Name: _____

Class: _____

Date: _____

Chemical Changes part 3 AQA Triple Chemistry

Time: **81 minutes**

Marks: **77 marks**

Comments:

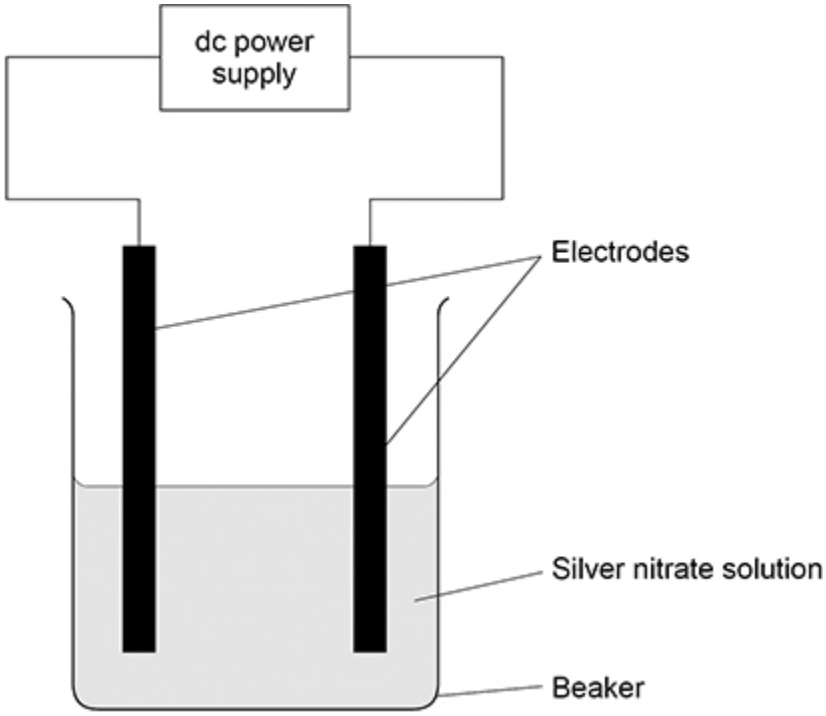
1. This question is about electrolysis.

Some students investigated the electrolysis of silver nitrate solution.

This electrolysis produces silver at the negative electrode.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 1**.
3. Switch on the power supply.
4. Switch off the power supply after five minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.

(a) Some silver did not stick to the negative electrode but fell to the bottom of the beaker.

The students needed to weigh this silver.

How could the students separate the silver from the silver nitrate solution?

Tick (✓) **one** box.

By chromatography ☐

By crystallisation ☐

By distillation ☐

By filtration ☐

(1)

Table 1 shows the students' results.

Table 1

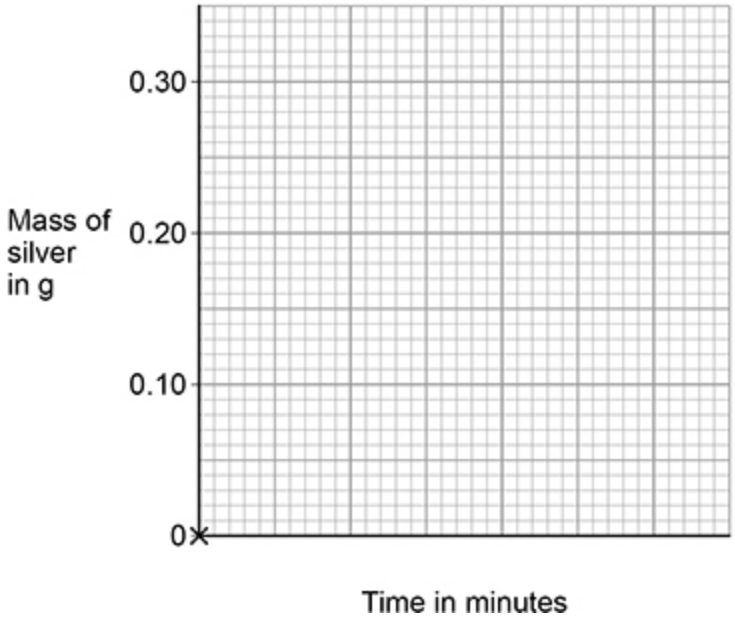
Time in minutes	Mass of silver in g
0	0.00
5	0.06
10	0.12
15	0.18
20	0.24
25	0.30

(b) Draw a graph on **Figure 2**.

You should:

- use a suitable scale for the x-axis
- plot the data from **Table 1**
- draw a line of best fit.

Figure 2



(4)

(c) Determine the mass of silver that would be produced after 12 minutes.

Use **Figure 2**.

Mass of silver = _____ g

(1)

(d) A student investigated the electrolysis of two aqueous salt solutions.

Hydrogen is produced at the negative electrode when the metal in the salt solution is more reactive than hydrogen.

Complete **Table 2** to show what the student would **observe** at the negative electrode for each salt solution.

Table 2

Salt solution	**Observation at negative electrode**
Copper sulfate	
Sodium chloride	

(2)

(e) A teacher demonstrates the electrolysis of molten lead bromide.

The products at the electrodes are lead and bromine.

Why should the teacher do the demonstration in a fume cupboard?

_____

_____

(1)

(f) Two other molten compounds are electrolysed.

Complete **Table 3** to show the molten compounds and the products.

Table 3

Molten compound electrolysed	**Product at the negative electrode**	**Product at the positive electrode**
Zinc chloride		
	Potassium	Iodine

(3)

(Total 12 marks)

2. This question is about chemical reactions and electricity.

(a) Electrolysis and chemical cells both involve chemical reactions and electricity.

Explain the difference between the processes in electrolysis and in a chemical cell.

_____

_____

_____

_____

(2)

(b) A teacher demonstrates the electrolysis of molten lead bromide.

Bromine is produced at the positive electrode.

Complete the half equation for the production of bromine.

You should balance the half equation.

$$Br^- \rightarrow \quad + \quad$$

(2)

(c) Two aqueous salt solutions are electrolysed using inert electrodes.

Complete the table below to show the product at each electrode.

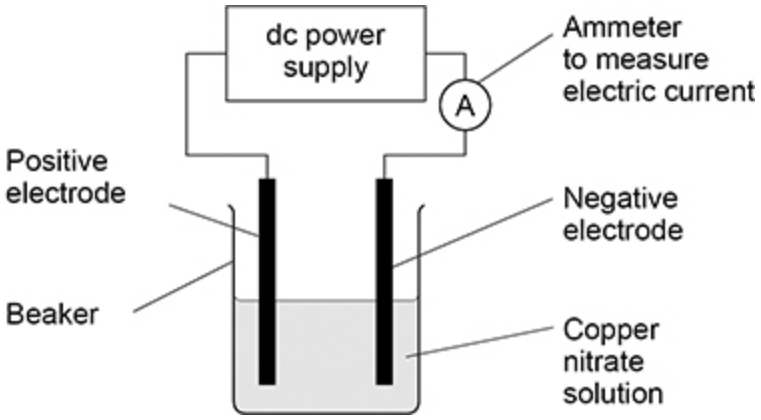
Salt solution	**Product at positive electrode**	**Product at negative electrode**
Copper nitrate		copper
Potassium iodide		

(3)

Some students investigated the electrolysis of copper nitrate solution using inert electrodes.

Figure 1 shows the apparatus.

Figure 1



The students investigated how the mass of copper produced at the negative electrode varied with:

- time
- current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 1**.
3. Adjust the power supply until the ammeter shows a current of 0.3 A
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.
8. Repeat steps 1 to 7 at different currents.

(d) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.

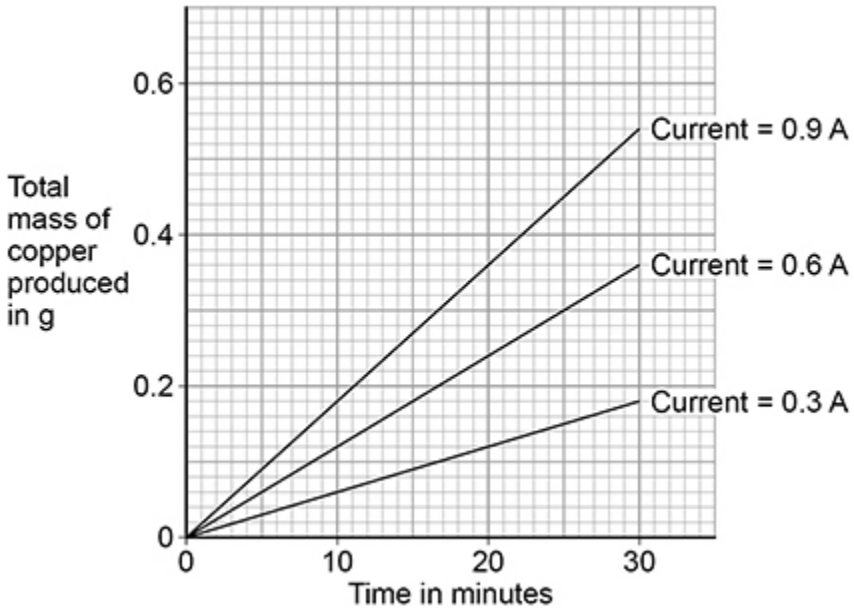
Suggest how the students could find the total mass of copper produced.

(4)

The students plotted their results on a graph.

Figure 2 shows the graph.

Figure 2



A student correctly concluded that the total mass of copper produced is directly proportional both to the time and to the current.

(e) How do the results in **Figure 2** support the conclusion that the total mass of copper produced is directly proportional to the time?

_____

_____

(1)

(f) How do the results in **Figure 2** support the conclusion that the total mass of copper produced is directly proportional to the current?

Use data from **Figure 2** in your answer.

_____

_____

(1)

(g) Copper nitrate solution is blue.

Suggest why the blue colour of the copper nitrate solution fades during the electrolysis.

_____

_____

(1)

(h) Determine the number of atoms of copper produced when copper nitrate solution is electrolysed for 20 minutes at a current of 0.6 A

Give your answer to 3 significant figures.

Use **Figure 2**.

Relative atomic mass (A_r): Cu = 63.5

The Avogadro constant = 6.02×10^{23} per mole

_____

_____

_____

_____

_____

_____

Number of atoms (3 significant figures) = _____

(3)

(Total 17 marks)

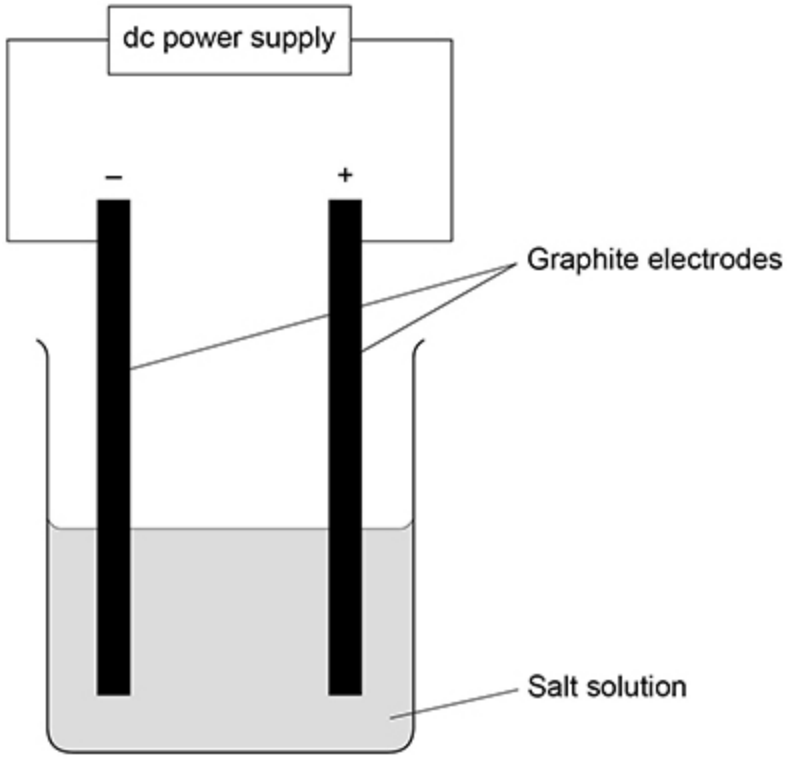
3. This question is about electrolysis.

A student investigated the hypothesis:

‘The electrolysis of a salt solution produces a metal at the negative electrode and a gas at the positive electrode.’

Figure 1 shows the apparatus used.

Figure 1



(a) What observation would be made at each electrode if the hypothesis is correct?

Observation if metal produced at the negative electrode

_____

_____

Observation if gas produced at the positive electrode

_____

_____

(2)

The table below shows the student's results.

Salt solution	**Product at the negative electrode**	**Product at the positive electrode**
Copper chloride	Copper	Chlorine
Potassium nitrate	Hydrogen	Oxygen
Silver nitrate	Silver	Oxygen

(b) Which salt solution in table above does **not** match the student's hypothesis?

Give **one** reason why.

Salt solution _____

Reason _____

_____

(2)

(c) Give **two** reasons why graphite is used for the electrodes.

1 _____

_____

2 _____

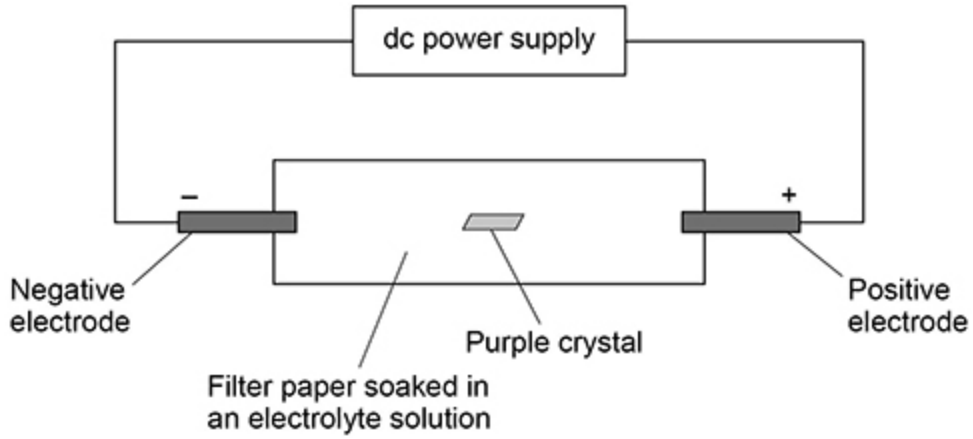
_____

(2)

A different student investigated what happens during electrolysis.

Figure 2 shows the apparatus.

Figure 2



The purple crystal contained:

- colourless positive ions
- purple coloured negative ions.

The purple crystal dissolved in the electrolyte solution.

(d) What happens to the purple coloured ions?

Give **one** reason for your answer.

Tick (✓) **one** box.

The ions do not move. ☐

The ions move towards the negative electrode. ☐

The ions move towards the positive electrode. ☐

Reason _____

_____

(2)

(Total 8 marks)

4. This question is about acids, bases and salts.

Zinc nitrate is a salt.

A student produces zinc nitrate using an acid and a base.

(a) Which acid should the student use to produce zinc nitrate?

Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Sulfuric acid ☐

(1)

(b) Which is a base the student could use to produce zinc nitrate?

Tick (✓) **one** box.

Zinc chloride ☐

Zinc oxide ☐

Zinc sulfate ☐

(1)

(c) Name the salt with the formula $MgBr_2$

_____

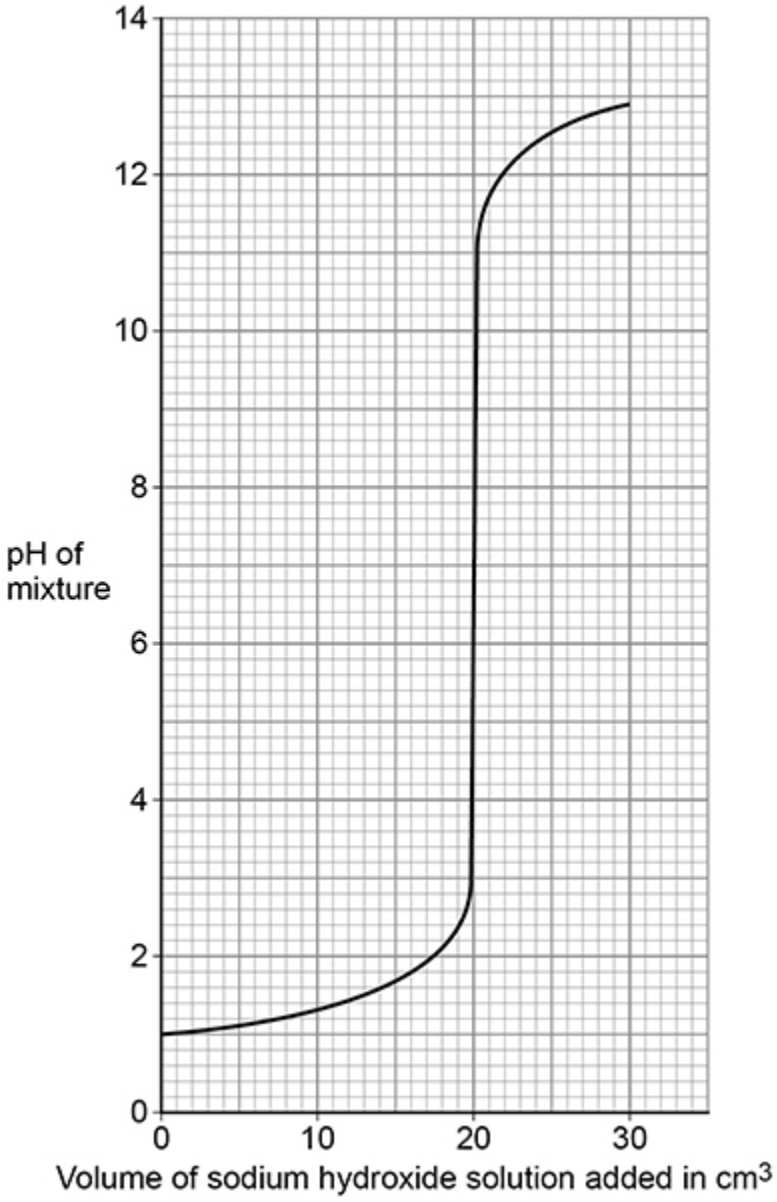
(1)

A student investigated how pH changes during a titration.

This is the method used.

1. Pour 25.0 cm^3 of hydrochloric acid into a beaker.
2. Measure the pH of the hydrochloric acid with a pH probe.
3. Add 1.0 cm^3 of sodium hydroxide solution from a burette.
4. Swirl the mixture.
5. Measure the pH of the mixture.
6. Repeat steps 3 to 5 until a total of 30.0 cm^3 of sodium hydroxide solution has been added.

The graph below shows the student's results.



(d) Describe how the pH of the mixture changes as sodium hydroxide solution is added to hydrochloric acid.

Use the data from the graph above in your answer.

_____

_____

_____

_____

_____

_____

(3)

(e) What volume of sodium hydroxide solution is needed to neutralise 25.0 cm^3 of hydrochloric acid?

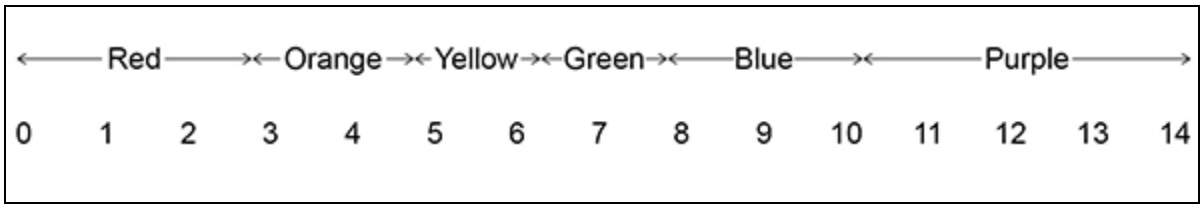
Use the graph above.

Volume = _____ cm^3

(1)

(f) **Figure 1** shows the colour of universal indicator at different pH values.

Figure 1



The student could have used universal indicator instead of a pH probe.

Determine the colour of universal indicator when 10.0 cm^3 of sodium hydroxide solution has been added to 25.0 cm^3 of hydrochloric acid.

Use the graph above and **Figure 1**.

Colour = _____

(1)

(g) The student used a pipette to measure 25.0 cm^3 of hydrochloric acid.

Figure 2 shows a pipette.

Figure 2

The pipette is labelled 25.0 ± 0.06 cm^3

Calculate the percentage uncertainty in the volume measured using this pipette.

Use the equation:

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{volume measured}} \times 100$$

Percentage uncertainty = _____ %

(2)

(h) Give **one** advantage of using a pipette rather than using a measuring cylinder to measure the volume of hydrochloric acid.

(1)

(Total 11 marks)

5. This question is about electrolysis.

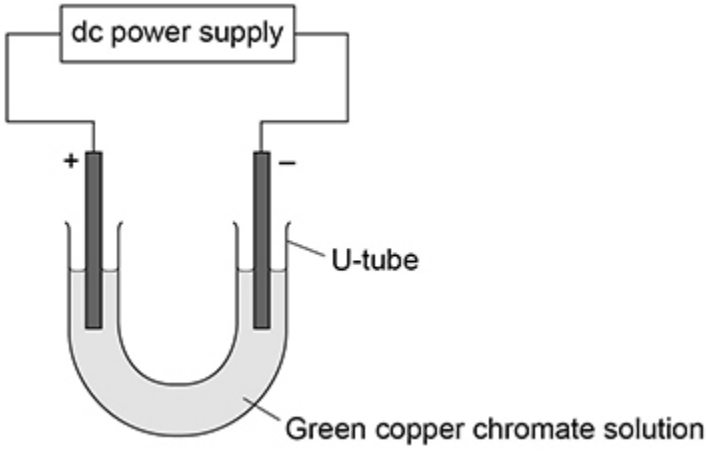
A student investigated the electrolysis of copper chromate solution.

Copper chromate solution is green.

Copper chromate contains:

- blue coloured Cu^{2+} ions
- yellow coloured CrO_4^{2-} ions.

The diagram below shows the apparatus used.



The student switched the power supply on.

The student observed the changes at each electrode.

The table below shows the student's observations.

Changes at positive electrode	Changes at negative electrode
Solution turned yellow Bubbles formed at the electrode	Solution turned blue Solid formed on the electrode

(a) Explain why the colour changed at the positive electrode.

_____

_____

_____

_____

(2)

(b) The gas produced at the positive electrode was oxygen.

The oxygen was produced from hydroxide ions.

Name the substance in the solution that provides the hydroxide ions.

_____

(1)

(c) Describe how the solid forms at the negative electrode.

_____

_____

_____

_____

_____

_____

(3)

(d) The student repeated the investigation using potassium iodide solution instead of copper chromate solution.

Name the product at each electrode when potassium iodide solution is electrolysed.

Negative electrode

_____

Positive electrode

_____

(2)

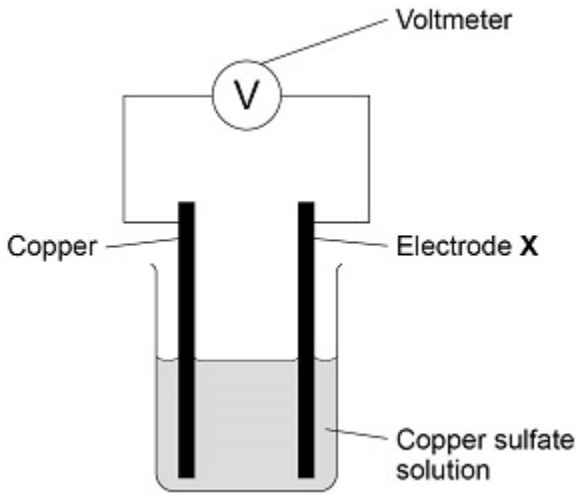
(Total 8 marks)

6. This question is about chemical cells and batteries.

A student investigated the voltage produced by different chemical cells.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Use cobalt metal as electrode **X**.

2. Record the cell voltage.

3. Repeat steps 1 and 2 using different metals as electrode **X**.

(a) Suggest **two** variables the student should keep the same to make the investigation valid.

1 _____

_____

2 _____

_____

(2)

The following table shows the student's results.

Electrode X	Voltage of the cell in volts
cobalt	0.62
magnesium	2.71
zinc	1.10

(b) Write the three metals used for electrode X in order of reactivity.

Use the table above.

Most reactive _____

_____

Least reactive _____

(1)

(c) Copper is used as electrode **X** in **Figure 1**.

Predict the voltage of this cell.

Give **one** reason for your answer.

Voltage = _____ volts

Reason _____

_____

(2)

(d) Describe how to make a 12 V battery using 1.5 V cells.

_____

_____

_____

_____

(2)

(e) Which is the most suitable use for a non-rechargeable cell?

Tick (✓) **one** box.

Electric toy ☐

Laptop computer ☐

Mobile phone ☐

(1)

(f) Hydrogen fuel cells or rechargeable cells can be used to power electric vehicles.

Suggest **one** advantage and **one** disadvantage of using a hydrogen fuel cell compared with a rechargeable cell.

Advantage of hydrogen fuel cell _____

_____

Disadvantage of hydrogen fuel cell _____

_____

(2)

(Total 10 marks)

7. This question is about acids and alkalis.

(a) Which ion do all acids produce in aqueous solution?

Tick (✓) **one** box.

H^+ ☐

H^- ☐

O^{2-} ☐

OH^- ☐

(1)

(b) Calcium hydroxide solution reacts with an acid to form calcium chloride.

Complete the word equation for the reaction.

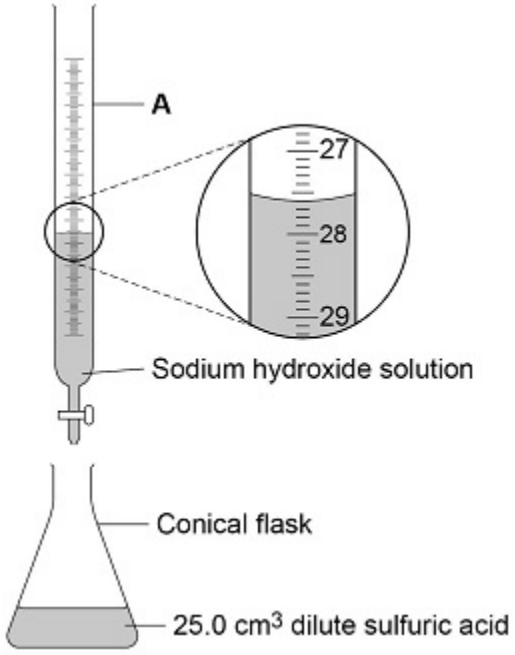
calcium hydroxide + _____ acid → calcium chloride + _____

(2)

A student investigates the volume of sodium hydroxide solution that reacts with 25.0 cm^3 of dilute sulfuric acid.

Figure 1 shows the apparatus the student uses.

Figure 1



Use **Figure 1** to answer parts (c) and (d).

(c) Name apparatus **A**.

_____

(1)

(d) What is the reading on apparatus **A**?

_____ cm^3

(1)

(e) The higher the concentration of a sample of dilute sulfuric acid, the greater the volume of sodium hydroxide needed to neutralise the acid.

The student tested two samples of dilute sulfuric acid, **P** and **Q**.

Describe how the student could use titrations to find which sample, **P** or **Q**, is more concentrated.

(6)

(Total 11 marks)

1. (a) by filtration

1

(b) 10 minutes per 2 cm on x-axis

allow 5 minutes per 1 cm on x-axis

1

all points plotted correctly

allow a tolerance of ± ½ a small square

*allow **1** mark for 3 or 4 points plotted correctly*

2

line of best fit

allow line of best fit drawn using incorrect plots

1

(c) 0.14 (g)

*allow ecf from question **(b)***

allow a tolerance of ± ½ a small square

1

(d) (copper sulfate solution) pink / orange / red / brown solid

allow copper plating

allow metal for solid

1

(sodium chloride solution) bubbles / effervescence / fizzing

*if no other mark awarded allow **1** mark for copper **and** hydrogen*

1

(e) toxic / poisonous (fumes)

allow harmful / corrosive (fumes)

ignore dangerous / deadly / lethal

1

(f)

Molten compound electrolysed	**Product at the negative electrode**	**Product at the positive electrode**
(zinc chloride)	zinc (1)	chlorine (1)
potassium iodide	(potassium)	(iodine)

allow **1** mark if zinc and chlorine the wrong way round

2

1

[12]

2.

(a) electrolysis uses electricity to produce a chemical reaction

allow voltage for electricity

allow potential difference for electricity

allow (electrical) current for electricity

allow electrolysis uses electricity to decompose a compound / electrolyte

1

(but) cells use a chemical reaction to produce electricity

1

(b) $2Br^- \rightarrow Br_2 + 2e^-$

allow multiples

*allow **1** mark for Br_2 **and** e^-*

2

(c)

Salt solution	**Product at positive electrode**	**Product at negative electrode**
(copper nitrate)	oxygen (1)	(copper)
(potassium iodide)	iodine (1)	hydrogen (1)

1
2

(d) filter the mixture

1

wash and dry the copper / residue

1

weigh the copper collected

1

add to the increase in mass of the electrode

1

(e) (for given current) straight line through the origin

allow (for given current) when time doubles, mass doubles

1

(f) (for given time) when current doubles, mass doubles with supporting data

1

(g) copper ions are discharged (from the solution)

allow the solution becomes less concentrated

allow copper ions are removed (from the solution)

allow copper ions are used up (from the solution)

1

(h) (number of moles = $\frac{0.24}{63.5}$ =)

3.78×10^{-3} **or** 0.00378

1

(number of atoms =)

$0.00378 \times 6.02 \times 10^{23}$

allow correct use of an incorrectly calculated number of moles

1

$= 2.28 \times 10^{21}$

allow a correct evaluation to 3 significant figures of an incorrect expression which involves only a mass from the graph, the A_r of copper and the Avogadro constant

1

[17]

3.

(a) (negative electrode) solid produced

allow the electrode changes colour

ignore metal produced

1

(positive electrode) bubbles / fizzing / effervescence

ignore gas produced

1

(b) potassium nitrate

1

hydrogen is not a metal

allow hydrogen is a gas
allow hydrogen is not a solid
allow the products at both electrodes are gases
allow the product at the negative electrode is not potassium
allow potassium is more reactive than hydrogen

1

(c) (graphite) conducts (electricity)

allow (graphite) has delocalised / free electrons

1

(graphite) is inert

allow (graphite) is unreactive

1

(d) the ions move towards the positive electrode

1

the electrode attracts ions of the opposite charge

allow opposite charges attract

1

[8]

4. (a) nitric acid

1

(b) zinc oxide

1

(c) magnesium bromide

1

(d) (from 0) to 20 cm^3 the pH increases (gradually)

allow a tolerance of 1 cm^3 on volumes
allow a tolerance of 0.2 on pH values
allow increase from pH 1 to pH 3

1

at 20 cm^3 the pH changes from pH 3 to pH 11

allow sudden / steep increase at 20 cm^3
allow sudden / steep increase from pH 3 to pH 11

1

from 20 cm^3 the pH increases (gradually)

allow (gradual) increase from pH 11
*if no other marks awarded allow **1** mark for a description of the three stages with no values used.*

1

(e) 20 (cm^3)

allow 20.0 (cm^3)

1

(f) red

1

(g)

$$\frac{0.06}{25(.0)} \times 100$$

1

= 0.24 (%)

1

(h) (pipette) measures volume more accurately
or
(pipette has a) smaller (percentage) uncertainty

allow (pipette is) more accurate

1

[11]

5. (a) CrO_4^{2-} / chromate ions moved to the positive electrode

allow anode for positive electrode

allow yellow (coloured) ions moved to the positive electrode

1

(because) opposite charges attract

allow (because) negative ions are attracted to the positive electrode

1

(b) water

ignore copper chromate solution

1

(c) copper ions gain two electrons

allow Cu^{2+} for copper ions

*allow **1** mark for copper ions gain electrons*
or
*allow **1** mark for copper ions are reduced*
*do **not** accept copper ions are oxidised*

2

(to) form copper (atoms)

allow Cu for copper (atoms)

the equation:
$Cu^{2+} + 2e^- \rightarrow Cu$
*scores **3** marks*

1

(d) (negative electrode) hydrogen

allow H_2

1

(positive electrode) iodine

allow I_2

1

[8]

6. (a) concentration (of solution / electrolyte)

1

temperature (of solution / electrolyte)

ignore room temperature

allow volume (of solution / electrolyte)

allow size of electrodes

allow distance between electrodes

*do **not** accept electrode **X** unqualified*

*do **not** accept (measured) voltage*

1

(b) (most reactive) magnesium
allow Mg

zinc
allow Zn

(least reactive) cobalt
allow Co

1

(c) 0 (volts)

1

two different metals are needed to produce a voltage

dependent on voltage being given as 0 volts

allow the two electrodes are the same metal
allow there is no difference in reactivity (between the electrodes)

1

(d) connect cells (in series)

ignore putting cells together

1

use $\left(\frac{12}{1.5} =\right)$ 8 cells

1

(e) electric toy

1

(f) (advantage)
any **one** from:

- faster to refuel (than recharging)
- can travel further (before refuelling)
  allow lasts longer
- hydrogen can be renewable
  allow hydrogen is renewable
- produces a constant voltage
- no toxic chemicals released after disposal
  allow the only product is water
  ignore no emissions

1

(disadvantage)
any **one** from:

- hydrogen is made from fossil fuels
- hydrogen is made from non-renewable resources
- hydrogen is difficult to store
- hydrogen is flammable / explosive
- costs more to refuel (than recharging)
- costs more to manufacture

  ignore expensive unqualified
- not many hydrogen filling stations

1

[10]

7. (a) H^+

1

(b) hydrochloric (acid)

allow HCl

1

water

allow H_2O

1

(c) burette

*do **not** accept biuret*

1

(d) 27.6 (cm^3)

allow 27.60 (cm^3)

1

(e) **Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3–4

Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

allow converse using acid added to alkali

Key steps

- measure the volume of acid
- add indicator to the acid
- add sodium hydroxide solution
- until the colour changes
- record volume of sodium hydroxide solution added
- repeat procedure with the other acid

Use of results

- compare the two volumes of sodium hydroxide solution to find which sample **P** or **Q** is more concentrated

Other points

- pipette to measure volume of acid
- use a few drops of indicator
- swirl
- use a white tile
- rough titration to find approximate end point
- add dropwise near the endpoint
- read volume from bottom of meniscus
- repeat and take a mean

[11]