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Tuesday 10 November – Morning

GCSE (9–1) Combined Science B (Twenty First Century Science)

J260/06 Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

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You must have:
- a ruler (cm/mm)
- the Data Sheet for GCSE (9-1) Combined Science (Chemistry) B (inside this document)

You can use:
- an HB pencil
- a scientific or graphical calculator

J260006

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **95**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*****).
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

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Answer **all** the questions.

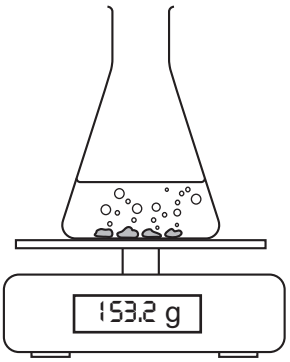
1 Sundip investigates the rate of reaction between calcium carbonate and hydrochloric acid.

This is the symbol equation for the reaction.

$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

She adds 50 cm^3 of 1 mol / dm^3 hydrochloric acid to a flask and puts the flask on a balance.

She adds 10 g of calcium carbonate pieces to the acid.



She measures the mass of the flask and its contents at the start, and again after 1 minute.

Results

Mass of flask and contents at the start	=	153.2 g
Mass of flask and contents after 1 minute	=	152.5 g

(a) (i) Why does the mass of the flask and its contents decrease after 1 minute?

Tick (✓) **one** box.

- Gases are lighter than liquids. ☐
- Gas particles leave the flask. ☐
- The products have less total mass than the reactants. ☐
- The reactants have less total mass than the products. ☐

[1]

(ii) Calculate the rate of reaction for this experiment.

Use the equation: rate of reaction (g / s) = $\frac{\text{change in mass (g)}}{\text{time (s)}}$

Give your answer to **2** significant figures.

Rate of reaction = ... g / s

[3]

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(b) What can Sundip do to make the reaction faster?

Tick (✓) **two** boxes.

Use a smaller volume of acid. ☐

Use larger pieces of calcium carbonate. ☐

Use a lower temperature. ☐

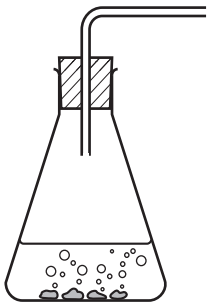
Use more concentrated acid. ☐

Use powdered calcium carbonate instead of pieces ☐

[2]

(c) Sundip also collects and measures the volume of gas given off during the reaction.

(i) Complete the diagram to show how she could measure the volume of gas given off.



[2]

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(ii) Sundip measures the volume of gas given off after 1 minute.

She repeats the experiment at different temperatures. Here are her results.

Temperature (°C)	20	30	40	50
Volume of gas given off after 1 minute (cm^3)	11	22	44	88

Sundip looks at her results and writes this relationship.

rate of reaction ∝ temperature

Do Sundip's results agree with this relationship?

Yes ☐

No ☐

Use Sundip's results to explain your answer.

.....

.....

.....

..... **[2]**

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2 Elements in the Periodic Table are arranged in order of atomic number.

(a) The atomic number and relative atomic mass of an element can be used to work out the number of protons, electrons and neutrons in its atoms and ions.

Complete the table.

Use the Data Sheet.

Symbol	Na **atom**	F^- **ion**
Atomic number	.....	9
Number of protons	11	9
Number of electrons	.....	.....
Number of neutrons	.....	.....

[3]

(b) **(i)** Magnesium is a metal and phosphorus is a non-metal.

They have different electron arrangements.

	Electron arrangement
Magnesium	2.8.2
Phosphorus	2.8.5

How do the electron arrangements of magnesium and phosphorus show that they are in the same **period** but in different **groups**?

Same period.....

.....

Different groups .....

.....

[2]

(ii) The electron arrangement of argon is 2.8.8.

What does this tell you about the reactivity of argon?

.....

..... **[1]**

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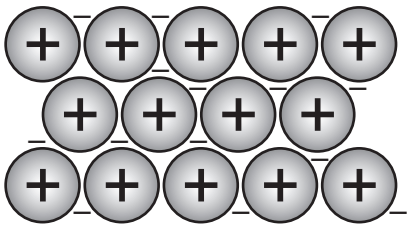
(c) The diagram shows how the particles in magnesium metal are arranged.



(i) Complete the key to the diagram.

Key

+	
–	

[1]

(ii) The structure of metals explains why their properties are different from those of non-metals.

Draw lines to connect each metal property with its explanation.

Metal Property	Explanation
	Metal ions can slide over each other
Malleable	
	Metal ions have positive charges
Solid metal conducts electricity	
	Outer shell electrons move freely
High melting point	
	Strong attraction between charged particles in the metal structure

[2]

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3 **Fig. 3.1** shows a model for the arrangement of particles in solids, liquids, and gases.

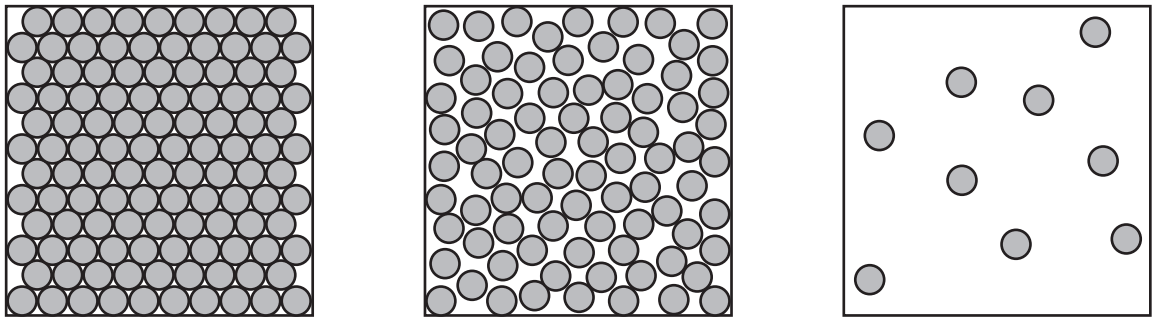

Fig 3.1

Bromine (Br_2) and water (H_2O) are both liquids at room temperature (20 °C).

The table shows their melting and boiling points.

	Melting point (°C)	Boiling point (°C)
Bromine	−7	59
Water	0	100

(a) (i) Describe what happens to the arrangement and movement of the **particles** in bromine and water when the temperature changes from −1 °C to 70 °C.

Bromine.....

.....

.....

.....

Water .....

.....

.....

.....

[4]

(ii) Give **two** ways in which the gas particles in **bromine gas** are different from the gas particles shown in **Fig. 3.1**.

1 .....

.....

2 .....

.....

[2]

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(b) (i) The melting point of a substance can be used to test its purity.

Ben measures the melting point of an aspirin tablet and compares his results with the melting point given in a data book.

How will his results compare with those in the data book if the aspirin is **impure**?

Explain your answer.

.....

.....

.....

..... **[2]**

(ii) Which other experiment can Ben use to find out whether his sample of aspirin is **pure**?

Tick (✓) **one** box.

Dissolve the aspirin in water ☐

Use paper chromatography ☐

Do a flame test ☐

React the aspirin with a dilute acid ☐

[1]

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4 Atoms contain protons, neutrons and electrons.

(a) (i) Complete the table to show the relative masses and charges of these particles.

Particle	Relative mass	Relative charge
Proton	.....	.....
Neutron	.....	.....
Electron	.....	.....

[2]

(ii) Describe how these **three** particles are arranged in an atom.

.....

.....

.....

..... **[2]**

(b) James builds a model of an atom.

He uses a golf ball with a diameter of 43 mm to represent the nucleus in his model.

The diameter of an atom is 1×10^5 times larger than the diameter of its nucleus.

What diameter should James use for his model of the atom?

Give your answer in **metres**.

Diameter of model of atom = ... m **[2]**

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5 Carbon compounds form molecules of many different shapes and sizes.

(a) **(i)** How many bonds does carbon form when it makes molecules?

.....

[1]

(ii) Give **two** reasons why carbon forms molecules of many different shapes and sizes.

1 .....

.....

2 .....

.....

[2]

(b) Carbon compounds are grouped into families called homologous series.

(i) Members of the alkane homologous series all have the general formula, C_nH_{2n+2}.

What is the formula of the alkane with 6 carbon atoms?

.....

[1]

(ii) Give **two other** properties of a homologous series.

1. .....

.....

2. .....

.....

[2]

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6* Information about the bonding, structure and melting points of **three** different compounds are shown in the table.

Compound	Sodium chloride	Phosphorus(III) chloride	PVC
Formula	$NaCl$	PCl_3	$(C_2H_3Cl)_n$
Type of bonding and structure	ionic	simple covalent molecules	covalent polymer
Melting point (°C)	801	−96	100–260

Describe and explain the differences in the melting points of the **three** compounds.

Use ideas about their structures, bonding, and intermolecular forces in your answer.

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..... **[6]**

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7 **Fig. 7.1** shows the change in concentration of carbon dioxide in the atmosphere from 1500 to 2000.

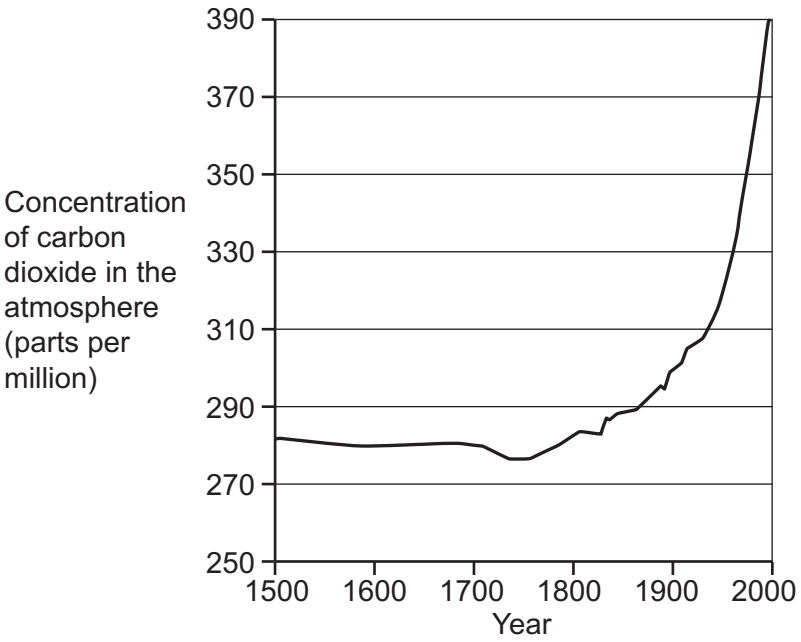

Fig. 7.1

Fig. 7.2 shows the total world carbon emissions from fossil fuels from 1700 to 2014.

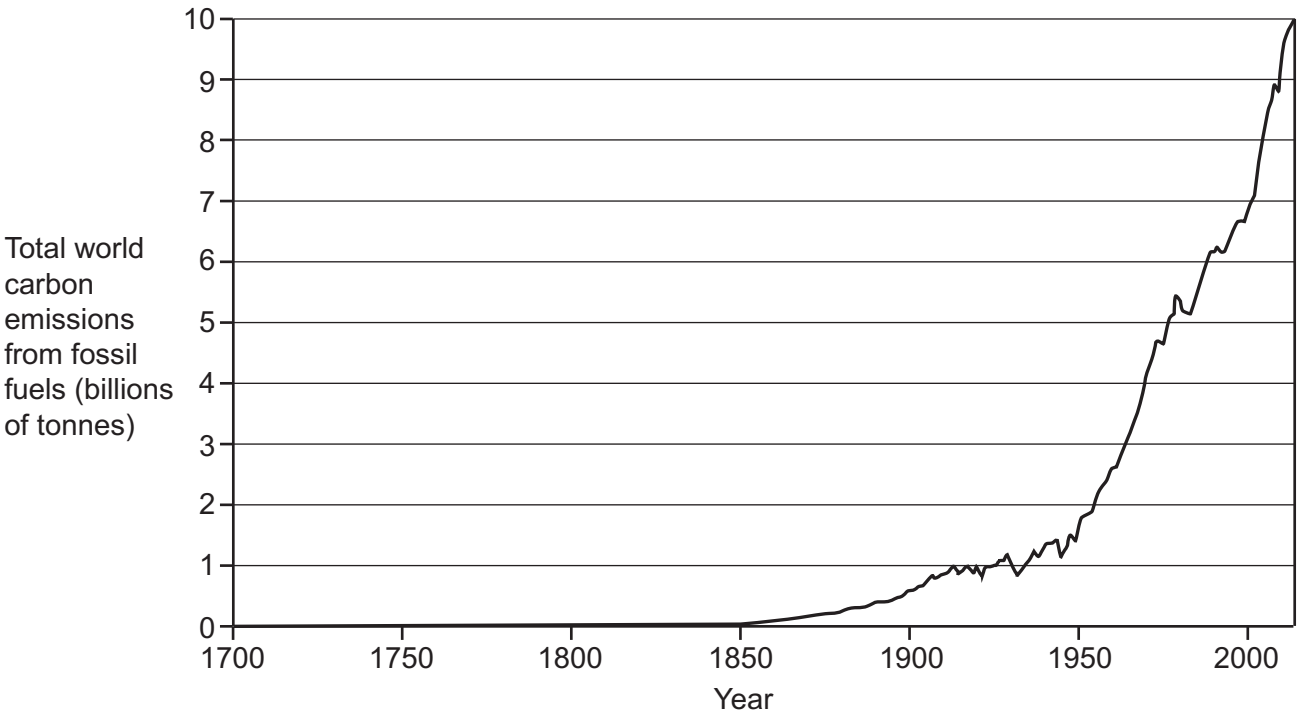

Fig. 7.2

(a) Describe the relationship between the concentration of carbon dioxide in the atmosphere and the total world carbon emissions from fossil fuels, shown by **Fig. 7.1** and **Fig. 7.2**.

.....

..... **[1]**

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(b) Scientists are developing ways of reducing the concentration of carbon dioxide in the atmosphere, because of the link between increased greenhouse gas emissions and recent climate change.

One way of reducing the concentration of carbon dioxide in the atmosphere is by using alternative sources of energy instead of fossil fuels.

Suggest **two** other ways that the concentration of carbon dioxide in the atmosphere can be reduced.

1 .....

2 .....

[2]

(c) Electric cars are being developed to reduce the dependency on fossil-fuel powered cars.

An electric car has a battery which is recharged by mains electricity.

(i) Discuss the use of electric cars as a way of reducing the concentration of carbon dioxide in the atmosphere.

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..... **[3]**

(ii) Mia drives 15 000 km in her car each year.

She used to drive a car which burned 1200 kg of petrol each year. Each kilogram of petrol produced 2.1 kg of carbon dioxide.

Mia now drives a new car which produces 90 g of carbon dioxide per km.

Calculate the decrease in the mass of carbon dioxide produced in one year in Mia's new car compared to her old one.

Decrease in mass of carbon dioxide = ... kg **[4]**

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8 Jamal is researching the mole, and the Avogadro constant.

(a) (i) Draw lines to connect the Avogadro constant and the mole with their definitions.

	Definition
The mole	The amount of substance containing the same number of particles as there are atoms in 12 g of carbon-12.
	The number of atoms in 1 kg of carbon-12.
Avogadro constant	The number of atoms in 12 g of carbon-12.
	The mass of 1 million atoms.

[2]

(ii) 1 mole of a substance contains 6.0×10^{23} molecules.

Complete the table by calculating the missing values.

Substance	**Relative formula mass**	**Mass of substance (g)**	**Number of moles of substance**	**Number of molecules**
O_2	32	32	1	6.0×10^{23}
H_2	2	.....	2	.....
H_2O	.....	9	0.5	.....

[3]

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(iii) Counting atoms and molecules is important when balancing symbol equations.

This is the balanced symbol equation for the reaction between hydrogen and oxygen.

$2H_2 + O_2 \longrightarrow 2H_2O$

Which statements about the balanced symbol equation are **true** and which are **false**?

Tick (✓) **one** box in each row.

Statement	true	false
The total number of reactant molecules is the same as the total number of product molecules.		
The total number of reactant atoms is the same as the total number of product atoms.		
The number of each type of atom in the reactants is equal to the number of each type of atom in the products.		

[2]

(b) Jamal reads about an experiment where 6.2 g of phosphorus (P) reacts with 21.3 g of chlorine (Cl_2) gas to form phosphorus chloride.

$2P(s) + xCl_2(g) \longrightarrow 2PCl_x(s)$

(i) Calculate the number of moles of chlorine that react with **2** moles of phosphorus.

Use the relationship: number of moles $= \dfrac{\text{mass of substance (g)}}{\text{relative formula mass (g)}}$

$A_r(Cl) = 35.5$ $A_r(P) = 31$

Moles of chlorine = ... **[3]**

(ii) Explain the effect on the mass of phosphorus chloride formed if **50 g** of chlorine is added to 6.2 g of phosphorus.

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..... **[2]**

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9 Beth has **four** solutions, **A**, **B**, **C** and **D**, two of which contain dilute hydrochloric acid, and two of which contain dilute ethanoic acid, as shown in **Table 9.1**.

	Hydrochloric acid		Ethanoic acid	
	Solution A	**Solution B**	**Solution C**	**Solution D**
Concentration (mol/dm^3)	0.1	0.01	1.0	0.1
Concentration of H^+ ions (mol/dm^3)	1×10^{-1}	1×10^{-2}	1×10^{-2}	1×10^{-3}
pH	1	2	2	3

Table 9.1

(a) (i) Give **two** ways in which **Table 9.1** shows that ethanoic acid and hydrochloric acid are both acids.

1 .....

2 .....

[2]

(ii) Predict the pH and concentration of hydrogen ions for a solution of 0.001 mol/dm^3 hydrochloric acid.

pH = ...

Concentration of hydrogen ions = ... mol/dm^3

[2]

(b) Hydrochloric acid is a strong acid. Ethanoic acid is a weak acid.

(i) Explain what is meant by a strong acid and a weak acid.

.....

.....

.....

..... **[2]**

(ii) How does the information in **Table 9.1** show that hydrochloric acid is a strong acid and ethanoic acid is a weak acid?

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..... **[2]**

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(c) Magnesium reacts with hydrogen ions in dilute acid to form magnesium ions and hydrogen gas.

(i) Write the **ionic** equation for this reaction.

..... **[2]**

(ii) Beth adds 10 g of magnesium ribbon to 100 cm^3 of the four solutions.

She measures how long it takes to collect 10 cm^3 of hydrogen for each acid.

Her results are shown in **Table 9.2**.

	Hydrochloric acid		**Ethanoic acid**	
	Solution A	**Solution B**	**Solution C**	**Solution D**
Concentration (mol/dm^3)	0.1	0.01	1.0	0.1
Concentration of H^+ ions (mol/dm^3)	1×10^{-1}	1×10^{-2}	1×10^{-2}	1×10^{-3}
Time taken to collect 10 cm^3 hydrogen (s)	39	388	392	More than 1 hour

Table 9.2

Compare the rates of reaction for solutions **A**, **B** and **C**.

Use data from **Table 9.2** to support your answer.

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.....

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..... **[3]**

(iii) Solutions **A** and **D** both have concentrations of 0.1 mol/dm^3.

Explain why solution **D** takes much longer to react than solution **A**.

Use data from **Table 9.2** to support your answer.

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..... **[2]**

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10 Electrolysis of molten sodium chloride produces sodium metal and chlorine gas.

These are the half equations for the reaction at each electrode.

Positive electrode: $2Cl^- \longrightarrow Cl_2 + 2e^-$

Negative electrode: $Na^+ + e^- \longrightarrow Na$

(a) Explain the reactions at each electrode when molten sodium chloride is electrolysed.

Use ideas about oxidation, reduction, and electrons in your answer.

.....

.....

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.....

..... **[3]**

(b) Alex electrolyses a **solution** of sodium chloride.

(i) Draw a fully labelled diagram in the box to show how he does this.

[2]

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(ii) Sodium chloride solution contains sodium and chloride ions dissolved in water.

Give the **names** and **formulae** for the ions that come from the **water**.

Names: ..... **and** .....

Formulae: ..... **and** .....

[2]

(iii) When Alex passes electricity through the sodium chloride solution, he sees bubbles of hydrogen gas forming at the negative electrode.

Explain why, at the negative electrode, **sodium** metal is produced when molten sodium chloride is electrolysed but **hydrogen** gas is produced when sodium chloride solution is electrolysed.

Use ideas about reactivity in your answer.

.....

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.....

..... **[3]**

(iv) Suggest what Alex could do to test for the presence of chlorine gas at the positive electrode, and what the test will show if chlorine gas is present.

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..... **[2]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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