2.8 Electrolysis of Molten and Aqueous Compounds: 30-minute Pack

EDEXCEL 4CH1 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 In an aqueous potassium nitrate cell, the solution contains mobile K^+ and NO_3^- ions. State the direction each ion moves when a direct current is switched on.

(Total for Question 1 is 2 marks)

2 Describe how inert electrodes differ from reactive electrodes during electrolysis, giving one example of an inert electrode material used in the laboratory.

(Total for Question 2 is 2 marks)

3 An aqueous silver nitrate solution is electrolysed using inert electrodes. Name the solid deposited at the negative electrode and the gas produced at the positive electrode.

(Total for Question 3 is 2 marks)

4 Molten magnesium chloride is electrolysed. Write the balanced half-equation at each electrode, showing electrons, and state the charge of the cathode.

(Total for Question 4 is 3 marks)

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5 Acidified water is electrolysed using inert electrodes. At the same temperature and pressure, 12 cm^3 of hydrogen is collected. Write the balanced overall equation for the decomposition and calculate the volume of oxygen collected.

(Total for Question 5 is 3 marks)

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6 Write balanced half-equations for the electrode reactions that occur during electrolysis of molten lead(II) bromide, showing electrons explicitly.

(Total for Question 6 is 3 marks)

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7 Explain, with reference to the ions present and the concept of preferential discharge, why electrolysis of molten lead(II) bromide gives different products from electrolysis of an aqueous solution of lead(II) bromide. Refer to what is discharged at each electrode in both molten and aqueous cases.

(Total for Question 7 is 6 marks)

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8 Concentrated aqueous potassium iodide is electrolysed with inert electrodes. Write a balanced half-equation for the anode reaction, give the expected colour of iodine in the solution, and write the cathode half-equation for hydrogen formation from water.

(Total for Question 8 is 3 marks)

9 A student electrolyses aqueous silver nitrate with inert graphite electrodes. State what appears at the cathode, name a test result for the anode gas, and identify the ion that remains in solution rather than being discharged at the anode.

(Total for Question 9 is 3 marks)

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Mark scheme · 2.8 Electrolysis of Molten and Aqueous Compounds: 30-minute Pack

Question 1

K^+ ions move towards the negative electrode (cathode) **B1**

NO_3^- ions move towards the positive electrode (anode) **B1**

Answer: K^+ moves to the negative cathode; NO_3^- moves to the positive anode.

Question 2

inert electrodes do not react or dissolve and only provide a surface for electron transfer **B1**

example: carbon (graphite) or platinum as an inert electrode material **B1**

Answer: Inert electrodes do not chemically react or dissolve, they only provide a surface for electron transfer; example: carbon (graphite) or platinum.

Question 3

silver metal (Ag) at the negative cathode **B1**

oxygen gas (O_2) at the positive anode **B1**

Answer: Silver metal is deposited at the cathode and oxygen gas forms at the anode.

Question 4

cathode half-equation: $Mg^{2+} + 2e^- \rightarrow Mg$ **M1**

anode half-equation: $2Cl^- \rightarrow Cl_2 + 2e^-$ **M1**

the cathode is negative **B1**

Answer: Cathode (negative): $Mg^{2+} + 2e^- \rightarrow Mg$. Anode: $2Cl^- \rightarrow Cl_2 + 2e^-$.

Question 5

balanced overall equation: $2H_2O \rightarrow 2H_2 + O_2$ **B1**

uses the 2:1 hydrogen-to-oxygen volume ratio from the equation, so 12 / 2 = 6 **M1**

6 cm^3 of oxygen cao **A1**

Answer: $2H_2O \rightarrow 2H_2 + O_2$. The oxygen volume is 6 cm^3.

Question 6

correct cathode half-equation: $Pb^{2+} + 2e^- \rightarrow Pb$ **M1**

correct anode half-equation: $2Br^- \rightarrow Br_2 + 2e^-$ **M1**

both half-equations balanced and electrons shown cao **A1**

Answer: Cathode: $Pb^{2+} + 2e^- \rightarrow Pb$. Anode: $2Br^- \rightarrow Br_2 + 2e^-$.

Question 7

Level 1 Gives a basic statement about different products in molten and aqueous electrolysis, or lists one correct electrode product for one case. **1-2**

Level 2 Explains the ions present in molten $PbBr_2$ and in aqueous $PbBr_2$ and identifies which ion is discharged at each electrode in both cases, with partial reasoning about preferential discharge. **3-4**

Level 3 Clearly explains that in molten $PbBr_2$ only Pb^{2+} and Br^- are present so Pb^{2+} is reduced at the cathode to Pb and Br^- is oxidised at the anode to Br_2, while in aqueous $PbBr_2$ water is also present so at the cathode H^+ or metal ion is considered and compares reactivity to decide whether Pb^{2+} or H^+ is discharged (either reasoned conclusion is credited), and at the anode explains that OH^- or Br^- may be oxidised, giving justified conclusion on products and mentioning how electrode type can affect the outcome. **5-6**

Indicative content:

- Molten $PbBr_2$ contains only Pb^{2+} and Br^-; no water is present so the ions from the compound are discharged at the electrodes.
- Molten case: at cathode $Pb^{2+} + 2e^- \rightarrow Pb(s)$; at anode $2Br^- \rightarrow Br_2(g) + 2e^-$.
- Aqueous $PbBr_2$ contains Pb^{2+}, Br^- and H_2O, so water can be involved in electrode reactions.
- Preferential discharge rules: the less reactive positive ion is discharged at the cathode; compare Pb^{2+} and H^+ relative reactivity to explain which is reduced.
- In aqueous solution either Pb^{2+} or H^+ (from water) could be reduced at the cathode. Lead is above hydrogen in the reactivity series, so by that rule H_2 is expected; also credit a justified statement that Pb is deposited in practice (high Pb^{2+} concentration, high hydrogen overpotential on lead). Credit either conclusion if it is reasoned.
- At the anode in aqueous solution either Br^- or OH^- (from water) may be oxidised; halide ions are often oxidised in preference to OH^- if halide concentration is significant, producing Br_2.
- Mention that inert versus reactive electrode may change observation, for example a reactive anode could dissolve, altering ion concentrations.

Question 8

anode: $2I^- \rightarrow I_2 + 2e^-$ **M1**

iodine gives a brown colour in the solution **B1**

cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ **M1**

Answer: Anode: $2I^- \rightarrow I_2 + 2e^-$; the iodine makes the solution brown. Cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$.

Question 9

a silver deposit forms at the cathode **B1**

oxygen at the anode relights a glowing splint **B1**

nitrate ions (NO_3^-) remain in solution and are not discharged at the inert anode **B1**

Answer: Silver deposits at the cathode; oxygen at the anode relights a glowing splint; nitrate ions remain in solution.

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