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Friday 27 May 2022 – Morning

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

J260/06 Chemistry (Higher Tier)

Time allowed: 1 hour 45 minutes

9901426287

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

J260606

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.

Answer **all** the questions.

1 The table gives information about some of the compounds present in crude oil.

Number of carbon atoms	Molecular formula	Empirical formula	Melting point (°C)	Boiling point (°C)	State at room temperature
4	C_4H_{10}	C_2H_5	–138	0	Gas
5	.....	C_5H_{12}	–130	36	
6	C_6H_{14}	C_3H_7	–95	69	Liquid
7	C_7H_{16}	C_7H_{16}	–90		Liquid
8	C_8H_{18}	.....	–57	126	Liquid

(a) (i) Complete the table to show the missing molecular formula and empirical formula. **[2]**

(ii) Predict the boiling point for the compound with 7 carbon atoms.

Boiling point = ... °C **[1]**

(iii) Predict the state of the 5 carbon compound at room temperature (20 °C).

Explain your answer.

State .....

Explanation .....

.....

.....

[2]

(b) All the compounds in the table are in the same homologous series.

All members of a homologous series have the same general formula.

(i) Give **two** other characteristics of a homologous series that are shown in the table.

1 .....

.....

2 .....

.....

[2]

(ii) Complete the sentences to describe the compounds present in crude oil that are shown in the table.

Put a (ring) around each correct answer.

Crude oil is a mixture of **hydrocarbons / polymers / salts**.

The compounds are from the homologous series **allotropes / alkanes / alkenes**.

They all have the general formula **C_nH_{2n} / C_nH_{2n+1} / C_nH_{2n+2}**.

[3]

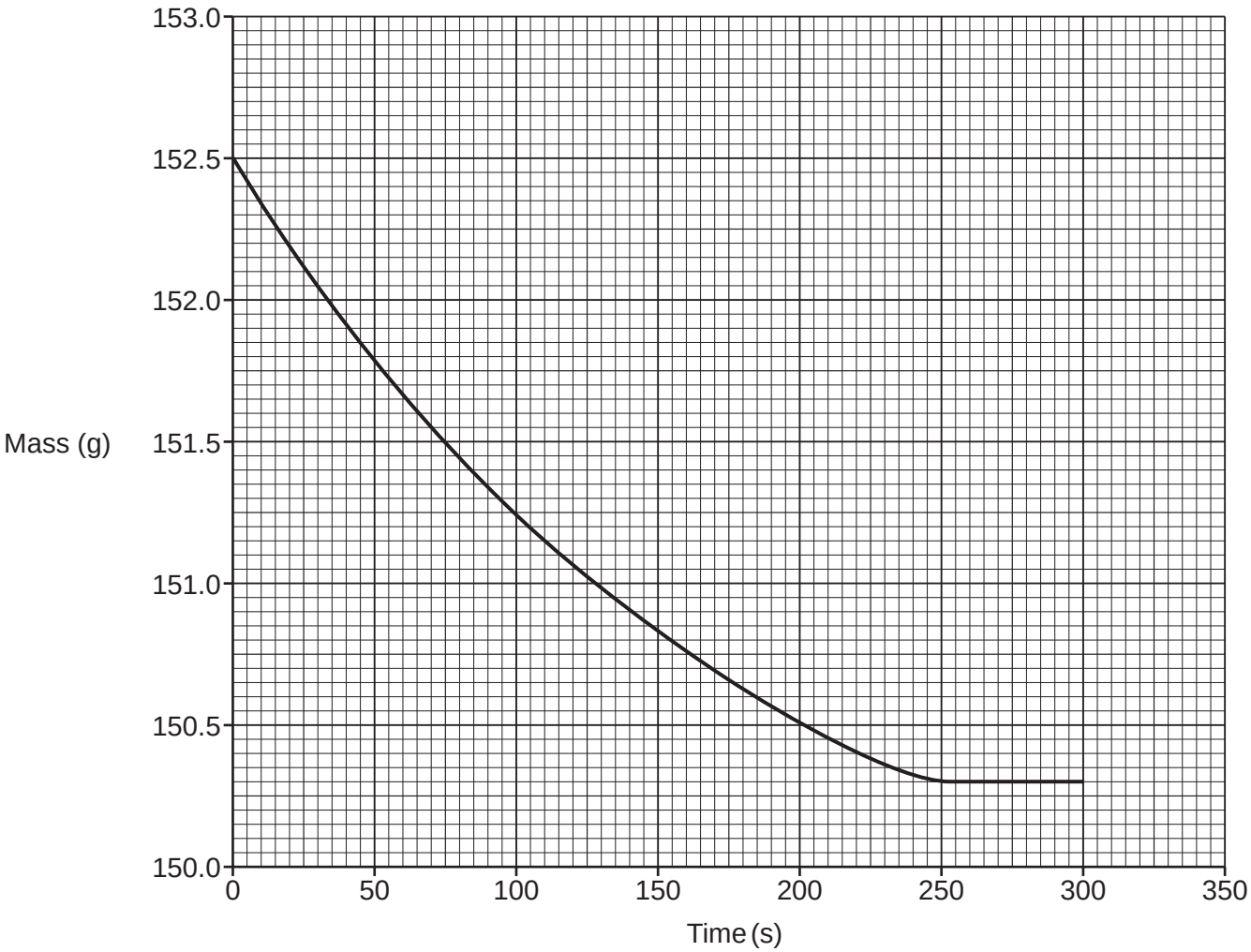
2 Solid calcium carbonate reacts with dilute hydrochloric acid to form calcium chloride, carbon dioxide and water.

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

(a) Jane investigates the rate of this reaction. She measures the change in mass during the reaction over five minutes.

She uses 10 g of calcium carbonate lumps and 50 cm^3 of dilute hydrochloric acid.

The graph shows Jane's results.



(i) What was the time taken for the reaction to finish?

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

(ii) What was the total mass lost during the reaction?

Total mass lost = ... g **[2]**

(iii) Calculate the average rate of the reaction.

Rate of reaction = ... g / s **[2]**

(b) Jane repeats the experiment with 10 g of calcium carbonate **powder** instead of 10 g of lumps. She keeps everything else the same.

Sketch a line on the graph to show the results she should expect. **[2]**

(c) Complete the sentences to explain why the rate of reaction changes when powdered calcium carbonate is used instead of lumps.

Put a (ring) around each correct answer.

The surface area of 10 g of powdered calcium carbonate is **larger than / smaller than / the same as** 10 g of lumps.

The total volume of 10 g of powdered calcium carbonate is **larger than / smaller than / the same as** 10 g of lumps.

[2]

3 Calcium is a metal in Group 2 of the Periodic Table.
Chlorine is a non-metal in Group 17(7) of the Periodic Table.

Table 3.1 shows some properties of calcium and chlorine.

Property	Calcium	Chlorine
Type of ions formed	positive	negative
Electrical conductivity	good	none
Boiling point (°C)	1484	–35

Table 3.1

(a) Describe **one** other property, not shown in **Table 3.1**, which is different for metals and non-metals.

.....

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

(b) The difference in properties of metals and non-metals is caused by their electronic structures.

(i) Give the electronic structures of calcium and chlorine.

Calcium .....

Chlorine .....
[2]

(ii) Explain why calcium and chlorine form different types of ions.

.....

.....

.....

.....

.....

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

(c) (i) The boiling points of calcium and chlorine are different because of the forces of attraction between particles.

Draw lines to connect each **element** to the **forces of attraction** between its particles.

Element	Forces of attraction
Calcium	between atoms
	between ions
Chlorine	between molecules
	between positive ions and delocalised electrons

[2]

(ii) Explain why the boiling points of calcium and chlorine are different.

Use your answer to **(i)** to support your answer.

.....

.....

.....

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

(d) Metals and non-metals react together to form ionic compounds.

Table 3.2 shows some information about three ionic compounds.

Ionic Compound	Ions	Formula
Sodium chloride	Na^+ and Cl^-	$NaCl$
Potassium oxide	.....	K_2O
Aluminium oxide	Al^{3+} and O^{2-}	.....

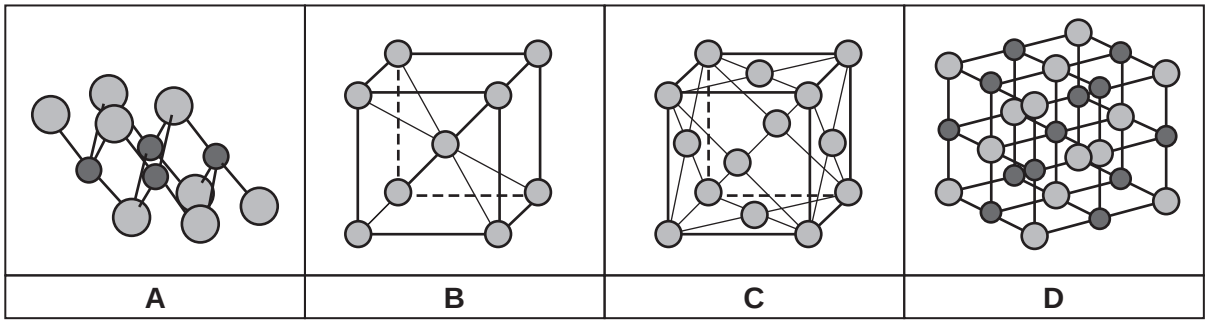
Table 3.2

Complete the table to show the ions in potassium oxide and the formula of aluminium oxide.

[2]

(e) Metals and ionic compounds can form lattices.

The diagram shows four different lattice structures.



A	B	C	D

(i) Which **two** structures are the lattice of a metal?

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

(ii) Which structure is the lattice of potassium oxide (K_2O)?

Explain your answer.

Structure .....

Explanation .....

.....

[2]

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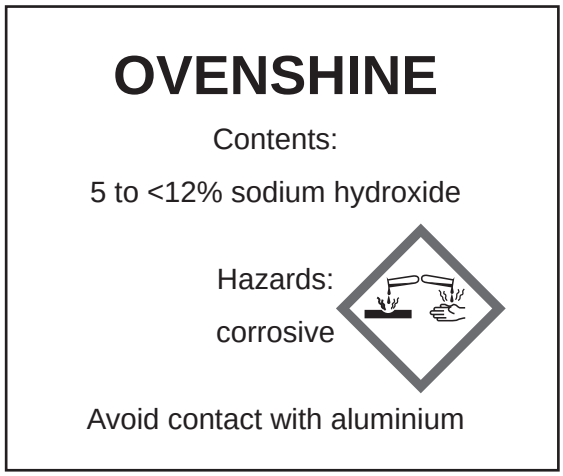
4 Ovenshine is used as an oven cleaner.

The label gives information about the product.



(a) (i) Complete the **balanced symbol** equation for the reaction of aluminium with sodium hydroxide.

.....Al + 2NaOH + ...H_2O → .....$NaAlO_2$ + ...H_2 **[1]**

(ii) How does the equation show that contact with aluminium surfaces is a hazard?

.....

.....

.....

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

(b) Tests can be used to identify gases produced in a reaction.

Complete the table to show the method and the result for the tests for the three gases.

Gas	Method	Result
hydrogen	.....	.....
carbon dioxide	.....	.....
oxygen	.....	.....

[3]

(c) Sam does a titration to find the amount of sodium hydroxide in the oven cleaner.

This is the method:

- Measure out 3.00 g of the cleaner into a conical flask
- Add a few drops of indicator
- Add 0.25 mol / dm^3 hydrochloric acid until all of the sodium hydroxide has reacted.

The equation shows the reaction of sodium hydroxide with hydrochloric acid.

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

(i) Calculate the range of the mass of sodium hydroxide expected in 3 g of oven cleaner.

Use information from the label.

Mass of sodium hydroxide is from ..... g to < ..... g **[3]**

(ii) How does Sam know when all the sodium hydroxide has reacted?

.....

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

(iii) Sam wants to measure the exact volume of acid needed for all of the sodium hydroxide to react.

Describe **one** thing Sam should do so that the titration result is accurate.

.....

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

(d) Sam finds that 24.8 cm^3 of 0.25 mol/dm^3 hydrochloric acid is needed to react with the sodium hydroxide in 3.00 g of oven cleaner.

(i) Calculate the number of moles of hydrochloric acid in 24.8 cm^3 of 0.25 mol/dm^3.

Use the formula: concentration (mol/dm^3) = $\frac{\text{number of moles of solute}}{\text{volume } (dm^3)}$

Number of moles of acid = ... **[3]**

(ii) Find out how many moles of sodium hydroxide react with this amount of acid.

Use the symbol equation: $NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$

Number of moles of sodium hydroxide = ... **[1]**

(iii) Calculate the mass of sodium hydroxide (NaOH) reacting with the acid.

Use the formula and the relative atomic masses given.

number of moles = $\frac{\text{mass of substance (g)}}{\text{relative formula mass (g)}}$

Relative atomic masses: Na = 23.0, O = 16.0, H = 1.0

Mass of sodium hydroxide = ...(g) **[3]**

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5 (a) **Table 5.1** shows information about some pollutants in the air over 100 days in 2020.

Year	Particulates ($\mu g / m^3$)	NO ($\mu g / m^3$)	NO_2 ($\mu g / m^3$)
	Change from five year average	**Change from five year average**	**Change from five year average**
2020	–1.60	–7.52	–9.71

Table 5.1

Calculate the orders of magnitude for the change in each pollutant in 2020.

Particulates ..... $\mu g / m^3$

NO ..... $\mu g / m^3$

NO_2 ..... $\mu g / m^3$

[3]

(b) **Table 5.2** shows information about the same pollutants in the air over a 100-day period in 5 years from 2015–2019.

Year	Particulates ($\mu g / m^3$)	NO ($\mu g / m^3$)	NO_2 ($\mu g / m^3$)
	Change from five year average	**Change from five year average**	**Change from five year average**
2015	–1.38	+0.78	–0.13
2016	–0.91	+2.17	+1.26
2017	+0.71	–0.10	–1.02
2018	+1.16	–0.99	–0.50
2019	+0.43	–1.84	–1.28

Table 5.2

Sundip looks at the data in **Table 5.1** and **Table 5.2** and says:
'The changes in these pollutants during 2020 are not significant. They go up and down each year.'

Explain why she is only partially correct.

Use data from **Table 5.1** and **Table 5.2** to support your answer.

.....

.....

.....

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

(c) These pollutants are all emitted from car exhausts.
Particulates are tiny carbon particles and NO and NO_2 are oxides of nitrogen.

(i) Describe how particulates and oxides of nitrogen are produced by car engines.

Particulates .....

.....

.....

.....

Oxides of nitrogen .....

.....

.....

.....

[4]

(ii) Carbon monoxide, carbon dioxide and sulfur dioxide are also emitted from car exhausts.

Draw lines to connect each **gas** with the main **problem** caused by increased amounts of the gas in the atmosphere.

Gas	**Problem**
CO	It causes acid rain.
CO_2	It causes global warming.
SO_2	It is toxic.

[2]

6 Ammonia is manufactured from nitrogen and hydrogen. When nitrogen and hydrogen gases are mixed, they come to a dynamic equilibrium.

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

(a) (i) What is meant by the $\rightleftharpoons$ symbol?

.....

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

(ii) What is happening to the rates of the forward and reverse reactions when it is at **dynamic equilibrium**?

.....

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

(iii) Why is the yield of the reaction **not** 100%?

.....

.....

.....

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

(b)* The yield of ammonia is affected by changing the conditions of the reaction vessel.

Table 6.1 shows the percentage yield at different temperatures and pressures.

	Percentage yield of ammonia at equilibrium (%)			
Pressure (atm)	**200 °C**	**300 °C**	**400 °C**	**500 °C**
10	51	15	4	1
25	64	27	9	3
50	74	40	15	6
100	82	53	25	11
200	89	67	39	18
400	95	80	55	32

Table 6.1

Chemical companies choose the most effective conditions for the manufacture of ammonia.

Table 6.2 shows the conditions chosen by one company.

Temperature (°C)	400–450
Pressure (atm)	150–300
Catalyst	iron

Table 6.2

Describe the effect of changing the conditions of the reaction vessel on the yield of ammonia shown in **Table 6.1** and explain why the chemical company chose the conditions shown in **Table 6.2**.

Use ideas about yield, rate, energy use and safety in your answer.

.....

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

7 Neutralisation is when an acid reacts with an alkali to form a salt and water. Neutralisation can also be described in terms of ions.

(a) Complete the word and balanced symbol equations for the reaction between nitric acid and sodium hydroxide.

nitric acid + sodium hydroxide → ..... + water

..... + ... → $NaNO_3$ + H_2O

[3]

(b) Identify the **two** ions involved in a neutralisation reaction **and** state where they come from.

1 .....

2 .....

[2]

(c) The pH scale is a measure of the H^+ concentration of a solution.

It is used to measure the relative acidity or alkalinity of a solution.

pH	1	3	5	7	9	11	13
H^+ concentration (mol / dm^3)	1×10^{-1}	1×10^{-3}	1×10^{-5}		1×10^{-9}	1×10^{-11}	1×10^{-13}

(i) Describe the change in H^+ concentration and the relative acidity and alkalinity of a solution as the pH number changes.

H^+ concentration .....

.....

acidity and alkalinity of the solution .....

.....

[2]

(ii) A solution with pH 7 is neutral.

What is the H^+ concentration of a neutral solution?

H^+ concentration = ... mol / dm^3 **[1]**

(d) Anika plans an experiment to find out how the pH changes when different amounts of alkali are added to an acid.

She starts with 25 cm^3 of nitric acid and adds 5 cm^3 increments of sodium hydroxide to it, measuring the pH after each addition.

What apparatus does she need to make these measurements?

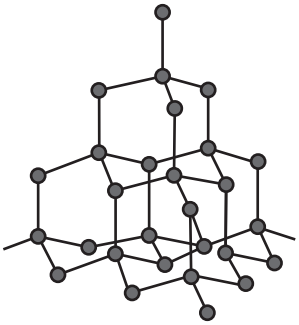
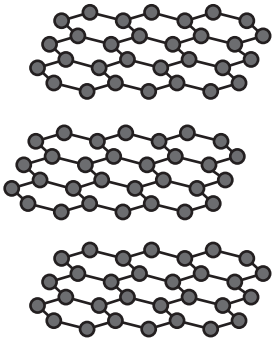
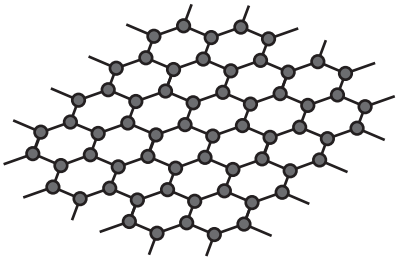
Tick (✓) **two** boxes.

- Balance ☐
- Gas syringe ☐
- Graduated flask ☐
- Measuring cylinder ☐
- pH meter ☐
- Thermometer ☐

[2]

8 Diamond, graphite and graphene are all allotropes of carbon.

The table shows the structure and some properties for these allotropes.

Diamond	**Graphite**	**Graphene**
		
giant covalent structure	giant structure with 2 dimensional covalent layers	single covalent layer
hard	soft	hard
non-conductor of electricity	good conductor of electricity	good conductor of electricity

(a) The properties of these allotropes depend on their structure.

(i) Explain why graphite and graphene are good conductors of electricity but diamond is not.

.....

.....

.....

.....

.....

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

(ii) Explain why diamond and graphene are hard but graphite is soft.

Diamond and graphene .....

.....

.....

.....

Graphite .....

.....

.....

..... **[4]**

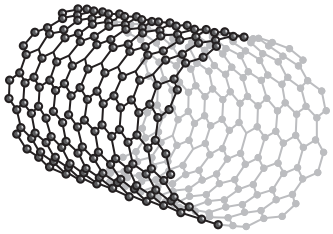
(iii) Graphene sheets are one atom deep.

What is the depth of a graphene sheet?

Put a (ring) around the correct answer.

1×10^{-11} m **1×10^{-10} m** **1×10^{-9} m** **1×10^{-8} m** **1×10^{-7} m** **[1]**

(b) Carbon nanotubes are graphene sheets rolled into a tube.



Graphene and nanotubes are examples of nanoparticles. Nanoparticles have important uses which depend on their structure and properties.

(i) Which **two** statements explain why nanotubes can be used to carry drugs into the body?

Tick (✓) **two** boxes.

- They act as molecular sieves. ☐
- They are good catalysts. ☐
- They are hollow. ☐
- They are made of carbon atoms. ☐
- They are very small. ☐
- They have a large surface area. ☐

[2]

(ii) Give **one** risk and **one** benefit of using nanoparticles to carry drugs into the body.

Risk .....

.....

Benefit .....

.....

[2]

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).