OCR
Oxford Cambridge and RSA

Friday 17 May 2024 – Morning

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

J260/06 Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

H

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

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 **24** pages.

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

1

(a) **Table 1.1** shows the diameters of some particles.

Table 1.1

Particle	Diameter (m)
Carbon atom	1.54×10^{-10}
Fullerene molecule	1.10×10^{-9}
Silver atom	2.88×10^{-10}
Platinum nanoparticle	1.00×10^{-8}

(i) Which **two** particles have diameters with the same order of magnitude?

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

(ii) Write down the particles in order of diameter.

Smallest .....

.....

.....

Largest .....

[2]

(b) Nanoparticles make effective catalysts because they have a high surface area to volume ratio.

Table 1.2 shows the surface area to volume ratio of some different sized particles.

Table 1.2

	Nanoparticle	Particle of Fine Powder	Particle of Coarse Powder
Size of Particle (nm)	60	600	6000
Surface Area to Volume Ratio	0.1	0.01	0.001

Describe the relationship between the size of a particle and its surface area to volume ratio.

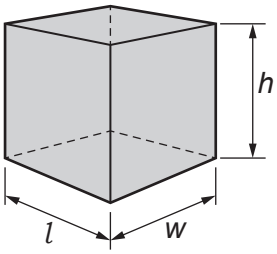
.....

.....

.....

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

(c) The nanoparticle shown is a cube. This nanoparticle has a volume of 1000 nm^3.



NOT TO SCALE

Calculate the surface area of the nanoparticle.

Use the formula: surface area = 6 × (h × w)

Surface area = ... nm^2

[3]

2 A student is investigating the reaction between calcium hydroxide and hydrochloric acid.

$Ca(OH)_2(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

(a) They want to find the temperature change during the reaction.

1 g masses of solid calcium hydroxide are added one by one to 50 cm^3 of dilute hydrochloric acid in a plastic cup.

Describe **two** measurements the student needs to make **and** the apparatus needed to make the measurements.

1. .....

.....

2. .....

.....

[2]

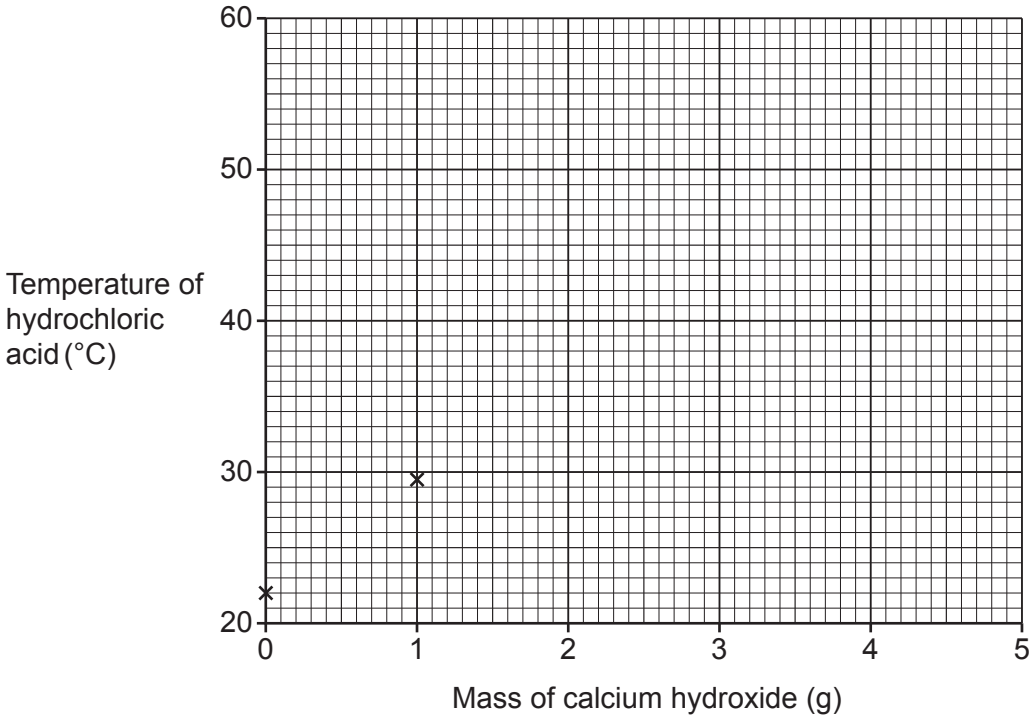
(b) The table shows the student's results:

Mass of calcium hydroxide (g)	Temperature of hydrochloric acid (°C)
0	22.0
1	29.5
2	37.0
3	44.5
4	52.0
5	59.5

Plot the results from the table on the graph.

Two points have already been plotted. **[2]**

(c) Draw a line of best fit. **[1]**



(d) Which relationship describes the graph?

Put a (ring) around the correct option.

y = mx **y = mx^2** **y = mx + c** **y = mx – c** **[1]**

(e) Calculate the **change** in temperature if 3.8 g of calcium hydroxide is added to the hydrochloric acid.

Use the graph.

Temperature change = ... °C **[2]**

(f) Calculate the change in thermal energy when 3.8 g of calcium hydroxide is added to 50 cm^3 of hydrochloric acid.

Use the formula:

Change in thermal energy (J) = 4.2 × temperature change (°C) × mass of hydrochloric acid (g)

1 cm^3 hydrochloric acid = 1.02 g

Change in thermal energy = ...J **[3]**

3 Atoms are made up of a small nucleus containing protons and neutrons. The rest of the space contains electrons.

(a) Complete the table to show the relative masses and charges of the three particles in the atom.

Particle	Relative Mass	Relative Charge
Proton	.....	.....
Neutron	.....	.....
Electron	.....	.....

[3]

(b) A student builds a model of an atom.

They use a tennis ball with a diameter of 6.7 cm to represent the nucleus in the model.

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

Calculate the diameter of the model of the atom.

Give your answer in **m**.

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

(c) The number of protons, neutrons and electrons in an atom or an ion can be calculated using the atomic number and relative atomic mass of the element.

Complete the table to show the number of each particle present in a phosphorus atom and a sodium ion.

Use the Data Sheet.

	Phosphorus atom, P	**Sodium ion, Na^+**
Number of **Protons**	.....	.....
Number of **Neutrons**	.....	.....
Number of **Electrons**	.....	.....

[3]

(d) The properties of elements depend on the electron arrangements of their atoms.

The electron arrangement of magnesium is 2.8.2.
The electron arrangement of fluorine is 2.7.

Explain why magnesium is a metal and fluorine is a non-metal.

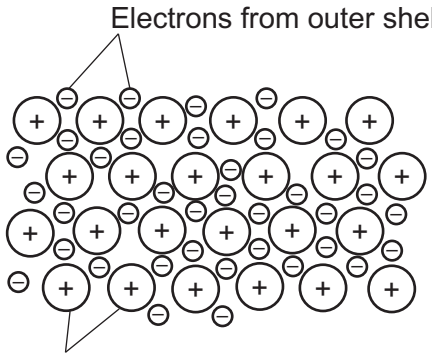
.....

.....

.....

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

4 The diagram shows the structure of a metal.



(a) Explain why metals are good electrical conductors, malleable, and have high melting points.

Good electrical conductors .....

.....

Malleable .....

.....

High melting points .....

.....

[3]

(b) A student does some experiments to find the reactivities of some metals.

In one experiment, they add a piece of magnesium to a blue aqueous solution of copper ions.

They see a reddish metal formed and the blue solution fades to colourless.

$Mg(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Mg^{2+}(aq)$

Explain how this reaction shows that magnesium is more reactive than copper.

.....

.....

.....

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

(c) The table shows the student's results from the other experiments:

	$Cu^{2+}(aq)$	$Fe^{2+}(aq)$	$Mg^{2+}(aq)$	$Ag^{+}(aq)$
Cu(s)		No change	No change	Change
Fe(s)	Change		No change	Change
Mg(s)	Change	Change		Change
Ag(s)	No change	No change	No change	

(i) Write a **balanced ionic equation** for the reaction between solid copper and aqueous silver ions.

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

(ii) Write down the metals in order of reactivity.

Most reactive .....

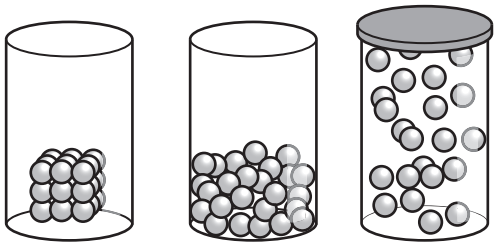
.....

.....

Least reactive .....

[2]

5 The particle models for the different states of matter are shown.



(a) State **two** limitations of the particle model.

1. .....

.....

2. .....

.....

[2]

(b) The table gives some information about the movement and arrangement of particles for the different states of matter.

Complete the table.

	Movement of Particles	**Arrangement of Particles**
Solid	.....	1 Regular 2 Close together
Liquid	.....	1 Random 2 .....
Gas	Move in all directions	1 ..... 2 .....

[4]

(c) Explain why heating a solid causes it to change state.

.....

.....

.....

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

(d) Sulfur dioxide has a melting point of –73 °C and a boiling point of –10 °C.

What is the state of sulfur dioxide at 20 °C?

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

6 A student wants to find the concentration of a sodium hydroxide solution. They do a titration using sodium hydroxide solution and 0.010 mol / dm^3 dilute hydrochloric acid.

(a)* Describe how the student can **accurately** find the concentration of the sodium hydroxide solution, using these solutions.

Include an explanation of **how** this method gives high quality data.

.....

.....

.....

.....

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.....

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.....

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.....

.....

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

(b) The table shows the student's results.

Titration	**1**	**2**	**3**	**4**	**5**
Volume of Acid Added (cm^3)	**27.2**	**25.4**	**25.3**	**25.2**	**25.2**

(i) Why is the first reading much higher than the others?

.....

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

(ii) Calculate the mean volume of acid which reacts with the sodium hydroxide solution.

Give your answer to **1** decimal place.

Mean volume of acid = ... cm^3 **[3]**

(iii) The student's teacher states that the volume of the hydrochloric acid needed to react with the sodium hydroxide should be **25.8** cm^3.

Explain what the student's results show about the accuracy and precision of their experiment.

Accuracy .....

.....

Precision .....

.....

[2]

7 Ammonia is made from nitrogen and hydrogen.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(a)

(i) Define this symbol $\rightleftharpoons$.

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

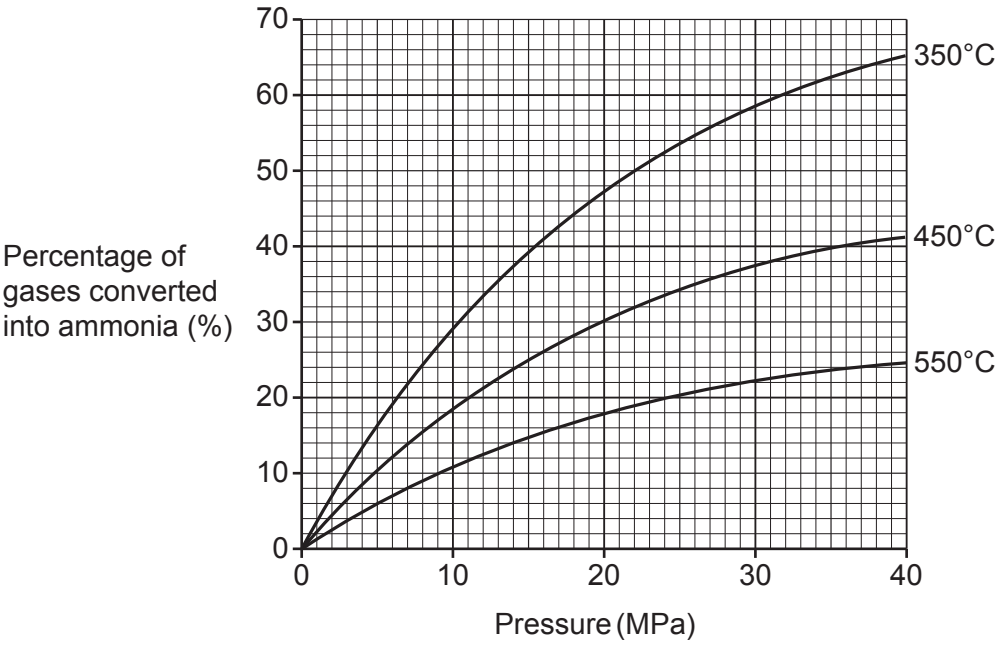
(ii) Explain why reactions like this **never** give a 100% yield.

.....

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

(b) The conditions of the reaction are carefully chosen to produce the best yield as quickly as possible.

The graph shows the effect of temperature and pressure on the yield of ammonia.



(i) Complete the table to show the effect of changing the conditions on yield and rate of reaction.

Use words from the list.

Increase	**Decrease**	**No Effect**

	Effect on yield	**Effect on rate of reaction**
Increasing the Temperature	.....	Increase
Increasing the Pressure	.....	Increase
Using a Catalyst	.....	.....

[4]

(ii) Explain why the rate of reaction increases when the temperature and pressure are increased.

Temperature .....

.....

.....

.....

Pressure .....

.....

.....

.....

[4]

(c) Ammonium sulfate, $(NH_4)_2SO_4$, is used by farmers as a fertiliser.

Ammonia gas is bubbled into dilute sulfuric acid, H_2SO_4, to form an aqueous solution of ammonium sulfate.

Write a **balanced symbol equation** for the reaction.

Include **state symbols**.

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

8 Acids react with some metal compounds to form salts.

(a) **Table 8.1** shows the reactants and products of some of these reactions.

Table 8.1

Acid	Metal Compound	Salt Formed
Hydrochloric acid	Sodium hydroxide	Sodium chloride
Sulfuric acid	Copper oxide	.....
.....	Calcium carbonate	Calcium nitrate

(i) Complete the table. **[2]**

(ii) Complete the **word equation** for the reaction between hydrochloric acid and sodium hydroxide.

Hydrochloric acid + sodium hydroxide → sodium chloride + ...

[1]

(b) **Table 8.2** shows the H^+ concentration and pH of different concentrations of dilute hydrochloric acid.

Table 8.2

Concentration of $HCl(aq)$ (mol/dm^3)	Concentration of $H^+(aq)$ (mol/dm^3)	pH
0.1	1×10^{-1}	1
0.01	1×10^{-2}	2
0.001	1×10^{-3}	3

(i) Describe the relationship between H^+ concentration and pH shown in **Table 8.2**.

.....

.....

.....

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

(ii) What is the pH of 0.0001 mol/dm^3 dilute hydrochloric acid?

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

(c) A student does an experiment to find the pH of different concentrations of dilute ethanoic acid, CH_3COOH.

Universal Indicator paper is dipped into a test-tube of each of the solutions.

(i) Describe how the student finds the pH using this test.

.....

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

(ii) The results of the experiment are shown in **Table 8.3**.

Table 8.3

Concentration of $CH_3COOH(aq)$ (mol/dm^3)	**pH**
0.1	3
0.01	3
0.001	4

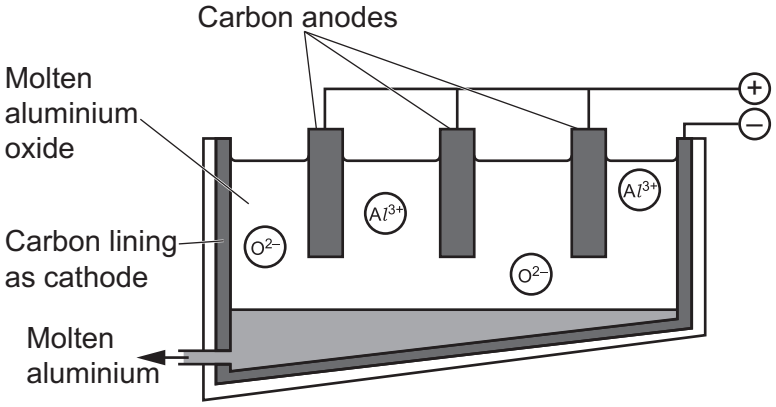
Describe how the student can change their method to get pH measurements correct to **1** decimal place.

.....

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

9 Electrolysis is the decomposition of ionic compounds using electricity.

(a) Aluminium is extracted from molten aluminium oxide by electrolysis.



(i) Explain why the electrolysis must use **molten** aluminium oxide, and **not** solid aluminium oxide.

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

(ii) The **half equations** show the reactions at the electrodes.

$Al^{3+} + 3e^- \rightarrow Al$

$2O^{2-} \rightarrow O_2 + 4e^-$

What is oxidised and what is reduced during the electrolysis of aluminium oxide?

Explain your answer.

Oxidised .....

Reduced .....

Explanation .....

.....

[3]

(iii) This is the balanced symbol equation for the decomposition of aluminium oxide by electrolysis:

$2Al_2O_3 \rightarrow 4Al + 3O_2$

Calculate the mass of aluminium that will be produced when 100 g of aluminium oxide is used.

Give your answer to **3** significant figures.

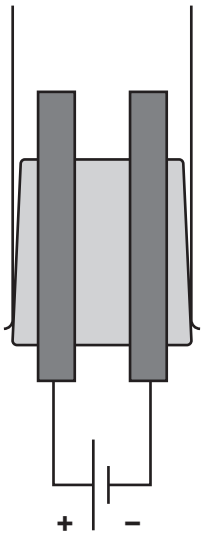
Relative atomic masses: Al = 27.0 O = 16.0.

Mass of aluminium produced = ... g **[4]**

(b) When aqueous sodium sulfate is electrolysed the products are hydrogen gas and oxygen gas.

(i) Complete the diagram to show how the gases can be collected by electrolysis of aqueous sodium sulfate.

Include labels.



[3]

(ii) The ions present in aqueous sodium sulfate are Na^+, SO_4^{2-}, H^+ and OH^-.

State where the H^+ **ions** and OH^- **ions** come from.

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

(iii) Explain why hydrogen is formed instead of sodium.

.....

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

(iv) Complete the table to show where hydrogen gas and oxygen gas are formed **and** the **half equations** for the reactions occurring at each electrode.

Electrode	Product	Half Equation
Anode (+)		
Cathode (–)		

[3]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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