2.15 Electrolysis: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 When molten lead bromide, $PbBr_2$, is electrolysed, bromide ions are oxidised at the anode to form bromine gas.

(a) Write the half-equation for bromide ions forming bromine at the anode. **(1)**

(b) One mole of $PbBr_2$ contains two moles of Br^-. Calculate the volume in dm3 of bromine gas, measured at room conditions where 1 mole gas occupies 24.0 dm3, produced from 0.50 mol of $PbBr_2$. **(2)**

.....

(Total for Question 1 is 3 marks)

2 A solution contains sodium chloride. During electrolysis using inert electrodes, chlorine gas forms at the anode and hydrogen gas may form at the cathode.

(a) State why chloride ions rather than hydroxide ions are oxidised at the anode in concentrated sodium chloride solution. **(2)**

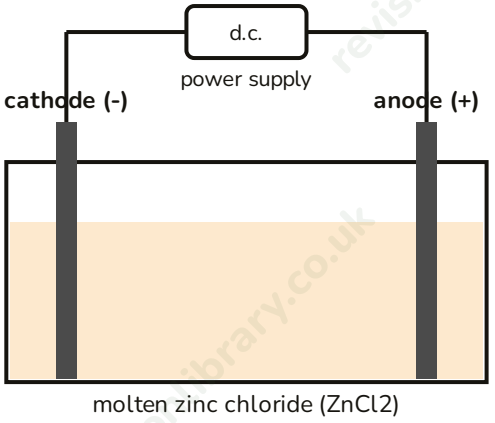
(b) Give the half-equation for hydrogen formation at the cathode from water. **(1)**

(Total for Question 2 is 3 marks)

© Revision Library | revisionlibrary.co.uk

3 Zinc chloride, $ZnCl_2$, is an ionic solid that can be melted and electrolysed using inert electrodes, as shown in Figure 1.

Figure 1: electrolysis of molten zinc chloride



(a) Name the product formed at the cathode when molten zinc chloride is electrolysed, and explain, in terms of ion movement and electron transfer, why it forms there. **(3)**

(b) Name the product formed at the anode, and explain why it forms there. **(3)**

(Total for Question 3 is 6 marks)

© Revision Library | revisionlibrary.co.uk

4 Electrolysis is the process used to break down ionic compounds using electricity.

(a) Define the term 'electrolysis'. **(1)**

(b) State what is meant by an 'electrolyte'. **(1)**

(c) Solid sodium chloride does not conduct electricity, so it cannot be electrolysed. Explain why molten sodium chloride, or sodium chloride dissolved in water, can be electrolysed. **(2)**

(Total for Question 4 is 4 marks)

© Revision Library | revisionlibrary.co.uk

5 Aluminium is extracted from purified aluminium oxide by electrolysis, rather than by reduction with carbon.

(a) Explain why aluminium must be extracted using electrolysis, rather than by reduction with carbon (as is used for iron). **(2)**

(b) State the purpose of dissolving aluminium oxide in molten cryolite before electrolysis, rather than melting pure aluminium oxide alone. **(2)**

(Total for Question 5 is 4 marks)

---

6 Aluminium oxide, dissolved in molten cryolite, is electrolysed using carbon (graphite) electrodes.

(a) Higher tier only. Write the half equation for the reaction at the cathode. **(2)**

(b) Higher tier only. Write the half equation for the reaction at the anode. **(2)**

(c) Explain why the carbon anodes used in this process need to be replaced regularly, giving a balanced symbol equation for the reaction responsible. **(2)**

(Total for Question 6 is 6 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 2.15 Electrolysis: 30-minute Pack

Question 1

(a) $2Br^- \rightarrow Br_2 + 2e^-$ cao **B1**

(a) Answer: $2Br^- \rightarrow Br_2 + 2e^-$

(b) calculate moles of Br_2 produced: 0.50 mol $PbBr_2$ gives 1.00 mol Br^- -> 0.50 mol Br_2 or show mole ratio $2Br^- \rightarrow Br_2$ **M1**

(b) 12.0 dm3 cao **A1**

(b) Answer: 12.0 dm3

Question 2

(a) states that chloride ions are discharged in preference to hydroxide when chloride concentration is high **M1**

(a) because chloride ions oxidise more easily under these conditions so $Cl^- \rightarrow Cl_2$ occurs rather than $4OH^- \rightarrow O_2 + 2H_2O$ (or mention relative ease / electrode potentials) **A1**

(a) Answer: Because in concentrated sodium chloride solution chloride ions are present at high concentration and are discharged at the anode in preference to hydroxide ions, so Cl^- is oxidised to Cl_2 rather than OH^- to O_2.

(b) $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ cao **B1**

(b) Answer: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Question 3

(a) zinc (metal) forms at the cathode **B1**

(a) positive Zn^{2+} ions are attracted to (move towards) the negative cathode oe **M1**

(a) the Zn^{2+} ions gain electrons (are reduced) at the cathode, forming zinc atoms oe **A1**

(a) Answer: Zinc metal forms at the cathode: positive Zn^{2+} ions are attracted to the negative cathode, where they gain electrons (are reduced) to form zinc atoms.

(b) chlorine (gas) forms at the anode **B1**

(b) negative Cl^- ions are attracted to (move towards) the positive anode oe **M1**

(b) the Cl^- ions lose electrons (are oxidised) at the anode, forming chlorine molecules (gas) oe **A1**

(b) Answer: Chlorine gas forms at the anode: negative Cl^- ions are attracted to the positive anode, where they lose electrons (are oxidised) to form chlorine gas.

Question 4

(a) the breakdown (decomposition) of an ionic compound, molten or dissolved in water, into its elements, using electricity (an electric current) oe **B1**

(a) Answer: Electrolysis is the breakdown (decomposition) of an ionic compound, molten or dissolved in water, into its elements, using electricity.

(b) a molten ionic compound, or an ionic compound dissolved in water, that conducts electricity and is decomposed during electrolysis oe **B1**

(b) Answer: An electrolyte is a molten ionic compound, or an ionic compound dissolved in water, that conducts electricity and is broken down during electrolysis.

(c) in a solid, the ions are held in fixed positions in the lattice and cannot move oe **M1**

(c) when molten or dissolved, the ions are free to move (are mobile) throughout the liquid, so they can carry electric charge to the electrodes oe **A1**

(c) Answer: In a solid, the ions are held in fixed positions in the lattice and cannot move, so they cannot carry charge. When molten or dissolved in water, the ions are free to move throughout the liquid, so they can carry an electric current to the electrodes.

Question 5

(a) aluminium is more reactive than carbon oe **M1**

(a) so carbon cannot displace/reduce aluminium from its oxide (aluminium oxide is too stable to be reduced by carbon) oe **A1**

(a) Answer: Aluminium is more reactive than carbon, so carbon cannot reduce (displace) aluminium from its oxide; electrolysis must be used instead.

(b) pure aluminium oxide has a very high melting point (over 2000°C) oe **M1**

(b) dissolving it in molten cryolite lowers the operating temperature needed (to around 900-1000°C), reducing the energy required and so the cost of the process oe **A1**

(b) Answer: Pure aluminium oxide has a very high melting point (over 2000°C). Dissolving it in molten cryolite lowers the temperature needed to around 900-1000°C, reducing the energy required and the cost of the process.

© Revision Library | revisionlibrary.co.uk

Question 6

(a) correct species and direction: $Al^{3+} + 3e- \rightarrow Al$ **M1**

(a) fully balanced cao **A1**

(a) Answer: $Al^{3+} + 3e- \rightarrow Al$

(b) correct species and direction: $2O^{2-} \rightarrow O_2 + 4e-$ **M1**

(b) fully balanced cao **A1**

(b) Answer: $2O^{2-} \rightarrow O_2 + 4e-$

(c) the oxygen produced at the hot anode reacts with the hot carbon of the anode itself, so the anode gradually burns away (erodes) and must be replaced oe **M1**

(c) balanced equation: $C + O_2 \rightarrow CO_2$ **A1**

(c) Answer: The oxygen gas produced at the hot anode reacts with the hot carbon anode itself, forming carbon dioxide gas ($C + O_2 \rightarrow CO_2$), so the anode gradually burns away and has to be replaced regularly.

© Revision Library | revisionlibrary.co.uk