Neap

Diagnostic Topic Test 2024

VCE Chemistry Units 3&4

Question and Answer Booklet

Test time: 45 minutes
Total marks: 35 marks

Test 4: How can the rate and yield of chemical reactions be optimised?

- Production of chemicals using electrolysis

Student's Name: _____

Teacher's Name: _____

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page.

A data booklet is provided.

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

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

SECTION A – MULTIPLE CHOICE QUESTIONS

Instructions for Section A

Circle 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

Which of the following comparisons between galvanic and electrolytic cells is **incorrect**?

	Galvanic cell	Electrolytic cell
A.	Spontaneous chemical reactions occur.	Non-spontaneous chemical reactions occur.
B.	Electricity is generated by a chemical reaction.	Electricity is provided by a power source.
C.	Reduction occurs at the cathode.	Reduction occurs at the cathode.
D.	Oxidation occurs at the positive electrode.	Oxidation occurs at the negative electrode.

Question 2

When a current is passed through a 1 M solution of $Fe(NO_3)_2(aq)$ in an electrolytic cell using copper electrodes, the main reaction that would occur initially at the anode would be

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

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

C. $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$

D. $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$

Question 3

During the electrolytic production of aluminium using the Hall–Héroult cell, aluminium is extracted from molten Al_2O_3 rather than an acidified aqueous solution of Al_2O_3.

The reason for the use of a molten electrolyte is that

A. water is a stronger reducing agent than the aluminium ion.

B. Al_2O_3 cannot be dissolved in an acidified aqueous solution.

C. water is a stronger oxidising agent than the aluminium ion.

D. using an aqueous electrolyte would produce a solid, rather than the required molten product.

Question 4

Cadmium metal is used to electroplate metal items to give them a lustrous coating that is resistant to corrosion. An item to be electroplated is placed into an electrolytic cell with a cadmium electrode and a solution of cadmium ions, which is stirred constantly.

The object to be plated is the

A. positively charged anode.

B. positively charged cathode.

C. negatively charged anode.

D. negatively charged cathode.

Use the following information to answer Questions 5–7.

A 1.0 M aqueous solution of nickel nitrate, $Ni(NO_3)_2$, was electrolysed using inert graphite electrodes.

Question 5

In this electrolysis of nickel nitrate solution, water acts as

A. an oxidising agent and as a solvent.

B. a reducing agent and as a solvent.

C. both an oxidising agent and reducing agent, and as a solvent.

D. a solvent only.

Question 6

During the electrolysis of the nickel nitrate solution, nitrate ions are

A. attracted to the anode, where they undergo oxidation.

B. attracted to the cathode, where they undergo reduction.

C. not attracted to either electrode, as they are spectator ions only.

D. attracted to one electrode, but are neither oxidised nor reduced.

Question 7

If one Faraday of charge is passed through the nickel nitrate solution, then

A. 9.6×10^3 coulombs of charge is passed through the solution.

B. $2 \times 6.0 \times 10^{23}$ electrons move through the electrodes.

C. 0.25 mole of gas is produced.

D. 2.0 mole of nickel ions are reacted.

Question 8

During an electrolytic process, the following reaction occurs.

$$Sc^{a+}(l) + ae^{-} \rightarrow Sc(s)$$

A current of 0.50 A runs for 45 minutes, which produces 0.21 g of Sc.

The charge on the scandium ion is

A. +1

B. +2

C. +3

D. +4

Question 9

The nickel–cadmium (NiCad) cell is a secondary cell with a wide variety of uses, such as in video cameras, cordless drills and phones. This cell uses an alkaline electrolyte.

The overall reaction occurring when the cell is in use is shown below.

$$Cd(s) + 2NiO(OH)(s) + 2H_2O(l) \rightarrow Cd(OH)_2(s) + 2Ni(OH)_2(s)$$

The products formed at the positive electrode when the cell is **recharged** are

A. Cd and H_2O.

B. NiO(OH) and H_2O.

C. Cd and OH^{-}.

D. NiO(OH) and H^{+}.

Question 10

Which of the following is a feature of both a primary and a secondary electrochemical cell?

A. Spontaneous redox reactions occur that allow the movement of electrons through a wire connecting the half-cells, producing an electric current.

B. A continuous supply of reactants are fed into the cell so that it operates without the need to interrupt the chemical reactions to regenerate depleted reactants.

C. Limited amounts of reactants are present in the cell and once these are depleted the chemical reactions and electricity production cease, and the cell must be disposed of.

D. The products of the cell reaction remain in contact with the electrodes so that once the reactants are used up, it is possible for more reactants to be regenerated.

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 (5 marks)

The lead–acid accumulator (car battery) is a well-known example of a secondary cell. The lead–acid accumulator consists of six separate cells connected in series. The electrolyte used is an approximately 4 M H_2SO_4 solution. The reaction occurring during discharge of the lead–acid accumulator may be represented by the following half-equations.

$$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$$

$$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$

a. Write the overall equation for the reaction occurring during discharge. 1 mark

b. What feature of the lead–acid accumulator enables it to function as a secondary cell? 1 mark

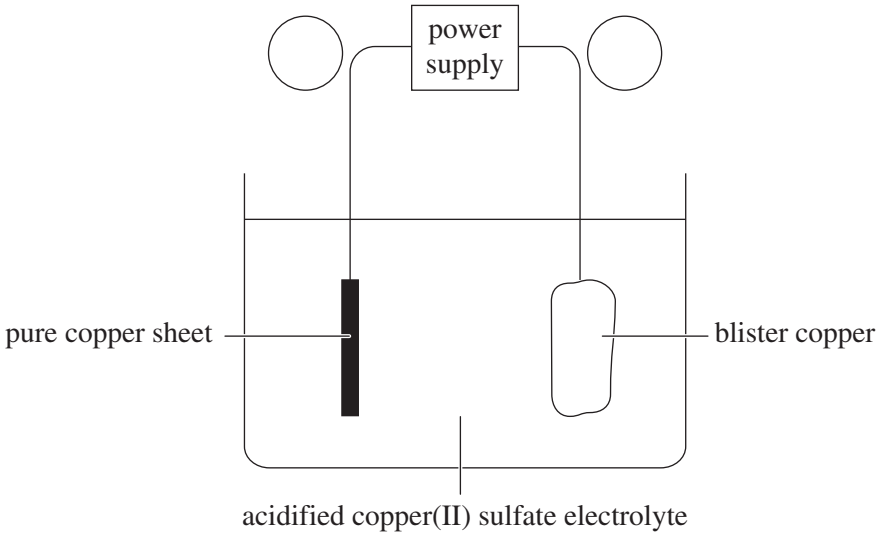
c. To which terminal of a power supply (positive or negative) would the PbO_2-coated electrode be connected for recharging of the lead–acid accumulator? Explain your choice. 2 marks

d. During recharging of the lead–acid accumulator, additional reactions may occur when the hydrogen ions and water in the electrolyte are reduced or oxidised.

Write a half-equation for the process involving either water or hydrogen ions that may occur at the anode during recharging of the lead–acid accumulator. 1 mark

Question 2 (4 marks)

One important use of electrolysis is the electrorefining of copper. After copper ore is heated in a blast furnace to remove non-metal elements, blocks of 'blister copper' of 98% purity are produced. These blocks become electrodes in electrolytic cells designed to yield almost pure copper.



a. 'Blister copper' contains the metal impurities silver, gold, zinc and nickel. The voltage is adjusted so that the copper in the 'blister copper' is oxidised to its ions.

i. Which of the metal impurities will **not** be oxidised to their ions in the cell? 1 mark

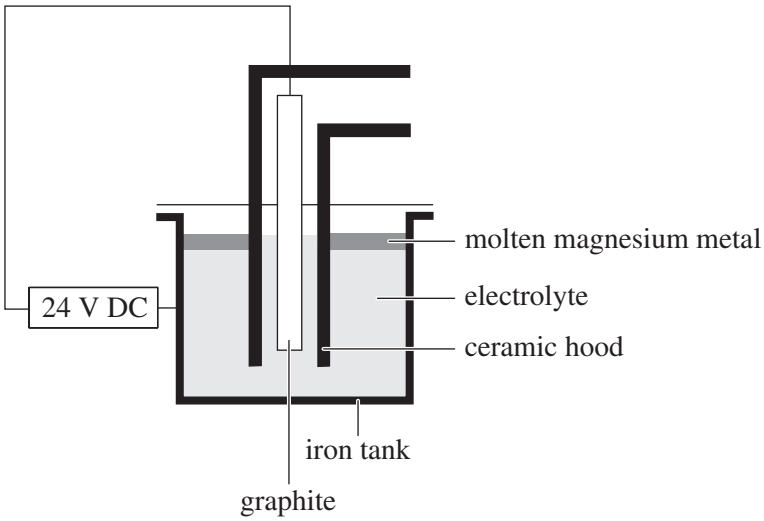
ii. Explain why some of the metal impurities will be oxidised in the cell. 1 mark

b. In the circles on the diagram above, mark the polarity (+ or –) of each electrode. 1 mark

c. Write the half-equation for the reaction at the pure copper sheet. 1 mark

Question 3 (6 marks)

Magnesium is produced by the electrolysis of molten magnesium chloride. The diagram below shows the main features of the electrolytic cell that is used.



a. To obtain the magnesium chloride electrolyte, the following reaction is used.

$$MgO(s) + C(s) + Cl_2(g) \rightarrow MgCl_2(s) + CO(g)$$

Suggest a reason why molten magnesium oxide is **not** used directly in the electrolytic cell to produce magnesium. 2 marks

b. **i.** Tick **one** box in the table below to show the identity and polarity of the graphite electrode in the electrolytic cell shown above. 1 mark

	Positive	**Negative**
Anode		
Cathode		

ii. Explain a likely role of the ceramic hood shown in the diagram above. 1 mark

c. **i.** An iron electrode is used to generate the molten magnesium, while a carbon (graphite) electrode is used to generate the chlorine gas.

Explain why iron is **not** used as the electrode for chlorine generation. 1 mark

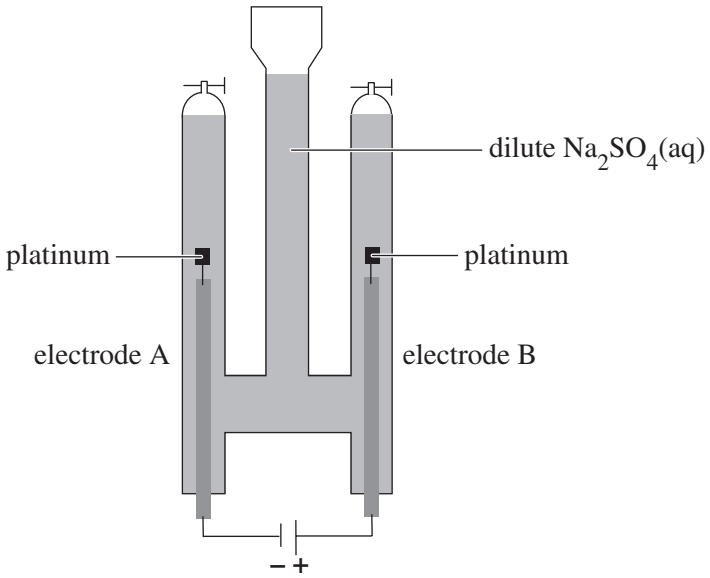
ii. Using the electrochemical series, it is predicted that iron will **not** react with magnesium ions.

Why might this prediction be unreliable in this industrial process? 1 mark

Question 4 (10 marks)

Hydrogen is a clean fuel that, when used in a fuel cell, produces only water. However, one of the problems with the hydrogen fuel cell is that hydrogen gas is almost never found as an element in nature and has to be extracted from other sources. Various methods of producing hydrogen are used.

a. Hydrogen may be obtained by the electrolysis of water. A simple laboratory version of this electrolysis process is shown below.



i. Write a balanced half-equation for the reaction occurring at electrode A. 1 mark

ii. Suggest why an electrolyte such as sodium sulfate is added to the water being electrolysed. 1 mark

iii. Calculate the volume of hydrogen gas collected at standard laboratory conditions (SLC) when the water is electrolysed with a current of 3.5 amperes for 5.0 minutes. 3 marks

b. Polymer electrolyte membrane (PEM) electrolysis is a promising technique for high-purity and efficient hydrogen production. In PEM the electrolytic cell holds a special solid polymer that insulates the electrodes electrically and allows the conduction of protons.

i. In which direction (anode to cathode or cathode to anode) do the protons move through the solid polymer when the PEM cell is electrolysing water? 1 mark

ii. Green hydrogen is defined as 'hydrogen produced by the splitting of water into hydrogen and oxygen using renewable electricity'.

Suggest **one** way in which the hydrogen produced by PEM electrolysis could be termed 'green' hydrogen. 1 mark

c. Describe **one** other process by which hydrogen may be produced and discuss whether this process would be regarded as a sustainable source of hydrogen. 3 marks

END OF TEST