Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ ( ) Date: _____

Class: 4E___

TOPIC: ELECTROCHEMISTRY (WORKSHEET 5) – REVIEW

Multiple-Choice Questions

1 Element X is extracted by the electrolysis of a molten compound of elements X and Y. The electrode reactions are as shown. What could be the identity of the compound?

positive electrode: $2Y^{2-} \rightarrow Y_2 + 4e^-$
negative electrode: $Y^{2+} + 2e^- \rightarrow X$

A aluminium oxide **B** magnesium oxide
C calcium chloride **D** potassium chloride (**B**)

2 A metal can be obtained by the electrolysis of its molten chloride. The table shows properties of the metal and its chloride.

substance	melting point / °C	boiling point / °C	density / gcm^{-3}
metal	328	1750	11
metal chloride	534	950	4.5

In which state will the metal be formed in electrolysis?

A as a solid below the molten chloride
B as a liquid below the molten chloride
C as a solid on the surface of the molten chloride
D as a liquid on the surface of the molten chloride (**B**)

3 Which of the following involves the largest number of electrons for complete discharge during electrolysis?

A 4 mol of Al^{3+} ions **B** 6 mol of Cu^{2+} ions
C 5 mol of OH^- ions **D** 7 mol of O^{2-} ions (**D**)

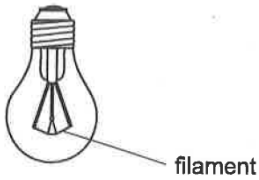
4 Dilute sulfuric acid was electrolysed using inert electrodes. What volumes (at r.t.p) of hydrogen and oxygen were formed by the passage of 1 mole of electrons?

	volume of hydrogen / dm^3	volume of oxygen / dm^3
A	24	12
B	12	6
C	6	12
D	12	24

(**B**)

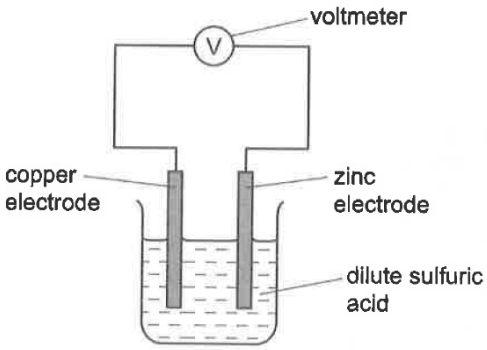
5 Processes 1, 2 and 3 each involve the movement of charged particles. Which process(es) involve(s) the movement of ions?

process 1



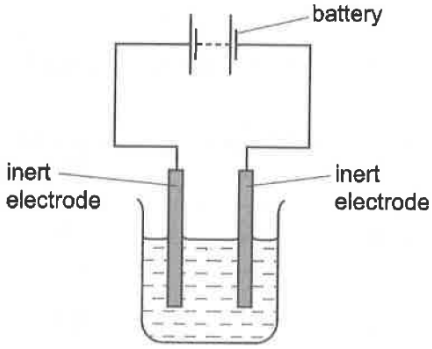
conduction of electricity through the metal filament of a light bulb

process 2



the production of electricity by a simple cell

process 3



electrolysis of aqueous sodium chloride

A process 1 only **B** process 2 only
C process 1 and 2 **D** process 2 and 3 (**D**)

6 Aluminium is obtained by electrolysis of molten aluminium oxide. Which statement about the electrolysis is correct?

A Aluminium ions are oxidised to aluminium at the negative electrode.
B Aluminium ions are oxidised to aluminium at the positive electrode.
C Aluminium ions are reduced to aluminium at the negative electrode.
D Aluminium ions are reduced to aluminium at the positive electrode. (**C**)

7 What happens to the ions that move to the negative electrode during electrolysis of molten potassium iodide?

A Ions are reduced. **B** Ions form molecules.
C Ions increase in charge. **D** Ions release electrons. (**A**)

8 In the electrolysis of molten sodium chloride, 46 g of sodium is formed at the cathode. How many moles of chlorine gas are formed at the anode?

$2Na^+(l) + 2e^- \rightarrow 2Na(l)$

$2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

A 0.5 mol **B** 1.0 mol
C 2.0 mol **D** 4.0 mol (**B**)

$\text{mol of Na} = \frac{46}{23} = 2\text{ mol}$

Compare mole ratio

Na : Cl_2

2 : 1 mol

9 The following three different solutions were electrolysed using inert electrodes.

1 aqueous sodium chloride
2 concentrated hydrochloric acid
3 dilute sulfuric acid

Which solution(s) produce(s) hydrogen at the cathode?

A 1 only **B** 1 and 2 only
C 1, 2 and 3 **D** 2 only (**C**)

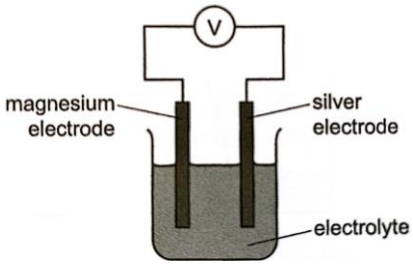
10 In the purification of copper, a sample of copper containing metal impurities that are below it in the reactivity series. The loss in mass of the positive electrode was 50 g and the gain in mass of the negative electrode was 45 g. What was the percentage purity of this sample of copper?

A 10.0% **B** 11.1%
C 90.0% **D** 95.0% (**C**)

11 Electrical energy is produced by a simple cell as a result of

A formation of covalent bonds between atoms.
B formation of negative ions from atoms.
C positive and negative ions coming together.
D transfer of electrons from a more reactive to a less reactive element. (**D**)

12 The diagram shows a cell. What statement about the cell is correct?



A Electrons pass from magnesium to the silver electrode through the electrolyte.
B The cell shows that silver is more reactive than magnesium.
C The magnesium electrode loses electrons.
D The silver electrode is oxidised. (**C**)

13 Which statement(s) about simple cells is/are correct?

1 A greater voltage is produced using magnesium and silver than using magnesium and copper.
2 The electrolyte is an aqueous solution containing positive and negative ions.
3 The more reactive metal will release electrons.

A 1, 2 and 3 **B** 1 and 3 only
C 1 only **D** 2 and 3 only (**A**)

Structured Questions

14 The table gives the colours of six salts.

salt	*colour*
copper(II) sulfate, $CuSO_4$	blue
copper(II) nitrate, $Cu(NO_3)_2$	blue
potassium chromate, K_2CrO_4	yellow
sodium chromate, Na_2CrO_4	yellow
sodium nitrate, $NaNO_3$	colourless
potassium nitrate, KNO_3	colourless

(a) Write down the names of the three elements combined in potassium chromate.

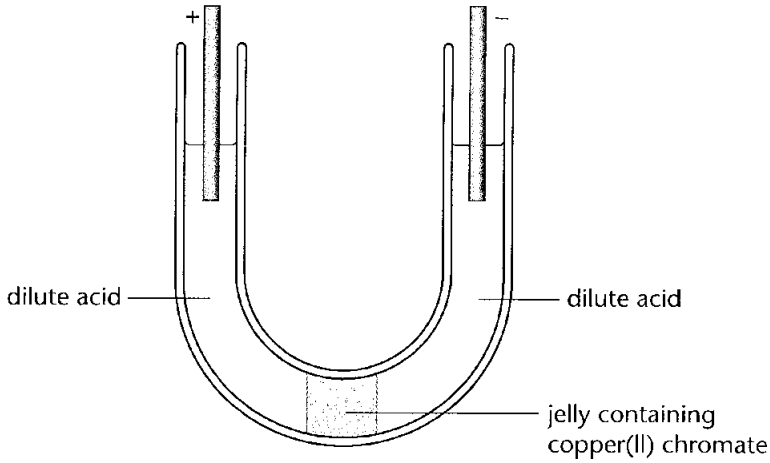
potassium, chromium and oxygen

(b) Suggest the colour of:

sodium ions: **colourless** copper(II) ions: **blue**

chromate ions: **yellow** copper(II) chromate solution: **green**

(c) The apparatus shown in the diagram below was set up.



(d) After some time, a yellow band moves through the gel towards the anode and a blue band towards the cathode. Explain these observations.

The positively charged copper(II) ions will migrate to the negative electrode while the negatively charged chromate ions ions will migrate to the positive electrode. Since copper(II) ions give a blue colouration, the blue band can be seen migrating towards the anode. As chromate ions give a yellow colouration, the yellow band can be seen migrating towards the cathode.

15 Both dilute aqueous potassium chloride and molten potassium chloride can be electrolysed.

Describe two differences between the **products** of the electrolysis of dilute aqueous potassium chloride and the electrolysis of molten potassium chloride.

At the negative electrode, hydrogen gas will be liberated from the electrolysis of aqueous potassium chloride, whereas molten potassium will be deposited from the electrolysis of molten potassium chloride.

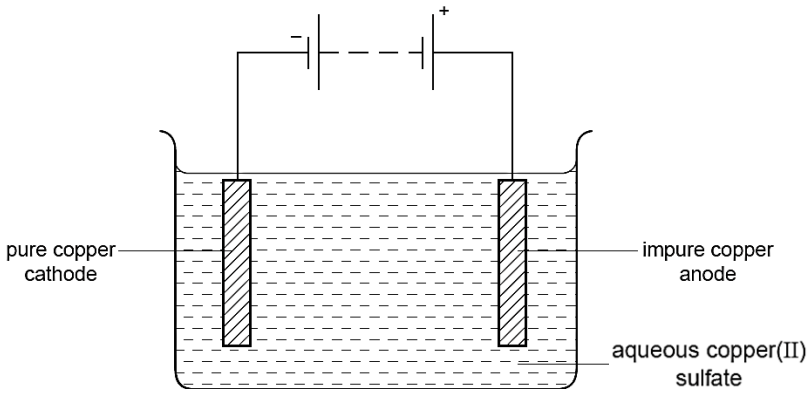
At the positive electrode, oxygen gas and water will be formed from the electrolysis of aqueous potassium chloride, whereas chlorine gas will be liberated from the electrolysis of molten potassium chloride.

16 The table shows information about the electrolysis of some substances. Complete the table by filling in the missing information.

substance	electrodes used	product of reaction at positive electrode	product of reaction at negative electrode
concentrated aqueous copper(II) chloride	carbon	**chlorine**	**copper metal**
dilute aqueous copper(II) chloride	copper	copper(II) ions	**copper metal**
molten sodium chloride	platinum	chlorine	sodium

copper(II) metal

17 The diagram shows a cell for purifying copper.



(a) Describe what you would observe during this electrolysis and write the equations for the reactions at the electrodes.

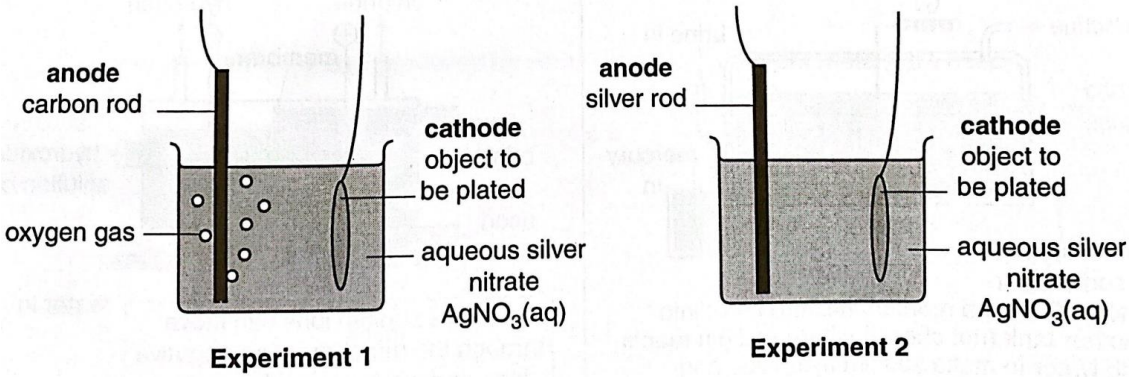
The anode will dissolve and decreases in mass and solid impurities can be observed sinking to bottom of the beaker.
Equation: $Cu\ (s) \rightarrow Cu^{2+}\ (aq) + 2e^-$

The cathode increases in mass with the reddish-brown copper deposit forming at the electrode.
Equation: $Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s)$

(b) Describe how the apparatus shown can be modified in order to electroplate an iron object, such as knife or nickel.

The pure copper electrode can be placed at the positive terminal / made the anode, while the iron object can be placed at the negative terminal / made the cathode.

18 A student sets up two different experiments for electroplating an object with silver.



(a) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

Experiment 1:

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

Cathode: $Ag^+(aq) + e^- \rightarrow Ag(s)$

Experiment 2:

Anode: $Ag(s) \rightarrow Ag^+(aq) + e^-$

Cathode: $Ag^+(aq) + e^- \rightarrow Ag(s)$

(b) At the beginning of each experiment the student removes a sample of the electrolyte, aqueous silver nitrate, and puts it in a test-tube. The student then adds a few drops of aqueous sodium chloride to the sample.

(i) Describe and explain what the student sees. Include an equation in your answer.

A white precipitate will be observed due to the formation of insoluble silver chloride.

$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

(ii) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is still being deposited on the object in experiment 2.

Suggest a reason for this observation and describe how he could use aqueous sodium chloride to find out if his reasoning is correct.

After some time, all the silver ions are discharged in Experiment 1. Thus, no more silver is being deposited on the object.

However, in Experiment 2, silver ions are continuously being produced as the silver rod (anode) dissolves into the electrolyte. Thus, silver ions are still being discharged and silver is being deposited on the object.

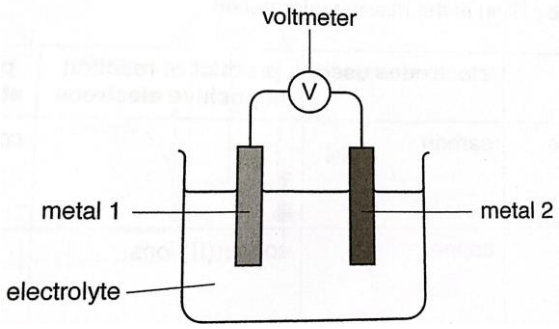
He could add a few drops of aqueous sodium chloride to a sample of each electrolyte from Experiment 1 and Experiment 2. A white precipitate will form in the electrolyte taken from Experiment 2 but not from Experiment 1, indicating the presence of silver ions. This shows that his reasoning is correct.

(c) If an iron object is placed in a beaker of aqueous silver nitrate, a silver coating forms on the iron. If a gold object is placed in aqueous silver nitrate, no reaction happens. Explain why.

Iron is more reactive than silver. Thus, iron will displace silver from its salt solution and a coating of silver forms on the iron.

However, gold is less reactive than silver. Hence, gold is not able to displace silver from its salt solution.

19 Two metal electrodes and an electrolyte can be used to produce electrical energy.



The table shows the voltage produced by some cells when different metals are used.

metal 1	metal 2	voltage / V
copper	zinc	1.10
copper	nickel	0.60
silver	zinc	1.56
silver	nickel	1.06
silver	iron	1.25

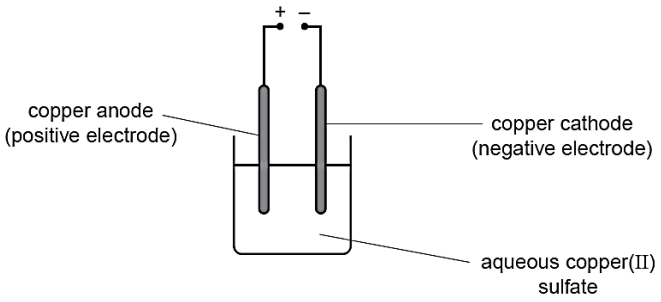
(a) Explain why different combinations of metals produce different voltages.

Metals have different reactivities. The more reactive the metal, the greater tendency to lose its valence electrons. In a simple cell, the more reactive metal will lose electrons to the less reactive metal, producing voltage. As such, the greater the difference in reactivity between the metals, the size of the voltage will be larger.

(b) Suggest the voltages that will be produced when the following metals are used.

metal 1	metal 2	predicted voltage / V
copper	iron	**0.79 (0.61 to 1.09)**
silver	magnesium	**2.56 (1.57 to 4.00)**

20 A student investigates the electrolysis of aqueous copper(II) sulfate using the apparatus shown below.



The student weighs the copper cathode before and after the electrolysis.

experiment number	current used / A	time taken / s	mass of cathode	
			before starting / g	after electrolysis / g
1	2.0	180	1.24	1.36
2	4.0	180	1.20	1.44
3	2.0	360	1.34	1.58

(a) Explain, with the aid of an equation, why the cathode increases in mass.

Equation: Cu^{2+} (aq) + $2e^- \rightarrow$ Cu (s)
Cu^{2+} ions from the solution gets preferentially discharged than H^+ ions as it is lower in the reactivity series and deposited as copper metal at the cathode. Hence, the cathode increases in mass.

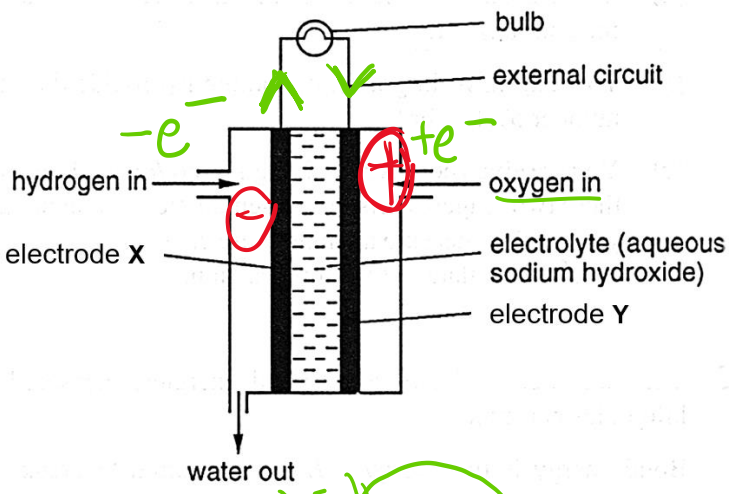
(b) In experiment 2, the student measures the mass of the anode both before and after the electrolysis. At the start the anode has a mass of 1.45 g. Determine the mass of the anode at the end of the electrolysis.

Mass of Cu deposited = 1.44 – 1.20 = 0.240 g
Mass of anode at the end = 1.45 – 0.240 = 1.21 g

(c) The student does a fourth experiment, this time using a current of 8.0 A for 90 seconds. At the start the cathode has a mass of 1.51 g. Predict the mass of the cathode at the end of the electrolysis.

Mass of cathode = 1.51 + 0.24 = 1.75 g

21 One type of fuel cell produces electricity from the controlled reaction of hydrogen with oxygen in the presence of an electrolyte. The diagram below shows the construction of such a fuel cell.



The reaction at electrode **X** is $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$
The reaction at electrode **Y** is $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

(a) Write down the names and formulae of the ions present in the electrolyte used in the fuel cell.

sodium ions, Na^+ ions, hydrogen ions, H^+ ions
hydroxide ions, OH^- ions

(b) Identify the negative and positive electrodes. At which electrode does oxidation take place? Give a reason for your answer.

The negative electrode is electrode X, while the positive electrode is electrode Y.
Oxidation occurs at electrode X as the reaction between hydrogen and hydroxide ions loses 2 moles of electrons to form water.

(c) Normally, hydrogen and oxygen react together to release heat energy.

(i) What is the name given to such a reaction?

combustion / exothermic reaction

(ii) What type of energy change occurs in the fuel cell?

Chemical energy to electrical energy

(iii) Why is it important to control the reaction between hydrogen and oxygen in the fuel cell?

This is to prevent oxygen and hydrogen from reacting together to form an explosive reaction.

(d) (i) Construct the chemical equation for the overall reaction taking place in the fuel cell.

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

(ii) What volume of oxygen, measured at room temperature and pressure, is needed to react completely with 1.2 dm^3 of hydrogen under the same conditions?

No of mol of hydrogen = 1.2 ÷ 24
= 0.0500 mol

Comparing mole ratio:

H_2 : O_2
2 : 1
0.05 : 0.025

Volume of oxygen = 0.0250 × 24
= 0.600 dm^3

(e) Give a reason why fuel cells are environmentally friendly.

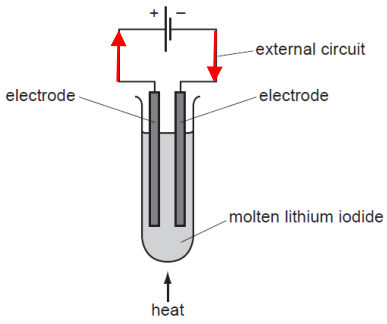
The only product of fuel cell is water and it is non-polluting.

(f) Suggest one disadvantage of using fuel cells.

Hydrogen is highly flammable / potentially explosive when burnt with oxygen
Method of storage of hydrogen is expensive as liquid hydrogen needs to be stored under high pressures.

22 During electrolysis, ions move in the electrolyte and electrons move in the external circuit. Reactions occur at the electrodes.

(a) The diagram shows the electrolysis of molten lithium iodide.



(i) Draw an arrow on the diagram to show the direction of the electron flow in the external circuit.

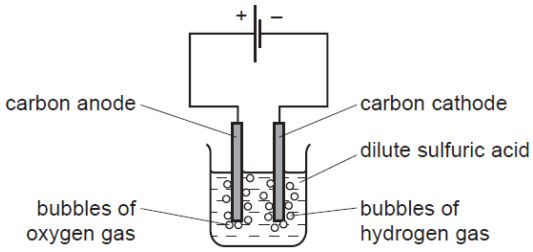
(ii) Electrons are supplied to the external circuit. How and where is this done?

Electrons are supplied from battery / power supply / cell
Electrons are supplied from negative electrode of battery to external circuit or from anode;
Electrons are supplied from iodide ion losing electrons or oxidation of anion;

(iii) Explain why solid lithium iodide does not conduct electricity but when molten it is a good conductor.

In the solid state, the ions are held together at its fixed positions by strong electrostatic forces of attraction. As a result, there are no mobile ions to function as charge carriers to conduct electricity. When in molten state, the giant ionic lattice is broken down, and there are mobile ions to conduct electricity.

(b) The diagram below shows the electrolysis of dilute sulfuric acid. Hydrogen is formed at the negative electrode (cathode) and oxygen at the positive electrode (anode) and the concentration of sulfuric acid increases.



(i) Write equations, including state symbols, for the reactions at each electrode.

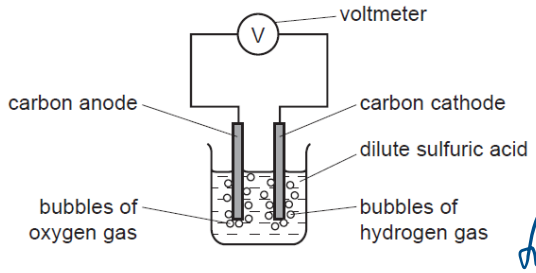
anode: **$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$**

cathode: **$2H^+(aq) + 2e^- \rightarrow H_2(g)$**

(ii) Explain why the concentration of the sulfuric acid increases.

During electrolysis, H^+ ions gets discharged and OH^- ions gets preferentially discharged over sulfate ions, as it is lower in the reactivity series.
As the ions remain in the electrolyte consists of H^+ and SO_4^{2-}, the net concentration of sulfuric acid increases.

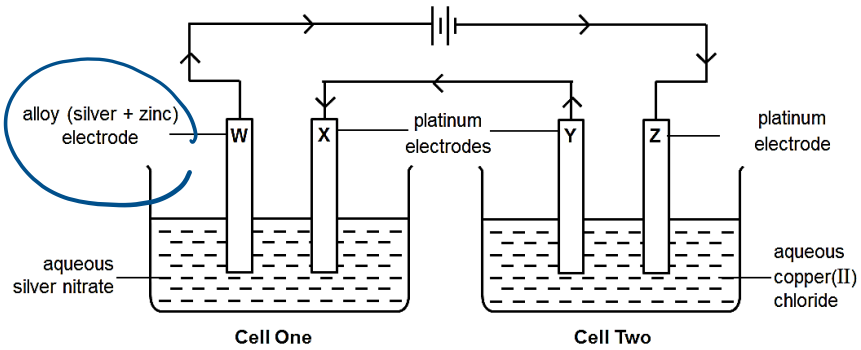
(c) In the apparatus used in **(b)**, the power supply is removed and immediately replaced by a voltmeter.



(d) A reading on the voltmeter shows that electrical energy is being produced. Suggest an explanation for how this energy is produced.

The setup shows a fuel cell, where hydrogen reacts with oxygen to form water. As such, there is a flow of electrons and chemical energy is converted to electrical energy.

23 Two electrochemical cells are connected in series as shown.



(a) Draw arrows on the diagram to show the direction of the flow of electrons in the wires.

(b) Describe what can be observed at electrode **W** and write an ionic equation to show the reaction that happens at electrode **W**.

observation: **Electrode W dissolves in the electrolyte / becomes smaller in size/mass**

ionic equation: **$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$**

(c) Describe and explain **two** observations that can be made in **Cell Two** and write an ionic equation to show the reaction that happens at electrode **Y**.

observations with explanations:

Effervescence can be observed at electrode Y due to the production of oxygen gas from the preferential discharge of hydroxide ions.

A reddish-brown/pink deposit is formed at electrode Z due to the formation of copper on the electrode from the discharge of copper(II) ions from aqueous copper(II) chloride.

Blue colour electrolyte fades away / turns colourless due to the decrease in concentration of copper(II) ions in the solution

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

(d) The experiment was repeated using concentrated copper(II) choride solution in **Cell Two**. Describe **one** similarity and **one** difference in the products of the electrolysis of concentrated copper(II) choride solution compared to aqueous copper(II) choride solution.

similarity: **Copper metal is deposited on electrode Z for both experiments**

difference: **The product liberated at electrode Y using concentrated copper(II) choride as the electrolyte is chlorine gas instead of oxygen gas in the first experiment**