hydrogen sulfide	oxygen
Formula	CH_4	CO_2	N_2	H_2	H_2S	O_2
Percentage composition by volume (%)	66	23	8.5	0.5	0.5	1.5

a. Calculate the mass of H_2 present in 1.0 m^3 of the biogas at 25°C and 100 kPa. 2 marks

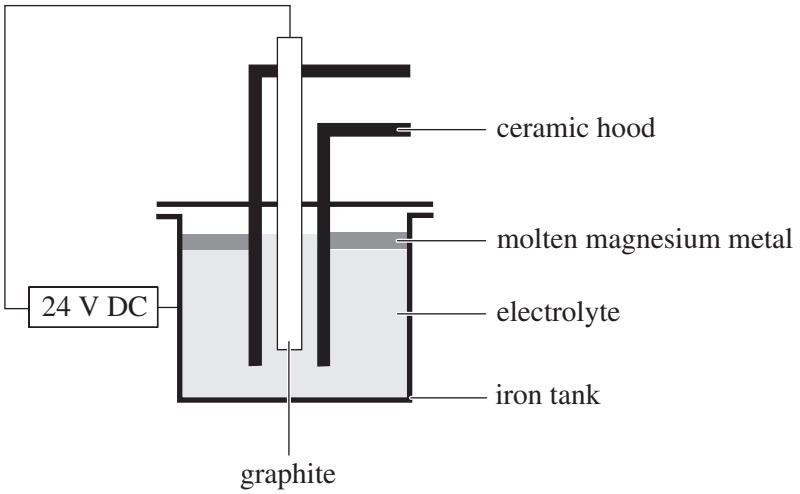
b. Explain how biogas could be a source of significant quantities of renewable H_2. 2 marks

c. H_2 can be used in a combustion reaction in a modified car or as fuel in a fuel cell for an electric car.

Explain which of these methods of using H_2 to fuel cars is more energy efficient. 2 marks

Question 5 (7 marks)

Magnesium metal is produced industrially through the electrolysis of molten magnesium chloride, $MgCl_2$, using the set-up shown in the following diagram.



a. Using a molten electrolyte is more expensive than using an aqueous electrolyte.

Explain why an aqueous electrolyte could **not** be used in this electrolytic cell. 2 marks

b. Outline why iron is used for one electrode but not for the other electrode. 2 marks

c. Write the balanced half-equation for the reaction occurring at the anode. 1 mark

d. All electrolytic cells have a design feature that prevents the products of the reaction from mixing.

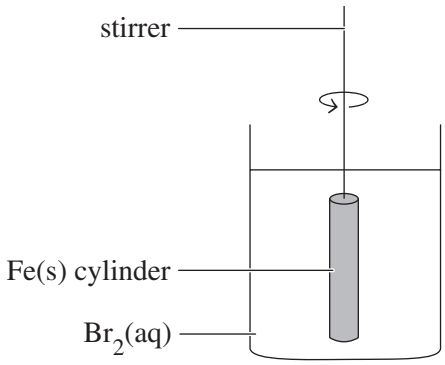
Identify this feature in the cell shown and explain why it is necessary for the cell's operation. 2 marks

Question 6 (6 marks)

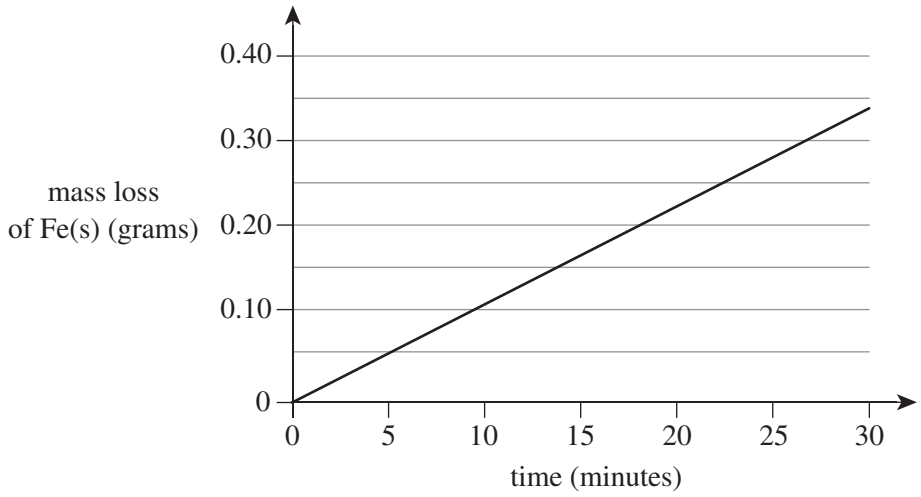
Experiments were undertaken to investigate the rate of the following reaction between iron and bromine.

$$Fe(s) + Br_2(aq) \rightarrow Fe^{2+}(aq) + 2Br^-(aq)$$

The set-up shown below was used with Br_2 solutions of different concentrations. In each experiment, the solid Fe cylinder was weighed, immersed in a Br_2 solution and rotated throughout the experiment. At regular intervals during and at the end of each experiment, the Fe cylinder was removed, washed, dried and weighed. There was no limiting reagent.



The results of the first experiment, which used 0.10 M Br_2 solution at 20°C, are shown in the following graph.



a. Using the graph, calculate the average rate of reaction. 1 mark

b. The experiment was repeated under identical conditions using 0.050 M Br_2 solution.

i. On the set of axes on page 21, draw the graph of the expected results of this experiment. 1 mark

ii. With reference to collision theory, explain the difference in the expected results when using 0.050 M Br_2 solution compared to the results obtained using 0.10 M Br_2 solution. 2 marks

c. Would you expect the reaction between Fe and Br_2 solution to be exothermic or endothermic? Explain your choice. 2 marks

END OF QUESTION AND ANSWER BOOKLET

Neap

Trial Examination 2023

VCE Chemistry Unit 3

Written Examination

Multiple-choice Answer Sheet

Student's Name: _____

Teacher's Name: _____

Instructions

Use a **pencil** for **all** entries. If you make a mistake, **erase** the incorrect answer – **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.

All answers must be completed like this example: [A] B C D

Use pencil only

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D

11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D