2.15 Electrolysis: Test Pack

AQA 8464 · Calculator allowed · about 45 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Electrolysis is the process of using an electric current to drive a non-spontaneous chemical change.

(a) Give the name of the electrode at which reduction occurs during electrolysis. **(1)**

(b) Give the name of the electrode at which oxidation occurs during electrolysis. **(1)**

(Total for Question 1 is 2 marks)

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2 A student sets up electrolysis of dilute sodium sulfate solution with inert electrodes. The expected products are hydrogen at the cathode and oxygen at the anode.

(a) Write the half-equation for oxygen formation from hydroxide ions at the anode. **(1)**

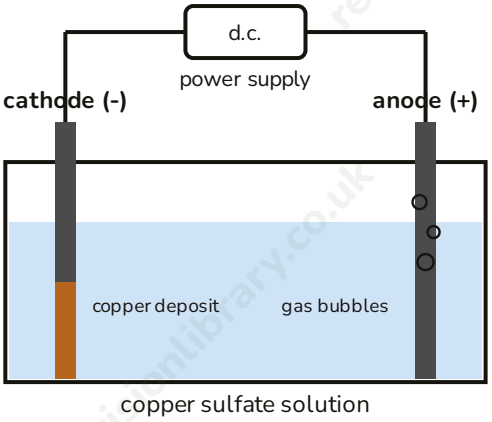
(b) Explain why oxygen, not ozone, is the usual product at the anode in this electrolysis. **(2)**

(Total for Question 2 is 3 marks)

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3 Required practical: a student, Priya, carries out the required practical investigation into the electrolysis of aqueous solutions, using copper sulfate solution as the electrolyte, as shown in Figure 2.

Figure 2: electrolysis of copper sulfate solution



(a) Name a suitable type of electrode for this investigation, and give a reason for using this type of electrode rather than a reactive metal electrode. **(2)**

(b) Describe how Priya should set up and carry out this investigation. **(4)**

(Total for Question 3 is 6 marks)

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4 Concentrated sodium chloride solution (brine) is electrolysed industrially using inert electrodes, producing three useful products.

(a) Name the gas produced at the anode. **(1)**

(b) Name the gas produced at the cathode. **(1)**

(c) Name the other useful substance that remains in solution, and give one industrial use for any one of the three products. **(2)**

(Total for Question 4 is 4 marks)

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5 Silver nitrate solution, $AgNO_3(aq)$, is electrolysed using inert (platinum) electrodes.

(a) Predict the product formed at the cathode, and explain your prediction. **(3)**

(b) Predict the product formed at the anode, and explain your prediction. **(3)**

(c) Higher tier only. The half equations for this electrolysis are $Ag^+ + e^- \rightarrow Ag$ (cathode) and $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ (anode). Combine these, balancing the electrons transferred, to give the overall ionic equation for this electrolysis. **(3)**

(Total for Question 5 is 9 marks)

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6 Copper sulfate solution can also be electrolysed using copper electrodes instead of inert electrodes. This method is used industrially to purify impure copper.

(a) State what happens at the copper anode when copper sulfate solution is electrolysed using copper electrodes. **(2)**

(b) State what happens at the copper cathode. **(1)**

(c) Explain why the blue colour of the copper sulfate solution stays approximately constant in this experiment, unlike when inert electrodes are used. **(2)**

(Total for Question 6 is 5 marks)

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7 The required practical: electrolysis of copper(II) sulfate using inert electrodes. A student records the mass of the copper cathode at intervals while passing a current of 0.50 A for 10 minutes.

(a) Calculate the total charge in coulombs passed through the cell in 10.0 minutes at 0.50 A. Use Q = I x t. **(2)**

(b) State the gas produced at the inert anode in this electrolysis of copper sulfate solution, and explain why it forms there rather than a product from the sulfate ion. **(2)**

(Total for Question 7 is 4 marks)

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Mark scheme · 2.15 Electrolysis: Test Pack

Question 1

(a) cathode cao **B1**

(a) Answer: Cathode.

(b) anode cao **B1**

(b) Answer: Anode.

Question 2

(a) $4OH^-$ -> O_2 + $2H_2O$ + 4e- cao **B1**

(a) Answer: $4OH^-$ -> O_2 + $2H_2O$ + 4e-

(b) states oxygen is more readily formed and is thermodynamically favoured **M1**

(b) mentions that ozone formation requires higher energy and specific conditions so O_2 is favoured at normal electrode potentials and concentrations **A1**

(b) Answer: Oxygen is formed because it is the thermodynamically favored product under normal conditions; ozone requires higher energy or special conditions to form, so O_2 is produced at the anode instead.

Question 3

(a) an inert electrode, e.g. graphite (carbon) or platinum **B1**

(a) inert electrodes do not react with the electrolyte or dissolve during electrolysis, so the results show only the reactions of the ions in solution oe **B1**

(a) Answer: Inert electrodes, such as graphite or platinum, should be used, because they do not react with the electrolyte or dissolve during electrolysis, so the results show only the reactions of the ions in solution.

(b) pour copper sulfate solution into the electrolysis cell (beaker) so that both graphite electrodes are covered by the solution oe **B1**

(b) connect the electrodes to a d.c. power supply, with wires/crocodile clips attached correctly oe **B1**

(b) switch on the power supply for a measured/fixed period of time and observe both electrodes throughout oe **B1**

(b) wear eye protection throughout the investigation **B1**

(b) Answer: Pour copper sulfate solution into the electrolysis cell so both graphite electrodes are covered, connect the electrodes to a d.c. power supply, then switch on for a measured period of time, observing both electrodes throughout and wearing eye protection.

Question 4

(a) chlorine **B1**

(a) Answer: Chlorine.

(b) hydrogen **B1**

(b) Answer: Hydrogen.

(c) sodium hydroxide solution remains in solution **B1**

(c) one valid industrial use, e.g. chlorine to sterilise water/make bleach or plastics (PVC); hydrogen to make margarine or as a fuel; sodium hydroxide to make soap, paper or bleach oe **B1**

(c) Answer: Sodium hydroxide solution remains in solution. For example, chlorine is used to sterilise water, hydrogen is used to make margarine, and sodium hydroxide is used to make soap.

Question 5

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

(a) silver is less reactive than hydrogen oe **M1**

(a) so Ag^+ ions are discharged (gain electrons/are reduced) at the cathode in preference to hydrogen oe **A1**

(a) Answer: Silver metal forms at the cathode, because silver is less reactive than hydrogen, so Ag^+ ions are discharged (reduced) at the cathode in preference to hydrogen.

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

(b) no halide ion is present (only nitrate ions), and nitrate ions are never discharged oe **M1**

(b) so hydroxide ions (from the water) are oxidised at the anode instead, forming oxygen gas oe **A1**

(b) Answer: Oxygen gas forms at the anode, because no halide ion is present (only nitrate, which is never discharged), so hydroxide ions from the water are oxidised at the anode instead.

(c) the cathode half equation is multiplied by 4, so that 4 electrons are transferred in both half equations: $4Ag^+$ + 4e- -> 4Ag **M1**

(c) the two half equations are added together and the electrons cancel **M1**

(c) correct overall balanced equation: $4Ag^+$ + $4OH^-$ -> 4Ag + O_2 + $2H_2O$ cao **A1**

(c) Answer: $4Ag^+$ + $4OH^-$ -> 4Ag + O_2 + $2H_2O$

Question 6

(a) copper atoms at the anode lose electrons (are oxidised) **B1**

(a) they dissolve into the solution as Cu^{2+} ions, so the anode loses mass oe **B1**

(a) Answer: Copper atoms at the anode lose electrons and dissolve into the solution as Cu^{2+} ions, so the anode gradually loses mass.

(b) Cu^{2+} ions from solution gain electrons (are reduced) and are deposited as pure copper, so the cathode gains mass **B1**

(b) Answer: Cu^{2+} ions from solution gain electrons and are deposited as pure copper, so the cathode gains mass.

(c) copper dissolves from the anode at approximately the same rate as copper is deposited at the cathode oe **M1**

(c) so the concentration of Cu^{2+} ions in solution stays roughly constant, unlike with inert electrodes, where Cu^{2+} ions are removed but not replaced oe **A1**

(c) Answer: Copper dissolves from the anode at approximately the same rate as it is deposited at the cathode, so the concentration of Cu^{2+} ions in solution (and the blue colour) stays roughly constant, unlike with inert electrodes, where Cu^{2+} ions are removed but not replaced.

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Question 7

(a) substitutes and converts time: Q = 0.50 x (10.0 x 60) **M1**

(a) 300 C cao **A1**

(a) Answer: 300 C

(b) identifies oxygen (O_2) as the gas produced at the anode **M1**

(b) explains that sulfate ions remain in solution because hydroxide ions from water are discharged in preference to sulfate ions, so oxygen forms from OH^- rather than a product forming from SO_4^{2-}, oe **A1**

(b) Answer: Oxygen gas. Sulfate ions are not discharged; hydroxide ions from the water are discharged in preference to sulfate ions, so oxygen gas forms at the anode from the hydroxide ions instead.

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