SPECIMEN MATERIAL

GCSE CHEMISTRY

H

Higher Tier Chemistry 1H

Specimen 2018 Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:

- a ruler
- a calculator
- the periodic table (enclosed).

Instructions

- Answer **all** questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- There are 100 marks available on this paper.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.
- When answering questions 02.3, 05.2, 08.5 and 09.4 you need to make sure that your answer:
  - is clear, logical, sensibly structured
  - fully meets the requirements of the question
  - shows that each separate point or step supports the overall answer.

Advice

In all calculations, show clearly how you work out your answer.

Please write clearly, in block capitals.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

Candidate signature _____

0 1 This question is about halogens and their compounds.

Table 1 shows the boiling points and properties of some of the elements in Group 7 of the periodic table.

Table 1

Element	**Boiling point in °C**	**Colour in aqueous solution**
Fluorine	-188	colourless
Chlorine	-35	pale green
Bromine	X	orange
Iodine	184	brown

0 1 . 1 Why does iodine have a higher boiling point than chlorine?

[1 mark]

Tick **one** box.

- Iodine is ionic and chlorine is covalent ☐
- Iodine is less reactive than chlorine ☐
- The covalent bonds between iodine atoms are stronger ☐
- The forces between iodine molecules are stronger ☐

0 1 . 2 Predict the boiling point of bromine.

[1 mark]

A redox reaction takes place when aqueous chlorine is added to potassium iodide solution.

The equation for this reaction is:

$$Cl_2(aq) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$$

0 1 . 3 Look at **Table 1**.

What is the colour of the final solution in this reaction?

[1 mark]

Tick **one** box.

- Brown ☐
- Orange ☐
- Pale green ☐
- Colourless ☐

0 1 . 4 What is the ionic equation for the reaction of chlorine with potassium iodide?

[1 mark]

Tick **one** box.

- $Cl_2 + 2K \rightarrow 2KCl$ ☐
- $2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$ ☐
- $I^- + Cl \rightarrow I + Cl^-$ ☐
- $I^- + K^+ \rightarrow KI$ ☐

Question 1 continues on the next page

0 1 . 5 Why does potassium iodide solution conduct electricity?

[1 mark]

Tick **one** box.

- It contains a metal ☐
- It contains electrons which can move ☐
- It contains ions which can move ☐
- It contains water ☐

0 1 . 6 What are the products of electrolysing potassium iodide solution?

[1 mark]

Tick **one** box.

Product at cathode	**Product at anode**	
hydrogen	iodine	☐
hydrogen	oxygen	☐
potassium	iodine	☐
potassium	oxygen	☐

0 2 An atom of aluminium has the symbol $^{27}_{13}Al$

0 2 . 1 Give the number of protons, neutrons and electrons in this atom of aluminium.

[3 marks]

Number of protons _____

Number of neutrons _____

Number of electrons _____

0 2 . 2 Why is aluminium positioned in Group 3 of the periodic table?

[1 mark]

_____

_____

Question 2 continues on the next page

0 2 . 3 In the periodic table, the transition elements and Group 1 elements are metals.

Some of the properties of two transition elements and two Group 1 elements are shown in **Table 2**.

Table 2

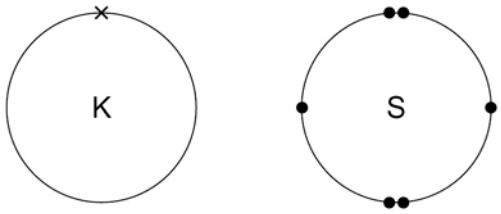
	Transition elements		**Group 1 elements**	
	Chromium	Iron	Sodium	Caesium
Melting point in °C	1857	1535	98	29
Formula of oxides	CrO Cr_2O_3 CrO_2 CrO_3	FeO Fe_2O_3 Fe_3O_4	Na_2O	Cs_2O

Use your own knowledge **and** the data in **Table 2** to compare the chemical and physical properties of transition elements and Group 1 elements.

[6 marks]

0 3 **Figure 1** shows the outer electrons in an atom of the Group 1 element potassium and in an atom of the Group 6 element sulfur.

Figure 1



0 3 . 1 Potassium forms an ionic compound with sulfur.

Describe what happens when **two** atoms of potassium react with **one** atom of sulfur.

Give your answer in terms of electron transfer.

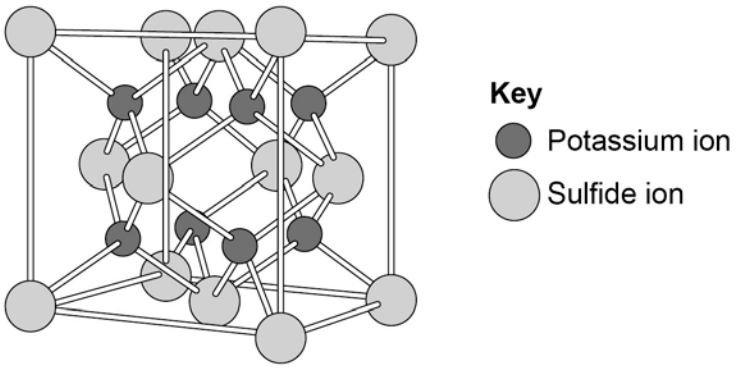
Give the formulae of the ions formed.

[5 marks]

Question 3 continues on the next page

0 3 . 2 The structure of potassium sulfide can be represented using the ball and stick model in **Figure 2**.

Figure 2



The ball and stick model is **not** a true representation of the structure of potassium sulfide.

Give **one** reason why.

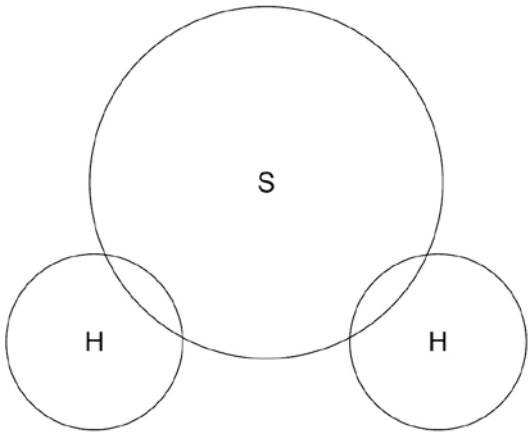
[1 mark]

0 3 . 3 Sulfur can also form covalent bonds.

Complete the dot and cross diagram to show the covalent bonding in a molecule of hydrogen sulfide.

Show the outer shell electrons only.

[2 marks]



0 3 . 4 Calculate the relative formula mass (M_r) of aluminium sulfate, $Al_2(SO_4)_3$

Relative atomic masses (A_r): oxygen = 16; aluminium = 27; sulfur = 32

[2 marks]

Relative formula mass = _____

Question 3 continues on the next page

0 3 . 5 Covalent compounds such as hydrogen sulfide have low melting points and do **not** conduct electricity when molten.

Draw **one** line from each property to the explanation of the property.

[2 marks]

Property	Explanation of property
Low melting point	There are no charged particles free to move
Does not conduct electricity when molten	Bonds are weak
	Electrons are free to move
	Ions are free to move
	Weak intermolecular forces of attraction
	Bonds are strong

0 3 . 6 Ionic compounds such as potassium sulfide have high boiling points and conduct electricity when dissolved in water.

Draw **one** line from each property to the explanation of the property.

[2 marks]

Property	Explanation of property
High boiling point	There are no charged particles free to move
Conduct electricity when molten	Ions are free to move
	Weak intermolecular forces of attraction
	Bonds are weak
	Bonds are strong

Turn over for the next question

0 4 Rock salt is a mixture of sand and salt.

Salt dissolves in water. Sand does **not** dissolve in water.

Some students separated rock salt.

This is the method used.

1. Place the rock salt in a beaker.
2. Add 100 cm^3 of cold water.
3. Allow the sand to settle to the bottom of the beaker.
4. Carefully pour the salty water into an evaporating dish.
5. Heat the contents of the evaporating dish with a Bunsen burner until salt crystals start to form.

0 4 . 1 Suggest **one** improvement to step 2 to make sure all the salt is dissolved in the water.

[1 mark]

0 4 . 2 The salty water in step 4 still contained very small grains of sand.

Suggest **one** improvement to step 4 to remove all the sand.

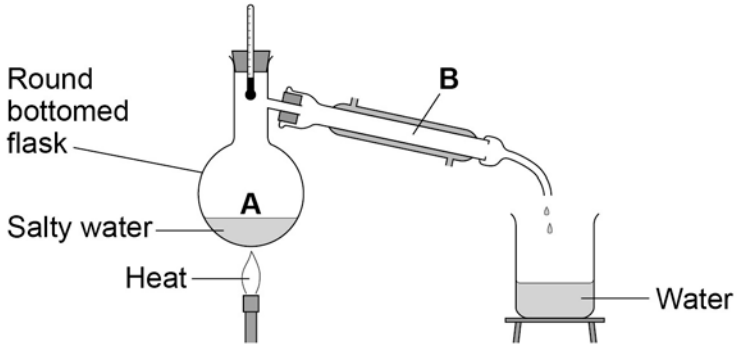
[1 mark]

0 4 . 3 Suggest **one** safety precaution the students should take in step 5.

[1 mark]

Another student removed water from salty water using the apparatus in **Figure 3**.

Figure 3



0 4 . 4 Describe how this technique works by referring to the processes at **A** and **B**.

[2 marks]

0 4 . 5 What is the reading on the thermometer during this process?

[1 mark]

_____ °C

0 5 A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

0 5 . 1 Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

[4 marks]

0 5 . 2 A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$$

Relative atomic masses, A_r: H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

[4 marks]

Mass of copper carbonate = _____ g

0 5 . 3 The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced.

[2 marks]

Actual mass of copper chloride produced = _____ g

Question 5 continues on the next page

0 5 . 4 Look at the equations for the two reactions:

Reaction 1 $CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l) + CO_2(g)$

Reaction 2 $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

Reactive formula masses: CuO = 79.5; HCl = 36.5; $CuCl_2$ = 134.5; H_2O = 18

The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

Calculate the percentage atom economy for Reaction 2.

[3 marks]

Percentage atom economy = _____ %

0 5 . 5 The atom economy for Reaction 1 is 68.45 %.
Compare the atom economies of the two reactions for making copper chloride.

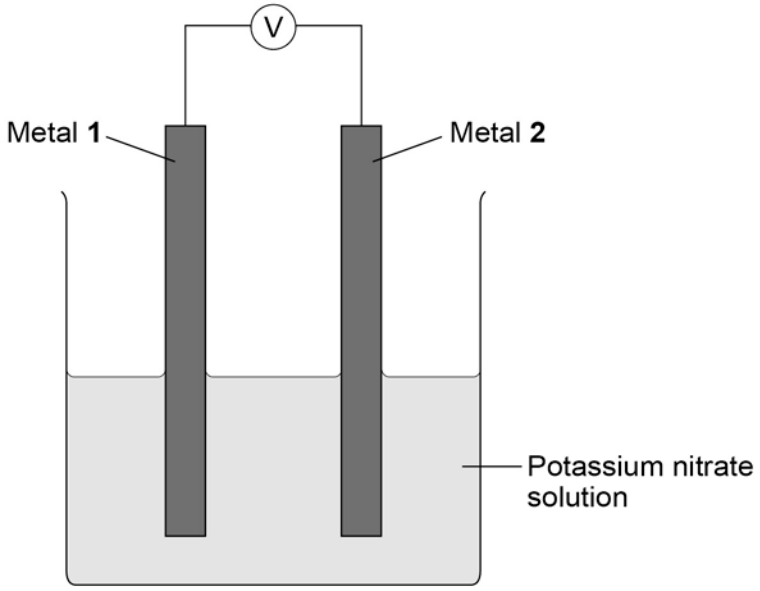
Give a reason for the difference.

[1 mark]

Turn over for the next question

0 6 A student investigated simple cells using the apparatus shown in **Figure 4**.

Figure 4



- If metal **2** is more reactive than metal **1** then the voltage measured is positive.
- If metal **1** is more reactive than metal **2** then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

The student's results are shown in **Table 3**.

Table 3

Metal 2 / Metal 1	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0 V				
Copper	1.2 V	0.0 V			
Iron	0.5 V	not measured	0.0 V		
Tin	0.8 V	-0.4 V	0.3 V	0.0 V	
Zinc	0.2 V	-1.0 V	-0.3 V	-0.6 V	0.0 V

0 6 . 1 The ionic equation for the reaction occuring at the zinc electrode in the simple cell made using copper and zinc electrodes is:

$$Zn \rightarrow Zn^{2+} + 2e^-$$

Zinc is oxidised in this reaction.

Give a reason why this is oxidation.

[1 mark]

0 6 . 2 Look at **Table 3**.

Which **one** of the metals used was the least reactive?

Give a reason for your answer.

[2 marks]

Metal

Reason

Question 6 continues on the next page

0 6 . 3 Predict the voltage that would be obtained for a simple cell that has iron as metal **1** and copper as metal **2**.

Explain your answer.

[3 marks]

0 6 . 4 Hydrogen fuel cells have been developed for cars.

Write a word equation for the overall reaction that takes place in a hydrogen fuel cell.

[1 mark]

0 6 . 5 Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

[2 marks]

Turn over for the next question

0 7 Sodium carbonate reacts with dilute hydrochloric acid:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

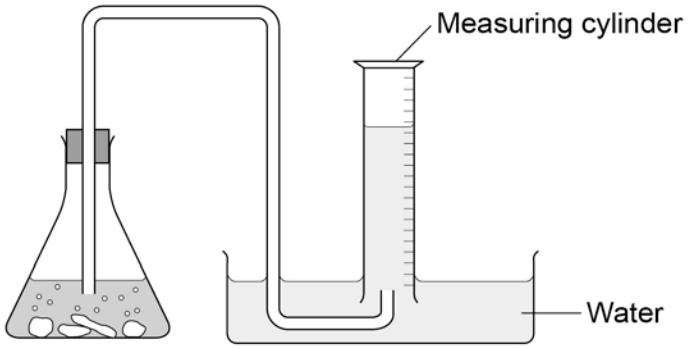
A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas until the reaction is complete.

0 7 . 1 The student set up the apparatus as shown in **Figure 5**.

Figure 5



Identify the error in the way the student set up the apparatus.

Describe what would happen if the student used the apparatus shown.

[2 marks]

The student corrected the error.

The student's results are shown in **Table 4**.

Table 4

Mass of sodium carbonate in g	Volume of carbon dioxide gas in cm^3
0.07	16.0
0.12	27.5
0.23	52.0
0.29	12.5
0.34	77.0
0.54	95.0
0.59	95.0
0.65	95.0

0 7 . 2 The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

[1 mark]

0 7 . 3 Why does the volume of carbon dioxide collected stop increasing at 95.0 cm^3?

[1 mark]

Question 7 continues on the next page

0 7 . 4 What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm^3 of carbon dioxide?

[1 mark]

0 7 . 5 The carbon dioxide was collected at room temperature and pressure.
The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3.

How many moles of carbon dioxide is 95.0 cm^3?

Give your answer in three significant figures.

[2 marks]

_____ mol

0 7 . 6 Suggest **one** improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

[2 marks]

0 7 . 7 One student said that the results of the experiment were wrong because the first few bubbles of gas collected were air.

A second student said this would make no difference to the results.

Explain why the second student was correct.

[2 marks]

Turn over for the next question

0 8 Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

0 8 . 1 Sulfuric acid is a strong acid.

What is meant by a strong acid?

[2 marks]

0 8 . 2 Write the ionic equation for this neutralisation reaction. Include state symbols.

[2 marks]

A student used a pipette to add 25.0 cm^3 of sodium hydroxide of unknown concentration to a conical flask.

The student carried out a titration to find out the volume of 0.100 mol/dm^3 sulfuric acid needed to neutralise the sodium hydroxide.

0 8 . 3 Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen.

[4 marks]

Question 8 continues on the next page

The student carried out five titrations. Her results are shown in **Table 5**.

Table 5

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of 0.100 mol/dm^3 sulfuric acid in cm^3	27.40	28.15	27.05	27.15	27.15

0 8 . 4 Concordant results are within 0.10 cm^3 of each other.

Use the student's concordant results to work out the mean volume of 0.100 mol/dm^3 sulfuric acid added.

[2 marks]

Mean volume = _____ cm^3

0 8 . 5 The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures.

[4 marks]

Concentration = _____ mol/dm^3

0 8 . 6 The student did another experiment using 20 cm^3 of sodium hydroxide solution with a concentration of 0.18 mol/dm^3.

Relative formula mass (M_r) of NaOH = 40

Calculate the mass of sodium hydroxide in 20 cm^3 of this solution.

[2 marks]

Mass = _____ g

Turn over for the next question

0 9 This question is about the reaction of ethene and bromine.

The equation for the reaction is:

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

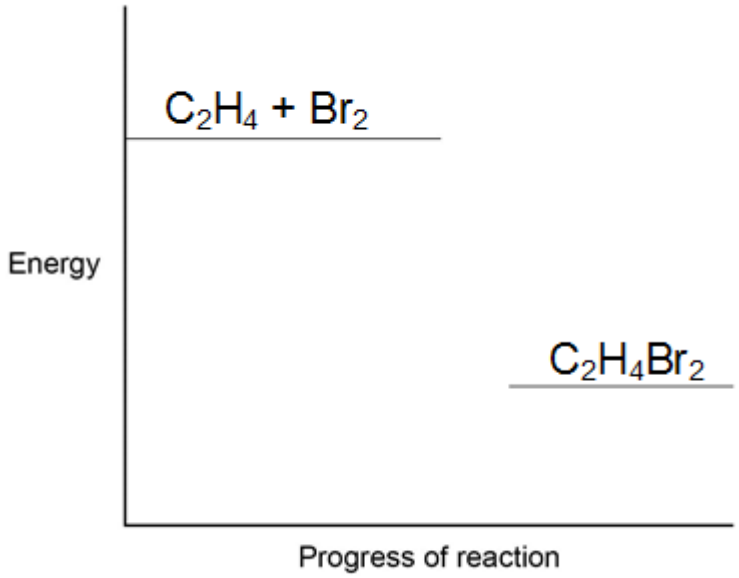
0 9 . 1 Complete the reaction profile in **Figure 6**.

Draw labelled arrows to show:

- The energy given out (ΔH)
- The activation energy.

[3 marks]

Figure 6



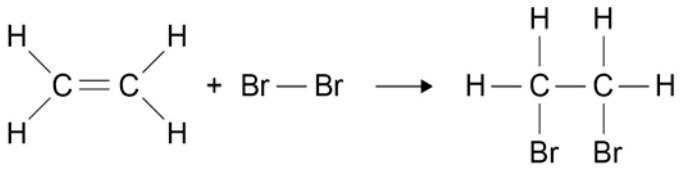
0 9 . 2 When ethene reacts with bromine, energy is required to break covalent bonds in the molecules.

Explain how a covalent bond holds two atoms together.

[2 marks]

Figure 7 shows the displayed formulae for the reaction of ethene with bromine.

Figure 7



The bond enthalpies and the overall energy change are shown in **Table 6**.

Table 6

	C=C	**C–H**	**C–C**	**C–Br**	**Overall energy change**
Energy in kJ/mole	612	412	348	276	-95

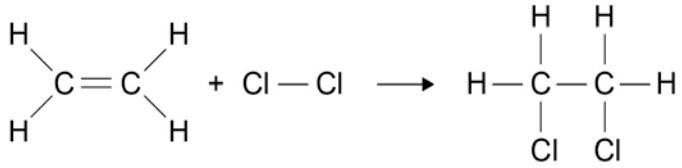
0 9 . 3 Use the information in **Table 6** and **Figure 7** to calculate the bond energy for the Br–Br bond.

[3 marks]

Bond energy _____ kJ/mole

0 9 . 4 **Figure 8** shows the reaction between ethene and chlorine and is similar to the reaction between ethene and bromine.

Figure 8



"The more energy levels (shells) of electrons an atom has, the weaker the covalent bonds that it forms."

Use the above statement to predict and explain how the overall energy change for the reaction of ethene with chlorine will differ from the overall energy change for the reaction of ethene with bromine.

[6 marks]

END OF QUESTIONS

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