Topic 9.2 Electrochemical Cells

Past Exam Questions (Paper 2)

1. *[1 mark]*

Sodium oxide, Na_2O, is a white solid with a high melting point.

Molten sodium oxide is a good conductor of electricity. State the half-equation for the reaction occurring at the positive electrode during the electrolysis of molten sodium oxide.

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2a. *[3 marks]*

Describe using a labelled diagram, the essential components of an electrolytic cell.

2b. *[2 marks]*

Explain why solid sodium chloride does not conduct electricity but **molten** sodium chloride does.

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2c. *[5 marks]*

Molten sodium chloride undergoes electrolysis in an electrolytic cell. For each electrode deduce the half-equation and state whether oxidation or reduction takes place. Deduce the equation of the overall cell reaction including state symbols.

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2d. *[1 mark]*

Electrolysis has made it possible to obtain reactive metals such as aluminium from their ores, which has resulted in significant developments in engineering and technology. State **one** reason why aluminium is preferred to iron in many uses.

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2e. *[2 marks]*

Outline **two** differences between an electrolytic cell and a voltaic cell.

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3a. *[6 marks]*

(i) Draw an annotated diagram of a voltaic cell composed of a magnesium electrode in 1. 0 $mol\,dm^{-3}$ magnesium nitrate solution and a silver electrode in 1. 0 $mol\,dm^{-3}$ silver nitrate solution. State the direction of electron flow on your diagram.

(ii) Deduce half-equations for the oxidation and reduction reactions.

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3b. *[6 marks]*

(i) Solid sodium chloride does not conduct electricity but molten sodium chloride does. Explain this difference.

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(ii) Outline what happens in an electrolytic cell during the electrolysis of molten sodium chloride using inert electrodes. Deduce equations for the reactions occurring at each electrode.

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4. *[10 marks]*

The periodic table shows the relationship between electron arrangement and the properties of elements and is a valuable tool for making predictions in chemistry.

The word *redox* comes from a combination of the terms *reduction* and *oxidation*. Redox reactions affect our daily lives.

The overall reaction that takes place in a voltaic cell is shown below.

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

(i) Determine the oxidation number of lead in Pb, PbO_2 and $PbSO_4$.

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(ii) Deduce the oxidation and reduction half-equations taking place at the negative lead electrode (anode) and the positive lead(IV) oxide electrode (cathode). Deduce the oxidizing and reducing agents and state the direction of the electron flow between the electrodes.

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(iii) In order to determine the position of three metals in a reactivity series, the metals were placed in different solutions of metal ions. The table below summarizes whether or not a reaction occurred.

	$Ag^{+}(aq)$	$Cu^{2+}(aq)$	$Pb^{2+}(aq)$
Ag (s)		No reaction	No reaction
Cu (s)	Reaction		No reaction
Pb (s)	Reaction	Reaction	

State the equations for the **three** reactions that take place. Use this information to place the metals Ag, Cu and Pb in a reactivity series, with the strongest reducing agent first, and explain your reasoning.

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5a. *[2 marks]*

Molten sodium chloride can be electrolysed using graphite electrodes.

Draw the essential components of this electrolytic cell and identify the products that form at each electrode.

Product formed at positive electrode (anode): . . . . . .

Product formed at negative electrode (cathode): . . . . . .

5b. *[2 marks]*

State the half-equations for the oxidation and reduction processes and deduce the overall cell reaction, including state symbols.

Oxidation half-equation:

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Reduction half-equation:

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Overall cell reaction:

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6a. *[4 marks]*

Iron is more reactive than copper.

Draw a labelled diagram of a voltaic cell made from an $Fe(s)/Fe^{2+}(aq)$ half-cell connected to a $Cu(s)/Cu^{2+}(aq)$ half-cell. In your diagram identify the positive electrode (cathode), the negative electrode (anode) and the direction of electron flow in the external circuit.

6b. *[2 marks]*

Deduce the half-equations for the reactions taking place at the positive electrode (cathode) and negative electrode (anode) of this voltaic cell.

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6c. *[2 marks]*

Deduce the overall equation for the reaction taking place in the voltaic cell and determine which species acts as the oxidizing agent and which species has been reduced.

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7. *[2 marks]*

A reactivity series comparing titanium, cadmium and europium is given below.

Least reactive $Cd < Ti < Eu$ Most reactive

The half-equations corresponding to these metals are:

$$Eu^{2+}(aq) + 2e^{-} \rightleftharpoons Eu(s)$$

$$Ti^{3+}(aq) + 3e^{-} \rightleftharpoons Ti(s)$$

$$Cd^{2+}(aq) + 2e^{-} \rightleftharpoons Cd(s)$$

A voltaic cell can be constructed using cadmium and europium half-cells. State how the two solutions involved should be connected and outline how this connection works.

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8. *[3 marks]*

Both sodium and sodium chloride can conduct electricity.

Sodium can be obtained by electrolysis from molten sodium chloride. Describe, using a diagram, the essential components of this electrolytic cell.

9. *[3 marks]*

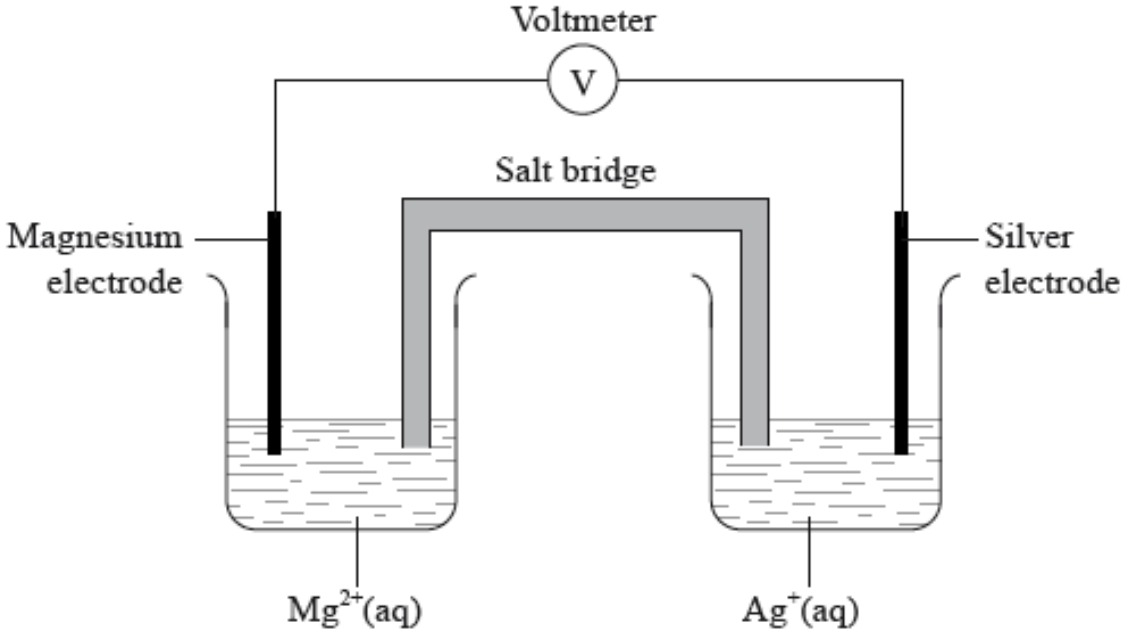
Iron rusts in the presence of oxygen and water. Rusting is a redox process involving several steps that produces hydrated iron(III) oxide, $Fe_2O_3 \bullet nH_2O$, as the final product.

The half-equations involved for the first step of rusting are given below.

Half-equation 1: $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

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

A voltaic cell is made from a half-cell containing a magnesium electrode in a solution of magnesium nitrate and a half-cell containing a silver electrode in a solution of silver(I) nitrate.



(i) Given that magnesium is more reactive than silver, deduce the half-equations for the reactions occurring at each electrode, including state symbols.

Negative electrode (anode):

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Positive electrode (cathode):

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(ii) Outline **one** function of the salt bridge.

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10. *[7 marks]*

Electrolysis has made it possible to obtain reactive metals from their ores.

(i) Draw a labelled electrolytic cell for the electrolysis of molten potassium bromide, KBr. Include the direction of electron flow, the positive electrode (anode) and the negative electrode (cathode), the location of oxidation and reduction, and the electrolyte.

(ii) Deduce a half-equation for the reaction that occurs at each electrode.

Positive electrode (anode):

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Negative electrode (cathode):

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(iii) Describe how current is conducted in a molten electrolyte.

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11. *[2 marks]*

Bromine can be produced by the electrolysis of **molten** sodium bromide. Deduce the half-equation for the reaction at each electrode.

Positive electrode (anode):

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Negative electrode (cathode):

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12a. *[2 marks]*

Electrolysis is an important industrial process used to obtain very reactive elements from their common ores.

Molten magnesium chloride can be electrolysed using inert graphite electrodes at 800 °C.

Describe, using a labelled diagram, the essential components of this electrolytic cell.

12b. *[3 marks]*

Molten magnesium chloride can be electrolysed using inert graphite electrodes at 800 °C.

Deduce the half-equations, including state symbols, for the reactions occurring at each electrode. (The melting points of $MgCl_2$ and Mg are 714 °C and 649 °C respectively.)

Positive electrode (anode):

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Negative electrode (cathode):

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12c. *[1 mark]*

Aluminium can also be obtained by electrolysis. Suggest **one** reason why aluminium is often used instead of iron by engineers.

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