OCR
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Friday 20 November 2020 – Morning

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

J258/04 Depth in Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

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

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

J258/04

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 **90**.
- 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 **24** pages.

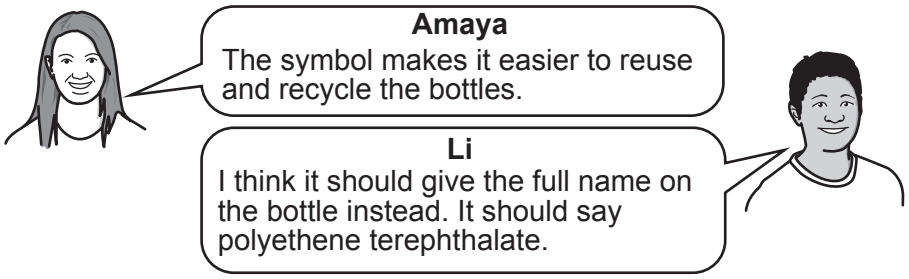
ADVICE
- Read each question carefully before you start your answer.

Answer **all** the questions.

1 Mixed plastic waste contains drinks bottles made from a polymer known as PET (polyethene terephthalate).

Bottles made from PET have this symbol on the bottle.

(a) Amaya and Li discuss the PET symbol.



Do you agree with each person's comments?

Give **one** reason for each of your answers.

Amaya .....

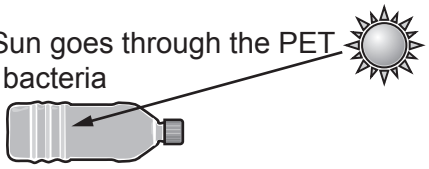
.....

Li .....

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

(b) In some countries, waste PET bottles are used to treat water to make it safe for drinking. They are washed and dried first, and then filled with water and left in the Sun.

UV radiation from the Sun goes through the PET into the water and kills bacteria



(i) If glass bottles are used instead of PET bottles, the bacteria are not killed.

Suggest why bacteria in water in a glass bottle are not killed.

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

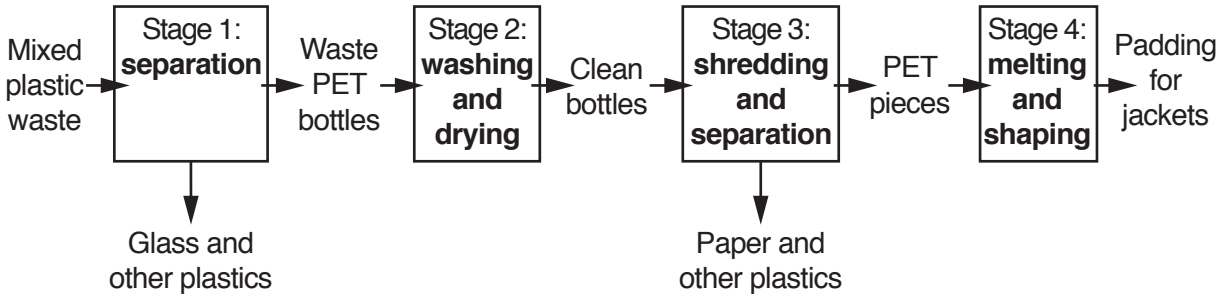
(ii) In the UK, bacteria in drinking water are killed by adding a substance to the water.

Name this substance.

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

(c) Waste PET bottles can also be processed to be remade into polymers for new products.

The flowchart shows how mixed plastic waste is processed to produce padding for jackets.



(i) Which stage of the flowchart produces pure PET?

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

(ii) Waste PET bottles that are used to treat water are removed from the process before the end.

After which stage should bottles that are used to treat water be removed?

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

(d) Using waste PET bottles to treat water or to make padding for jackets are two examples of ways to reduce mixed plastic waste.

Explain the difference between **reusing** and **recycling** PET bottles using these two examples.

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.....

.....

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

(e) Waste PET bottles used to treat water and to make padding for jackets have different Life Cycle Assessments.

Give **two** reasons why their Life Cycle Assessments are different.

1. .....

.....

2. .....

.....

[2]

2 Sundip passes electricity through solutions of some ionic compounds and finds out what products are formed at the positive and negative electrodes.

(a) Here are Sundip's results.

Solution	Product at positive electrode	Product at negative electrode
concentrated sodium chloride	chlorine gas	hydrogen gas
dilute sodium chloride	oxygen gas	hydrogen gas
dilute copper chloride	chlorine gas	copper metal
concentrated copper sulfate	oxygen gas	copper metal
concentrated copper chloride	.....	.....
dilute sodium sulfate	.....	.....

(i) Complete the table by predicting the products formed at each electrode when electricity is passed through concentrated copper chloride and dilute sodium sulfate. **[3]**

(ii) Sundip uses tests to identify the gases formed in her experiments.

Draw lines to connect each **gas** to its correct **test and result**.

Gas	Test and result
	relights a glowing splint
chlorine	makes a lighted splint go 'pop'
oxygen	turns lime water milky
hydrogen	turns blue litmus red and then bleaches it
	turns red litmus blue and then bleaches it

[2]

(iii) Explain why, at the negative electrode:

- **copper** metal is formed when electricity is passed through dilute copper chloride, **but**
- **hydrogen** gas is formed when electricity is passed through dilute sodium chloride.

.....

.....

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

(b) This is a list of apparatus Sundip uses to pass electricity through the solution of dilute sodium chloride:

- electrodes
- leads and clips
- a battery
- a beaker
- the solution of sodium chloride.

Draw a labelled diagram in the **box** to show how Sundip sets up her experiment to pass electricity through the solution of dilute sodium chloride.

[2]

3 Crude oil is a source of useful chemicals.

(a) Which **two** statements about crude oil are correct?

Tick (✓) **two** boxes.

Crude oil contains hydrocarbons which are used as fuels. ☐

All crude oil compounds have the same empirical formula. ☐

Most compounds in crude oil are alkenes. ☐

Crude oil is a renewable resource. ☐

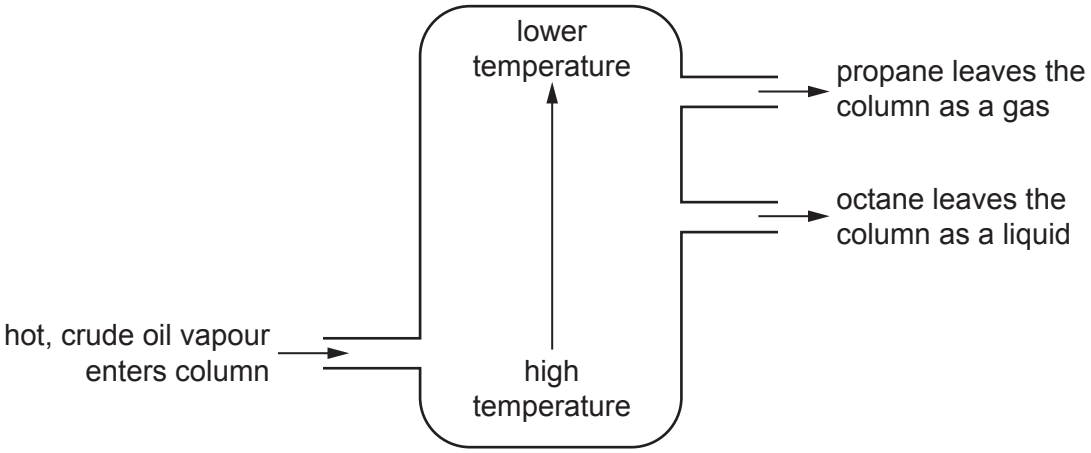
Compounds from crude oil are used as a feedstock for petrochemicals. ☐

[2]

(b) Crude oil is separated using fractional distillation.

Two compounds in crude oil are propane, C_3H_8, and octane, C_8H_{18}.

The diagram shows where hot, crude oil vapour enters and where propane gas and octane liquid leave the fractionating column.



Explain how propane and octane are separated in the column.

Use ideas about boiling points and intermolecular forces in your answer.

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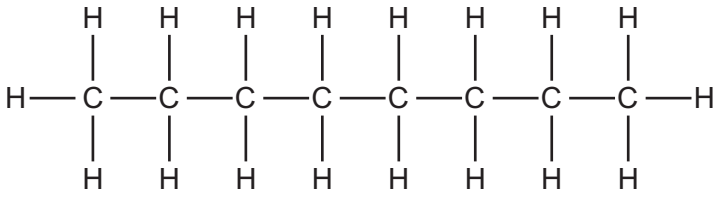
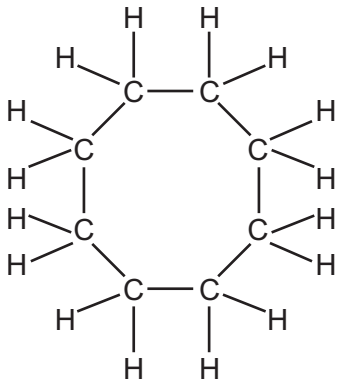
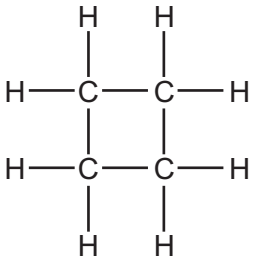
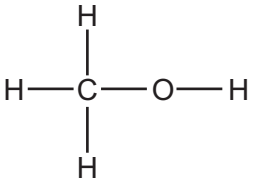
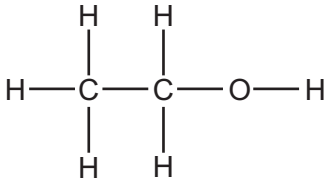
..... **[3]**

(c) Petrol contains octane, C_8H_{18}, mixed with other carbon compounds.

The table shows octane and some other compounds in petrol.

Type of compound	**Example**	
alkane	 **Name:** octane	
cycloalkane	 **Name:** …….	 **Name:** …….
alcohol	 **Name:** methanol	 **Name:** ethanol

(i) Complete the table by suggesting the names for each cycloalkane. **[2]**

(ii) The general formula for alkanes is C_nH_{2n+2}.

Suggest the general formulae for cycloalkanes and alcohols.

Use the examples in the table to help you.

General formula of cycloalkanes C_n .....

General formula of alcohols C_n .....

[2]

(iii) Carbon makes a greater range of different compounds than any other element.

Which **two** statements explain why?

Tick (✓) **two** boxes.

Carbon has a total of four electrons. ☐

Carbon forms four covalent bonds. ☐

Carbon forms compounds with oxygen and hydrogen. ☐

Carbon atoms can join together in chains and rings. ☐

Carbon is very abundant on Earth. ☐

[2]

4 Beth does an experiment to measure the rate of reaction between zinc and dilute hydrochloric acid.

(a) Complete the word and balanced symbol equation for the reaction.

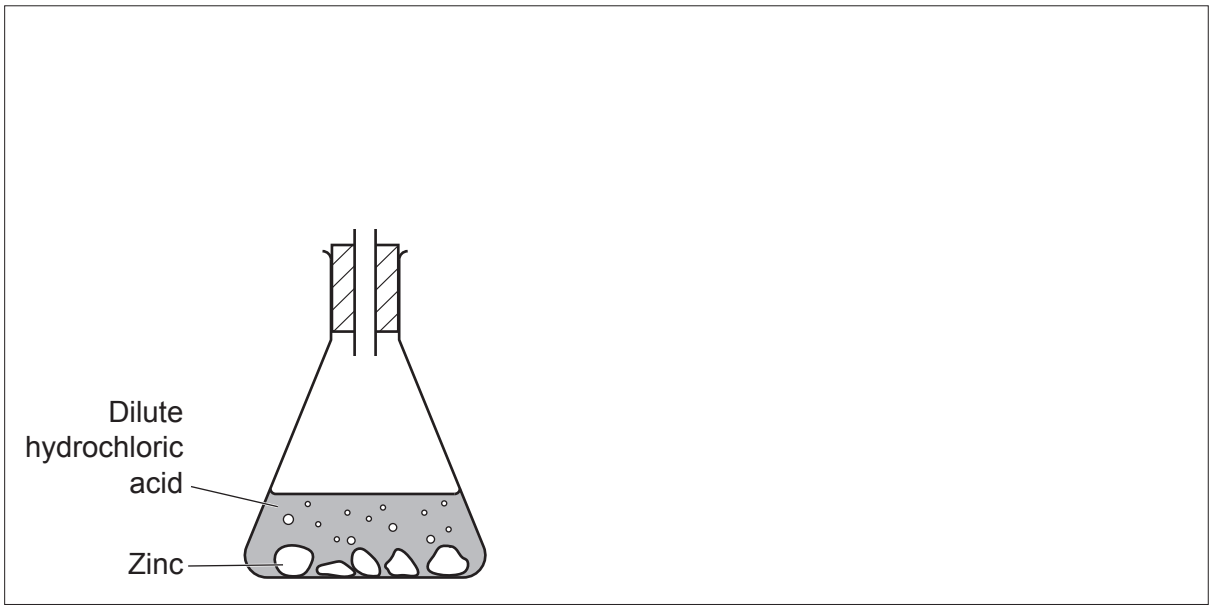
zinc + hydrochloric acid → hydrogen + ...

Zn + ...HCl → ..... + ZnCl_2

[2]

(b) Complete the diagram to suggest how the hydrogen gas could be collected and measured.

Include labels on your diagram.



[2]

(c) Beth repeats her experiment with different concentrations of dilute hydrochloric acid. She uses the same volume of acid each time.

She measures the volume of gas collected in 20 s for each experiment.

Fig. 4.1 shows her **five** results.

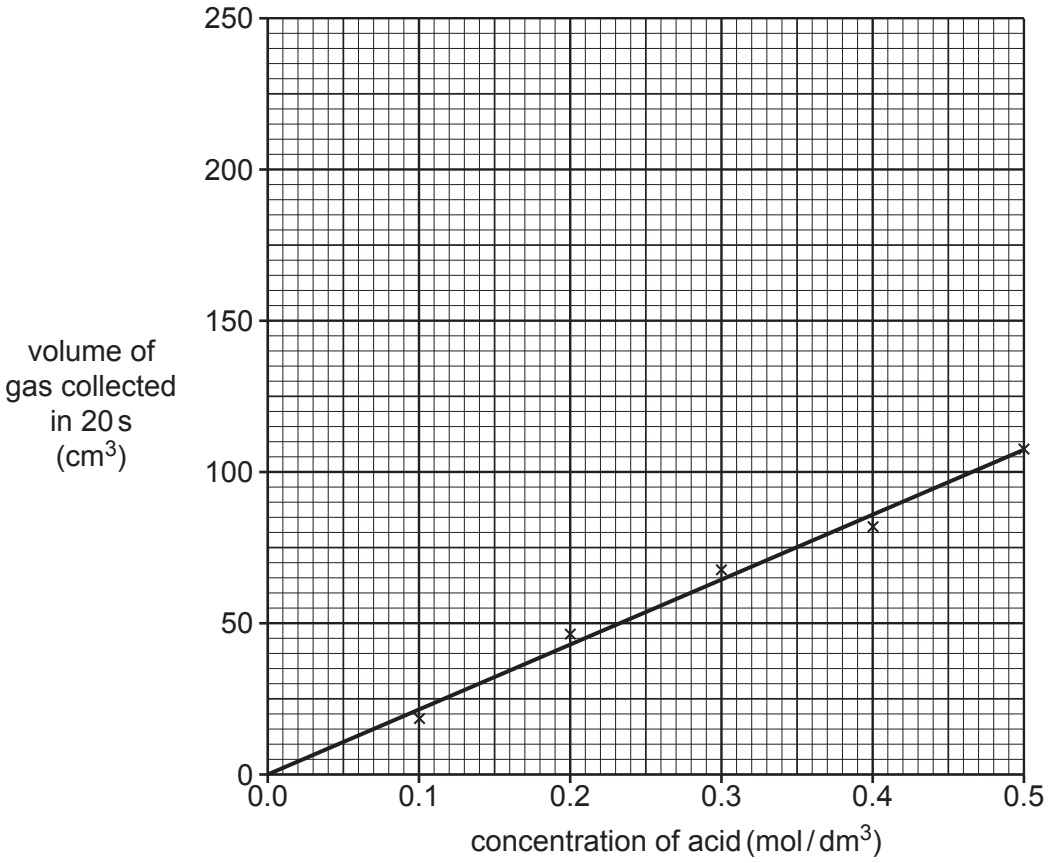


Fig. 4.1

(i) Calculate the gradient of the line.

Show your working on the graph.

Gradient = ... $cm^3 / mol / dm^3$ **[2]**

(ii) Estimate the concentration of dilute hydrochloric acid needed to produce 250 cm^3 of gas in 20 s.

Use the equation: volume of gas produced in 20 s = gradient × concentration of acid

Concentration = ... mol / dm^3 **[2]**

(d) Beth repeats her experiment again but this time measures the rate of reaction between zinc and dilute sulfuric acid, H_2SO_4, rather than dilute hydrochloric acid, HC*l*.

Table 4.1 shows her results.

Concentration of dilute sulfuric acid H_2SO_4 (mol / dm^3)	**Volume of gas produced in 20 s (cm^3)**
0.1	40
0.2	85
0.3	125
0.4	170
0.5	215

Table 4.1

(i) Plot the results in **Table 4.1** on **Fig. 4.1**.

Draw a line of best fit. **[2]**

(ii) Explain why the two lines on **Fig. 4.1** have different gradients.

.....

.....

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

5 Sodium oxide, Na_2O and magnesium oxide, MgO, are both oxides with ionic bonds. When ionic bonds form, electrons pass from one atom to another to form ions.

Fig. 5.1 and **Fig. 5.2** show the arrangement of electrons in the **atoms** and **ions** for each oxide.

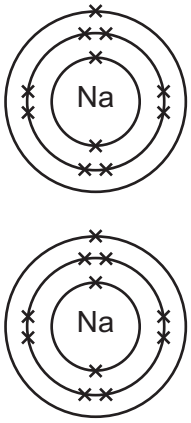
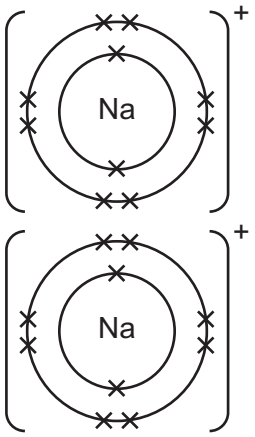
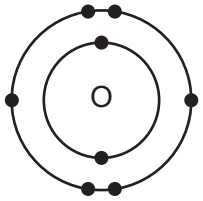
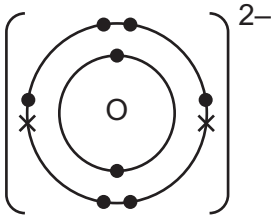
Sodium oxide Na_2O	
Atoms (before bonding)	**Ions (after bonding)**
two sodium atoms 	**two** sodium ions 
one oxygen atom 	**one** oxygen ion 

Fig. 5.1

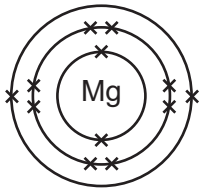
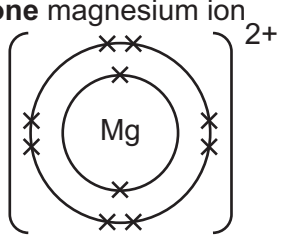
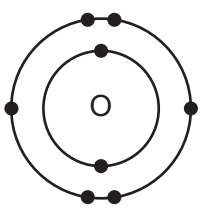
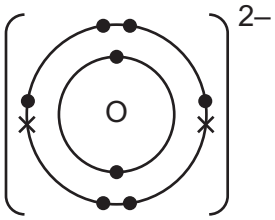
Magnesium oxide MgO	
Atoms (before bonding)	**Ions (after bonding)**
one magnesium atom 	**one** magnesium ion 
one oxygen atom 	**one** oxygen ion 

Fig. 5.2

(a)* **Describe** and **explain** how ionic bonds in sodium oxide (**Fig. 5.1**) and magnesium oxide (**Fig. 5.2**) form, and explain why the two oxides have different formulae.

Use ideas about electrons and electron shells in your answer.

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

(b) Sodium oxide and magnesium oxide are both ionic compounds.

Which statements about **both** sodium oxide **and** magnesium oxide are correct?

Tick (✓) **two** boxes.

Their boiling points are $>$ 100 °C. ☐

They conduct electricity when molten. ☐

They have very low melting points. ☐

They have weak intermolecular forces between their particles. ☐

They react with dilute acids to give a salt, water and carbon dioxide. ☐

[2]

6 Eve investigates the reaction between magnesium and oxygen to make magnesium oxide.
This is part of her method:

- Weigh the empty crucible.
- Put some magnesium ribbon into the crucible and weigh it again.
- Heat the magnesium ribbon in the crucible.

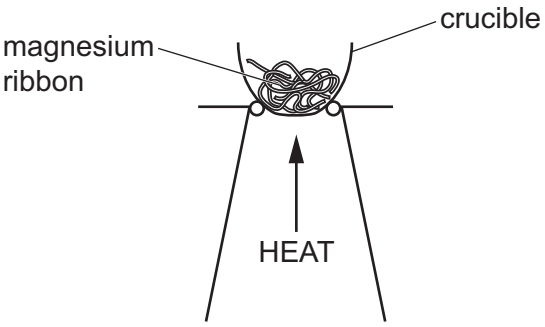


Table 6.1 shows Eve's results.

Mass of empty crucible (g)	20.0
Mass of crucible and magnesium ribbon before heating (g)	21.2
Mass of crucible and magnesium oxide after heating (g)	22.0

Table 6.1

(a) Eve weighs the crucible after heating. She heats it again and reweighs it.
She does this until the mass does **not** change.

Why does she do this?

.....

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

(b) Eve writes a word equation for the reaction.

magnesium + oxygen $\longrightarrow$ magnesium oxide

Which reactant limits the amount of magnesium oxide that can be formed?

Explain your answer.

.....

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

(c) Use Eve's results in **Table 6.1** to calculate the mass of magnesium and oxygen used and the mass of magnesium oxide formed in the experiment.

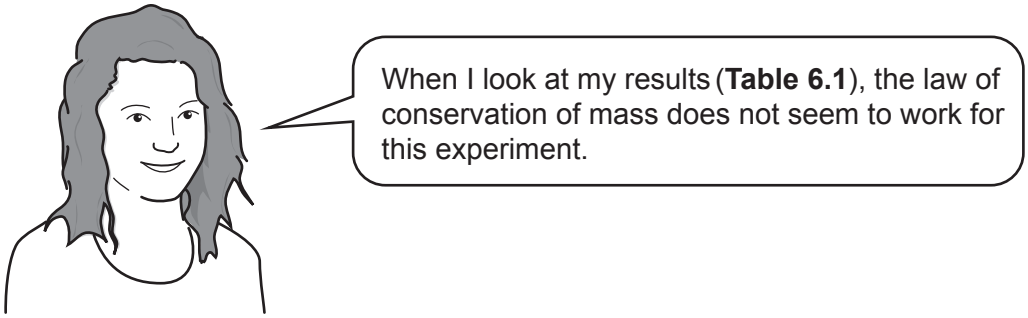
Write your answers in **Table 6.2**.

Mass of magnesium used (g)	.....
Mass of oxygen used (g)	.....
Mass of magnesium oxide formed (g)	.....

Table 6.2

[3]

(d) Eve thinks about her results.



Do you agree with Eve?

Yes ☐

No ☐

Explain your answer.

.....

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.....

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

(e) Eve repeats her experiment with a different mass of magnesium.

She measures the mass of magnesium and oxygen used and the mass of magnesium oxide formed.

Table 6.3 shows her results.

	Formula	**Mass used or formed in experiment (g)**	**Mass of one mole (g)**	**Number of moles used or formed in experiment**
magnesium	Mg	4.8	24	0.2
oxygen	O_2	3.2	.....	.....
magnesium oxide	MgO	8.0	40	.....

Table 6.3

(i) Complete **Table 6.3** by calculating the missing values.

[2]

(ii) Eve writes a balanced symbol equation for the reaction.

$2Mg + O_2 \rightarrow 2MgO$

Explain how the results in **Table 6.3** show that the balanced symbol equation is correct.

Use ideas about moles in your answer.

.....

.....

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

7 Calcium nitrate, $Ca(NO_3)_2$, and ammonium nitrate, NH_4NO_3, are ionic compounds which are used to make fertilisers.

(a) **Fig. 7.1** shows how the ions are arranged in a solid, ionic compound.

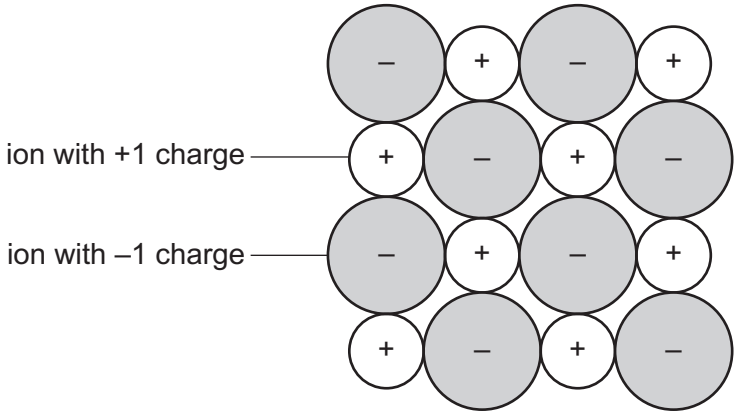

Fig. 7.1

(i) Give **two** reasons why **Fig. 7.1** is a better representation for the ions in solid ammonium nitrate, NH_4NO_3, than the ions in solid calcium nitrate, $Ca(NO_3)_2$.

1. .....

.....

2. .....

.....

[2]

(ii) In **Fig. 7.1** the ions are shown far larger than they actually are.

Suggest **two other** reasons why **Fig. 7.1** does not accurately represent a solid ionic compound.

1. .....

.....

2. .....

.....

[2]

(b)* The energy changes that happen when solid fertilisers dissolve in water are related to bond-breaking and bond-making.

Fig. 7.2 shows the process of a solid ionic compound dissolving in water, in terms of bond-breaking and bond-making.

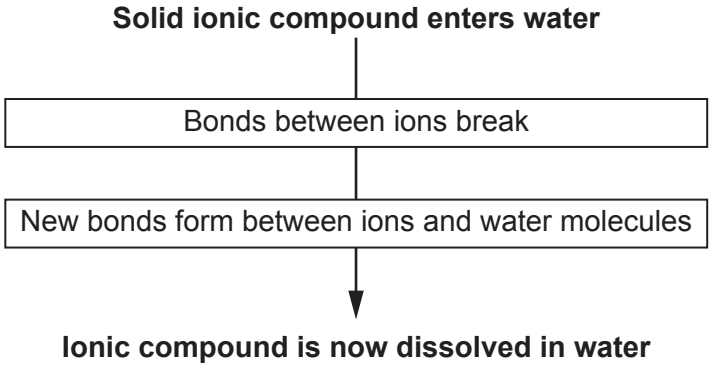

Fig. 7.2

Fig. 7.3 shows the energy changes when calcium nitrate and ammonium nitrate dissolve in water.

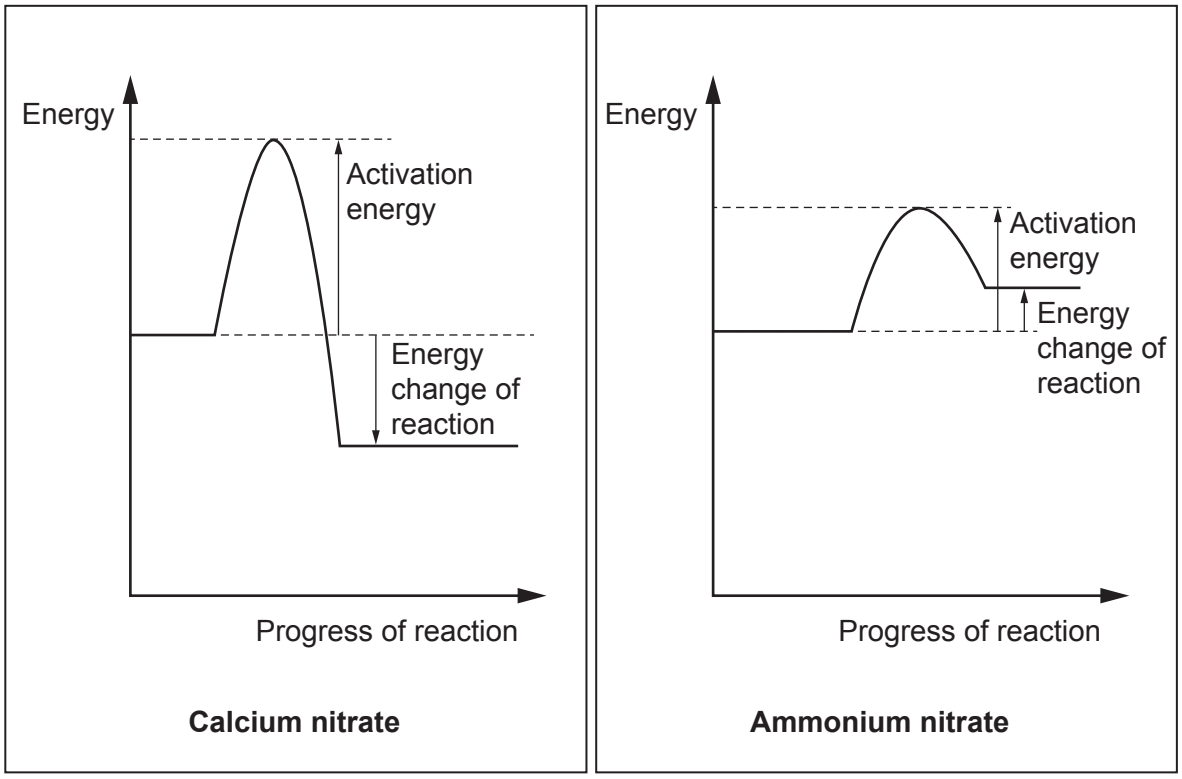

Fig. 7.3

Using **Fig. 7.2** and **Fig. 7.3**, describe and explain the differences in the energy changes when calcium nitrate and ammonium nitrate dissolve in water.

Use ideas about bond-breaking and bond-making in your answer.

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

(c) Some fertilisers contain more than one compound mixed together.

Which **two** compounds, when mixed together, contain the three elements nitrogen, phosphorus and potassium?

Put a (ring) around the **two** correct answers.

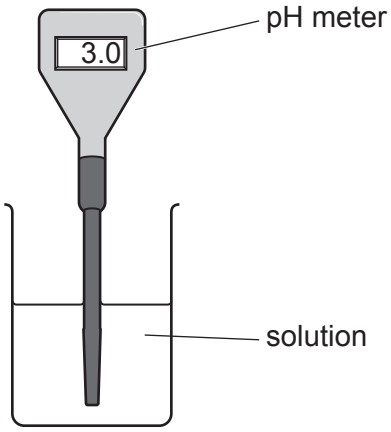
$Ca(NO_3)_2$ **$Ca_3(PO_4)_2$** **NH_4NO_3** **KNO_3** **K_2SO_4**

[1]

8 Nina tests three different pH meters to find out which pH meter gives the most accurate pH readings.

She prepares six solutions, **A**, **B**, **C**, **D**, **E** and **F**. Each solution has a different concentration of hydrogen ions, H^+.

She dips the pH meters into each solution and takes a reading.



The table shows her results.

Solution	Concentration of H^+ ions (mol/dm^3)	actual pH	Reading from pH meter 1	Reading from pH meter 2	Reading from pH meter 3
A	1.0×10^{-3}	3.0	2.9	3.3	2.6
B	1.0×10^{-5}	5.0	4.9	5.4	4.4
C	1.0×10^{-2}	2.0	2.1	2.2	2.7
D	1.0×10^{-1}	1.0	0.9	1.3	1.5
E	1.0×10^{-9}	9.0	9.1	9.2	8.4
F	1.0×10^{-7}	7.0	7.1	7.3	7.5

(a) Identify one neutral solution and one alkali solution from the table.

Neutral solution: .....

Alkali solution: .....

[1]

(b) Predict the actual pH of a solution with a concentration of $1.0 \times 10^{-4}\,mol/dm^3$ of hydrogen ions.

pH = ... **[1]**

(c) What is the trend in the relationship between concentration of hydrogen ions and pH?

.....

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

(d) What conclusions can you make about the relative accuracy of each pH meter?

Explain each conclusion.

pH meter 1: .....

.....

pH meter 2: .....

.....

pH meter 3: .....

.....

[3]

(e) Nina thinks that she has contaminated her solutions during the experiment.

What should Nina do to make sure that her solutions do not become contaminated during the experiment?

.....

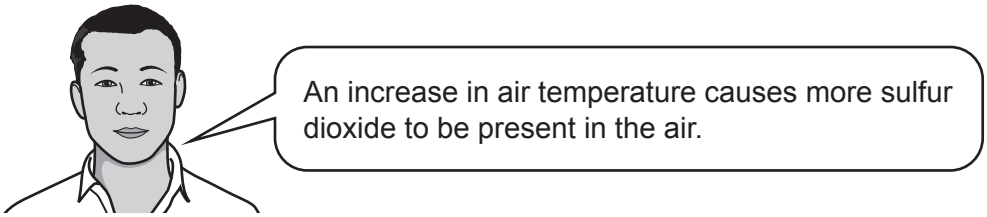
..... **[1]**

9 A monitoring station collects data about the weather and the concentration of sulfur dioxide, SO_2, near a power station.

The table shows some data collected at 12.00 midday each day for 7 days.

Day	Air temperature (°C)	Weather conditions	Concentration of SO_2 (mg/m^3)
Mon	24	no rain, no wind	25.0
Tues	20	light rain, windy	8.0
Thurs	16	heavy rain, no wind	3.5
Wed	21	light rain, no wind	16.2
Fri	19	light rain, windy	9.4
Sat	15	heavy rain, windy	
Sun	22	no rain, windy	

(a) Ali looks at the data from the monitoring station and says:



Discuss why this idea is **incorrect**.

Use data from the table to support your answer.

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.....

.....

.....

.....

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

(b) Use the table to predict the concentration of sulfur dioxide, SO_2, for Saturday and Sunday.

Explain your answers.

Concentration of SO_2 on Saturday ..... mg/m^3

Explanation .....

.....

.....

Concentration of SO_2 on Sunday ..... mg/m^3

Explanation .....

.....

.....

[4]

(c) The power station agrees to these targets for sulfur dioxide concentration in the air near the power station.

Targets
Sulfur dioxide concentration must be below….
• 200 mg/m^3 averaged over a 1-hour period
• 80 mg/m^3 averaged over a 24-hour period
• 20 mg/m^3 averaged over a one year period.

Jane is a scientist and wants to use the monitoring station to check whether the power station is meeting these targets.

Describe an outline plan for Jane.

Your plan should include:
- the frequency of measurements she needs to make,
- how she needs to process her results,
- how she can judge whether the targets are being met.

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

END OF QUESTION PAPER

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).