



Oxford Cambridge and RSA

F

Monday 29 November 2021 – Morning

GCSE (9–1) Chemistry A (Gateway Science)

J248/02 Paper 2 (Foundation Tier)

Time allowed: 1 hour 45 minutes

You must have:

- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Chemistry A (inside this document)

You can use:

- a scientific or graphical calculator
- an HB pencil



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

Centre number

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Candidate number

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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 **28** pages.

ADVICE

- Read each question carefully before you start your answer.

2

SECTION A

Answer **all** the questions.

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box provided.

- 1 The burning of fossil fuels can produce gases that cause **acid rain**.

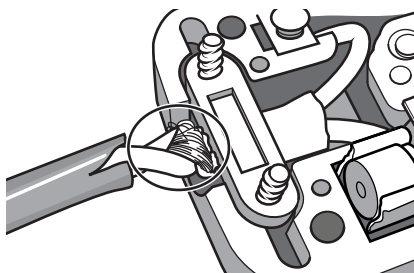
Which gas causes acid rain?

- A Carbon monoxide
- B Nitrogen
- C Oxygen
- D Sulfur dioxide

Your answer

[1]

- 2 The diagram shows the copper wires in a plug.



Why is this wire made of copper?

- A Copper conducts electricity.
- B Copper conducts heat.
- C Copper is hard.
- D Copper reacts only slowly with water.

Your answer

[1]

3

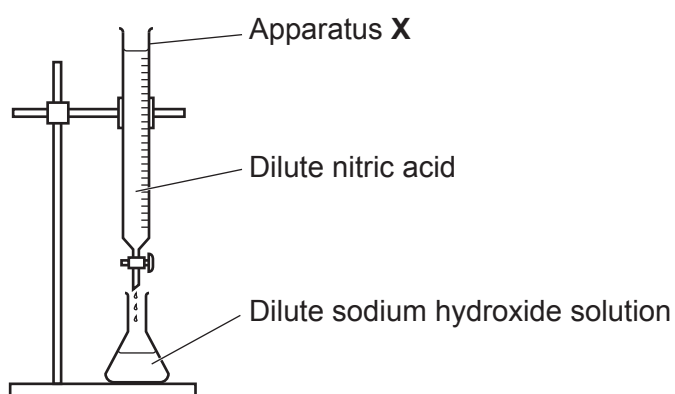
3 Which metal ion gives a lilac colour in a flame test?

- A Copper
- B Lithium
- C Potassium
- D Sodium

Your answer

[1]

4 Look at the diagram of a titration experiment.



What is the name of apparatus X?

- A Burette
- B Conical flask
- C Gas syringe
- D Pipette

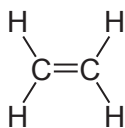
Your answer

[1]

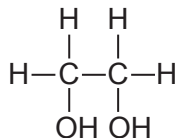
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5 What is the correctly displayed formula of **ethanoic acid**?

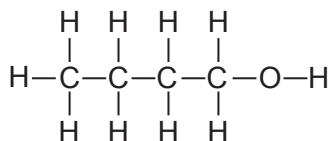
A



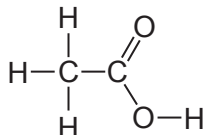
B



C



D



Your answer

[1]

6 The Earth's early atmosphere was mostly carbon dioxide gas.

The Earth's atmosphere now contains only about 0.04% carbon dioxide gas.

Which process **decreased** the amount of carbon dioxide in the Earth's early atmosphere?

A Burning hydrogen

B Carbon dioxide absorbing the Sun's energy

C Carbon dioxide dissolving in oceans

D Volcanic emissions

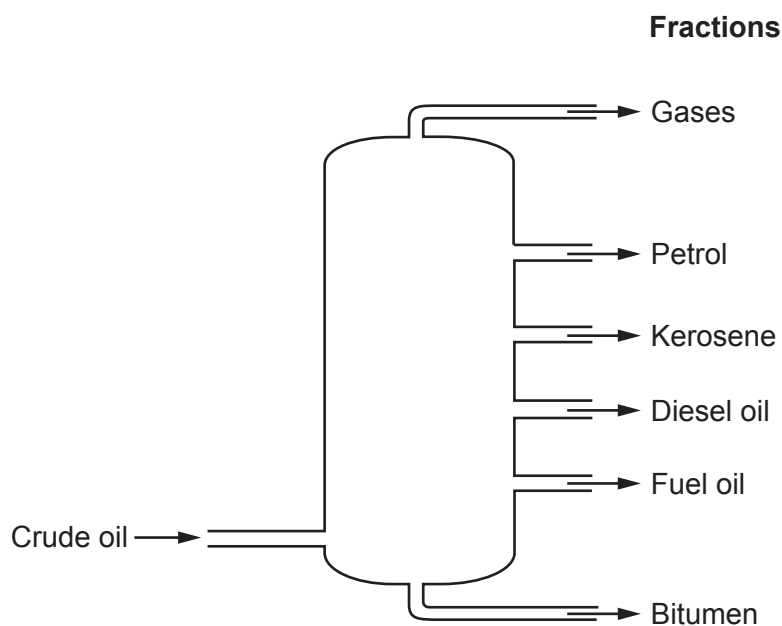
Your answer

[1]

5

- 7 Crude oil is separated into fractions by fractional distillation.

Look at the diagram of the fractions made in fractional distillation.



Which of these fractions has the **smallest** molecules?

- A Bitumen
- B Diesel oil
- C Gases
- D Petrol

Your answer

[1]

- 8 Transition metals have properties that are different from other metals in the Periodic Table.

Copper is a transition metal.

Which of the following describes copper?

- A A metal which forms blue compounds.
- B A metal which reacts violently with water.
- C A metal with a low density that floats on water.
- D A metal with a low melting point.

Your answer

[1]

- 9 A chemical cell has a voltage of 1.50 V.

What will the voltage be once the reactants are used up?

- A 0.00 V
- B 0.75 V
- C 1.50 V
- D 3.00 V

Your answer

[1]

- 10 Copper carbonate, CuCO_3 , decomposes when heated. Copper oxide, CuO , and carbon dioxide gas are made.



12.4 g of copper carbonate decomposes to make 8.0 g of copper oxide.

How much carbon dioxide gas is made?

- A 1.55 g
- B 4.4 g
- C 8.0 g
- D 20.4 g

Your answer

[1]

- 11 Propene gas is bubbled into bromine water.

What happens to the colour of the bromine water?

- A Changes from colourless to orange
- B Changes from orange to colourless
- C Stays colourless
- D Stays orange

Your answer

[1]

- 12 Sodium reacts with fluorine to form sodium fluoride.

What is the correctly **balanced symbol** equation for this reaction?

- A $\text{Na} + \text{F} \rightarrow \text{NaF}$
- B $\text{Na} + \text{F}_2 \rightarrow \text{NaF}_2$
- C $2\text{Na} + \text{F} \rightarrow \text{Na}_2\text{F}$
- D $2\text{Na} + \text{F}_2 \rightarrow 2\text{NaF}$

Your answer

[1]

- 13 Look at the results of a titration experiment.

	Titration 1 (rough)	Titration 2	Titration 3	Titration 4
Volume of acid used (cm^3)	26.00	25.20	25.50	25.60

What is the **accurate average volume of acid** used in the titration?

- A 25.35cm^3
- B 25.43cm^3
- C 25.55cm^3
- D 25.58cm^3

Your answer

[1]

- 14 Butene, pentene and hexene are alkenes. They are all members of the same homologous series.

Why are they members of the same homologous series?

- A Their molecules differ by $-\text{CH}_3$.
- B They have the same general formula.
- C They have the same molecular formula.
- D They have the same physical properties.

Your answer

[1]

8

15 Butane is a hydrocarbon molecule with a low boiling point.

Which statement about butane is correct?

- A** Butane is a large molecule and has strong intermolecular forces.
- B** Butane is a large molecule and has weak intermolecular forces.
- C** Butane is a small molecule and has strong intermolecular forces.
- D** Butane is a small molecule and has weak intermolecular forces.

Your answer

[1]

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10
SECTION B

Answer **all** the questions.

16 This question is about the elements in Group 1 of the Periodic Table.

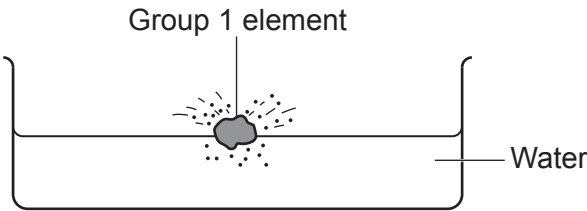
(a) Group 1 elements all react in a similar way.

Explain why.

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

(b) Lithium, sodium and potassium are Group 1 elements.

They react with water.



Look at the table.

Group 1 element	Time for element to react completely (s)	Observations
Lithium	24	fizzes moves slowly on the surface of the water makes an alkaline solution
Potassium	6	fizzes vigorously and gas catches fire melts moves very quickly on the surface of the water makes an alkaline solution
Sodium	14	fizzes vigorously melts moves quickly on the surface of the water makes an alkaline solution

All three elements make the same gas when they react with water.

(i) What is the name of this gas?

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

(ii) How would you test for this gas?

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

(iii)* Rubidium is another Group 1 element. It is below potassium in Group 1 of the Periodic Table.

Predict what you will **see** and the **reaction time** when rubidium reacts with water.

Include an **equation** for the reaction.

..... [6]

17 This question is about some of the hydrocarbons found in crude oil.

Table 17.1 shows information about four hydrocarbons found in crude oil.

Hydrocarbon	Molecular formula	Boiling point (°C)
Ethane	C ₂ H ₆	–89
Hexane	C ₆ H ₁₄	68
Nonane	C ₉ H ₂₀	
Pentadecane	C ₁₅ H ₃₂	271

Table 17.1

(a) Ethane is a **hydrocarbon**.

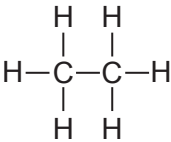
What is meant by a hydrocarbon?

.....

.....

..... [2]

(b) Look at the displayed formula for ethane.



Ethane is a **saturated** compound.

What is meant by a saturated compound?

.....

..... [1]

(c) Use the information in Table 17.1 to predict the boiling point of nonane.

..... [1]

- (d) Explain why a mixture of hexane, nonane and pentadecane can be separated by fractional distillation.

In your answer use information from **Table 17.1** and ideas about intermolecular forces.

.....

.....

.....

.....

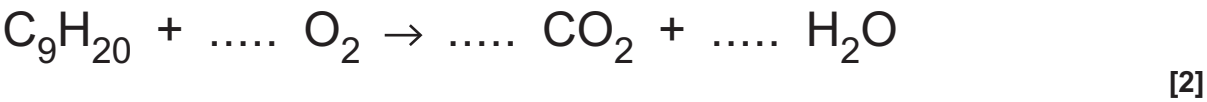
.....

..... [3]

- (e) Nonane is one of the hydrocarbons found in aircraft fuel.

Nonane burns completely in a plentiful supply of oxygen.

Complete the **balanced symbol** equation by putting numbers on the dotted lines.



- (f) Incomplete combustion of nonane makes **carbon monoxide** instead of carbon dioxide.

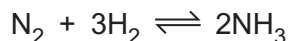
Describe and explain **one problem** caused by carbon monoxide.

.....

..... [2]

18 Ammonia, NH_3 , is made by the Haber process.

Look at the equation for the reaction.



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

..... [1]

(b) Fig. 18.1 shows the percentage of ammonia made at different temperatures and pressures.

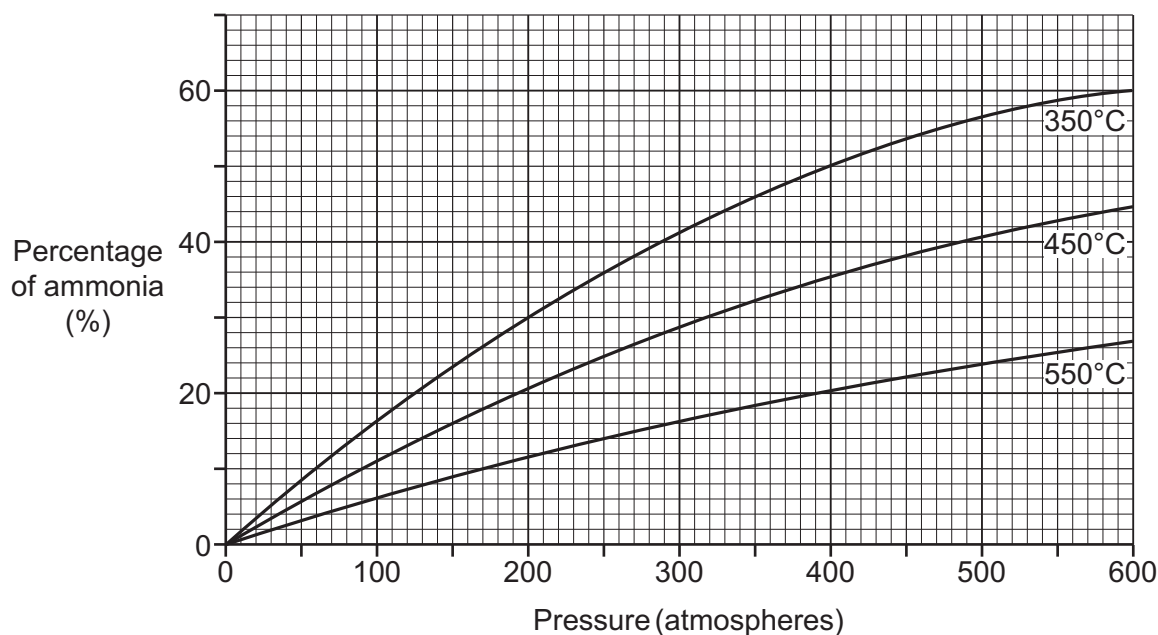


Fig. 18.1

(i) What is the percentage of ammonia made at **350°C** and **200 atmospheres**?

Percentage of ammonia = % [1]

(ii) What temperature and pressure, shown on Fig. 18.1, make the **highest** percentage of ammonia?

Temperature = °C

Pressure = atmospheres [1]

(c) Ammonia reacts with nitric acid, HNO_3 , to form the fertiliser ammonium nitrate, NH_4NO_3 .

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

..... [1]

(d) Ammonium sulfate is another fertiliser that is made using ammonia.

State the **name** of the **acid** that reacts with ammonia to form ammonium sulfate.

..... [1]

(e) State **one** reason why farmers add fertilisers to soil.

..... [1]

(f) Some fertilisers must be dissolved in water before farmers can add them to the soil.

Fig. 18.2 shows information about the solubility of three fertilisers at different water temperatures.

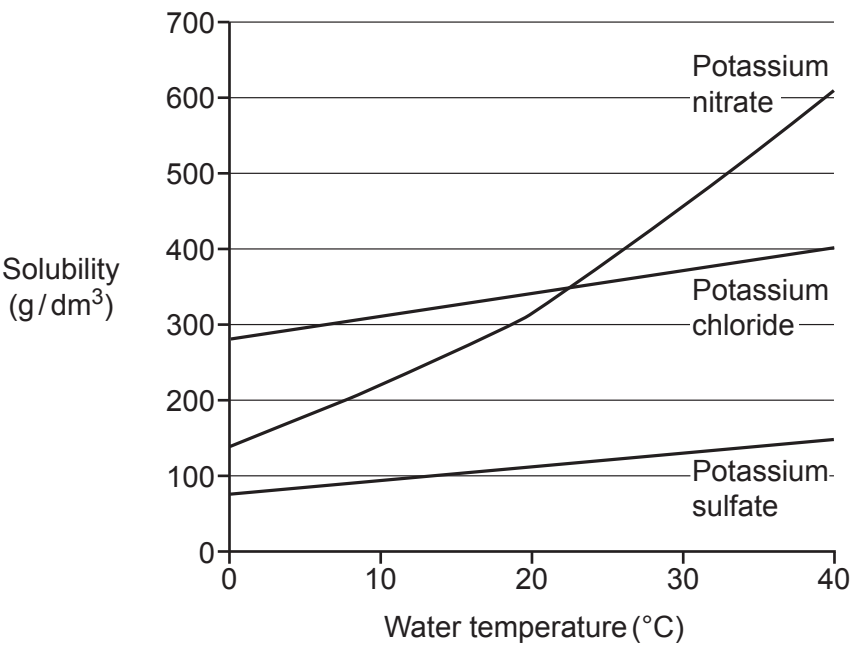


Fig. 18.2

Which fertiliser is **most** soluble in water at 20 °C?

Tick (✓) **one** box.

- | | |
|--------------------|--------------------------|
| Potassium nitrate | ☐ |
| Potassium chloride | ☐ |
| Potassium sulfate | ☐ |

[1]

(g) A student makes some ammonium sulfate in the laboratory.

This is the method she uses:

- Pour 25 cm³ of dilute ammonia solution into a conical flask.
- Add 2–3 drops of methyl orange indicator.
- Add dilute acid from a burette until the reaction is complete.

(i) Explain how the student can make sure that the reaction is complete.

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

(ii) Ammonia solution releases small amounts of ammonia gas.

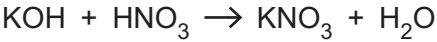
Ammonia is a colourless gas with a sharp, irritating smell.

Describe how to control **one** hazard when making ammonium sulfate.

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

(h) Potassium nitrate, KNO₃, is another fertiliser.

Potassium nitrate is made by reacting potassium hydroxide, KOH, with nitric acid, HNO₃.



Calculate the mass of potassium nitrate that can be made from 315 tonnes of nitric acid.

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

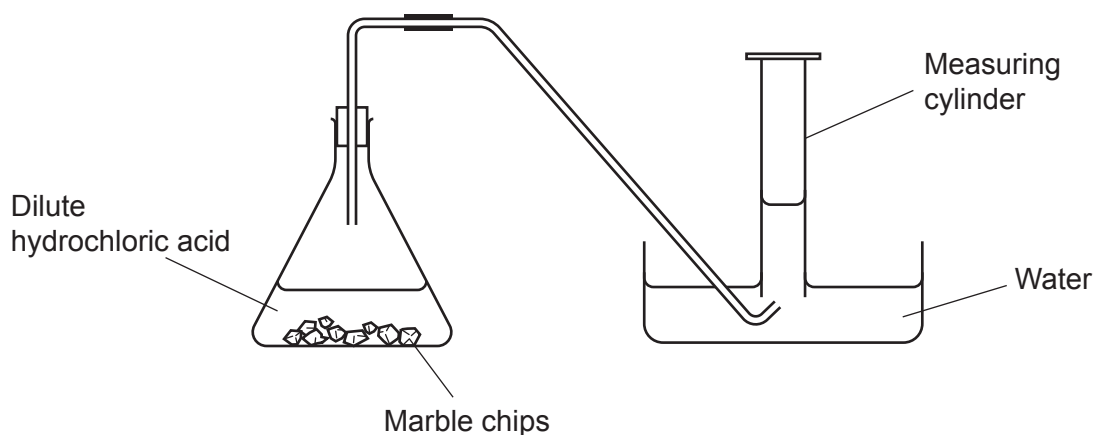
(The relative atomic mass, A_r, of H is 1.0, of K is 39.1, of N is 14.0 and of O is 16.0).

Mass of potassium nitrate = tonnes [4]

- 19 A student investigates the rate of reaction between marble chips and dilute hydrochloric acid.

The student measures the volume of carbon dioxide gas given off every 30 seconds.

Look at the apparatus they use.



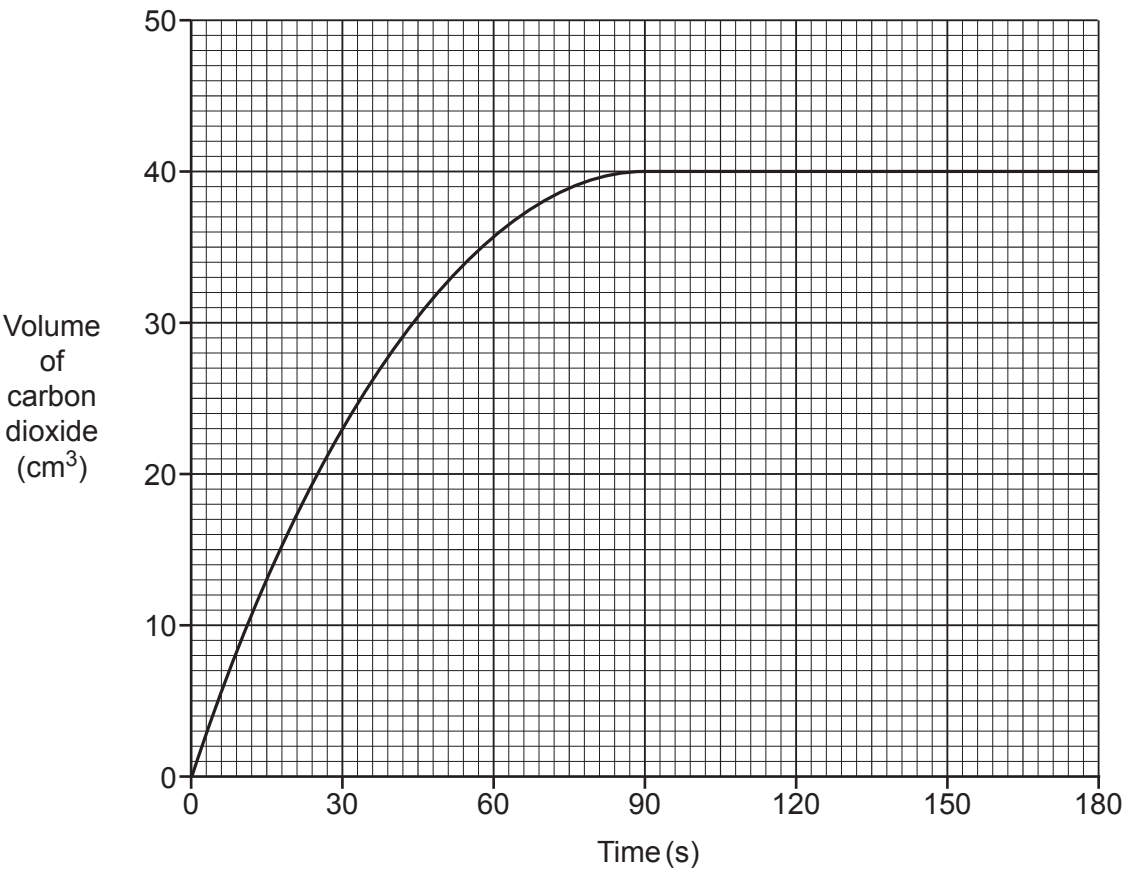
- (a) Suggest a piece of apparatus that the student could use to measure the **volume** of carbon dioxide more accurately.

..... [1]

- (b) Describe the test for carbon dioxide gas.

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

(c) The graph shows the student's results.



(i) What is the time taken to make 23 cm³ of carbon dioxide?

Time = s [1]

(ii) The student repeats the experiment. The only difference is they use **larger** marble chips.

Draw a line on the graph to show the results of this experiment. [2]

(d) The student made 0.073 g of carbon dioxide in their experiment.

They predicted that they should have made 0.088 g.

Calculate the **percentage yield**.

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

Percentage yield = % [3]

- (e) Another student investigates the effect of changing the temperature of the dilute hydrochloric acid on the rate of the reaction.

The table shows the student’s results.

Experiment	Temperature (°C)	Time for reaction to finish (s)
1	20	107
2	30	61
3	40	35
4	50	17

Describe and explain the effect of changing the temperature on the **rate** of the reaction.

Use the student’s results and the reacting particle model in your answer.

.....

.....

.....

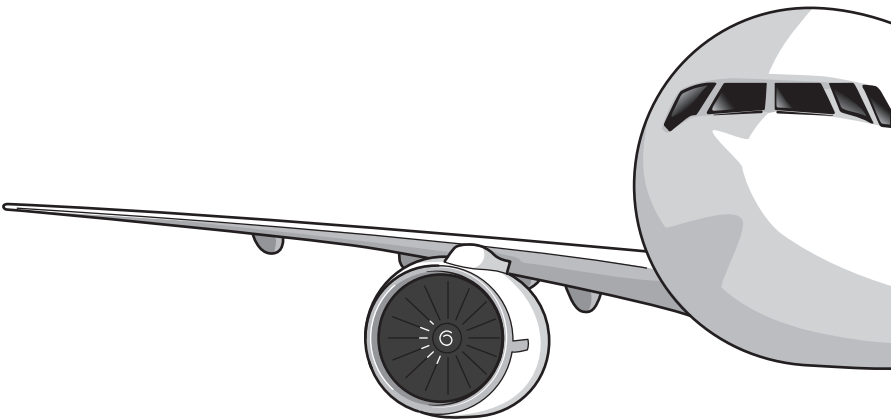
.....

.....

..... [3]

20 This question is about metals.

Look at the picture. It shows an aircraft wing.



The table shows the properties of three metals.

	Density (g/cm ³)	Relative electrical conductivity (0 = low, 10 = high)	Relative strength (0 = low, 10 = high)	Corrosion in moist air	Cost per tonne (£)
Aluminium	2.7	4	3	does not corrode	770
Copper	8.9	6	4	corrodes slowly	5900
Iron	7.9	1	6	corrodes	200

(a) Which metal in the table would you use to make the aircraft wing?

Explain your answer. Use information from the table to help you.

Metal

Explanation

.....

.....

..... [4]

(b) Aluminium can be made into an alloy called **duralumin**.

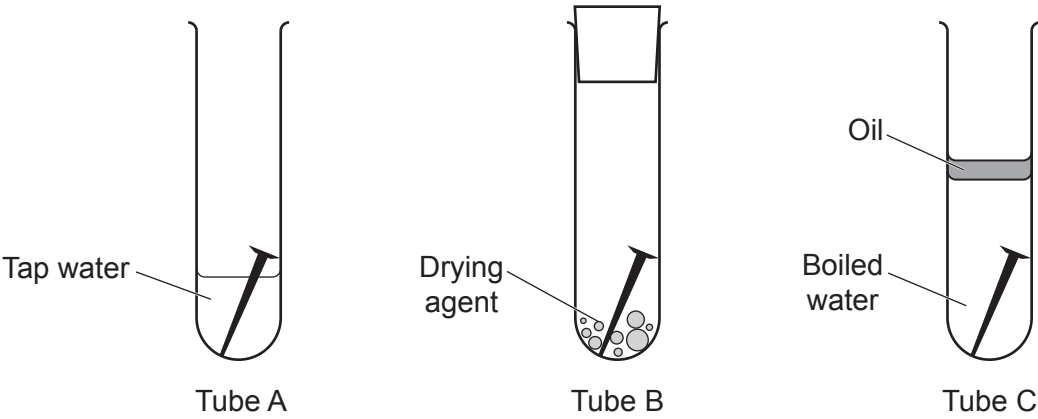
Which metal is mixed with aluminium to make duralumin?

..... [1]

(c) Iron corrodes. This is called rusting.

A student does an experiment to find out what conditions are needed to cause an iron nail to rust.

Look at the diagram of their experiment.



They leave the tubes for one week.

Predict in which tube the iron nail will rust.

Explain your answer.

Tube

Explanation

..... [4]

(d) Describe and explain **one** way to prevent an iron bridge from rusting.

..... [2]

21 A student analyses a sample of ethanol, $\text{C}_2\text{H}_5\text{OH}$, using a mass spectrometer.

The structure of ethanol is shown.

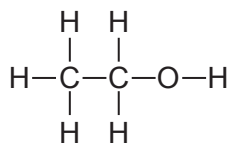


Fig. 21.1 shows the mass spectrum of the ethanol.

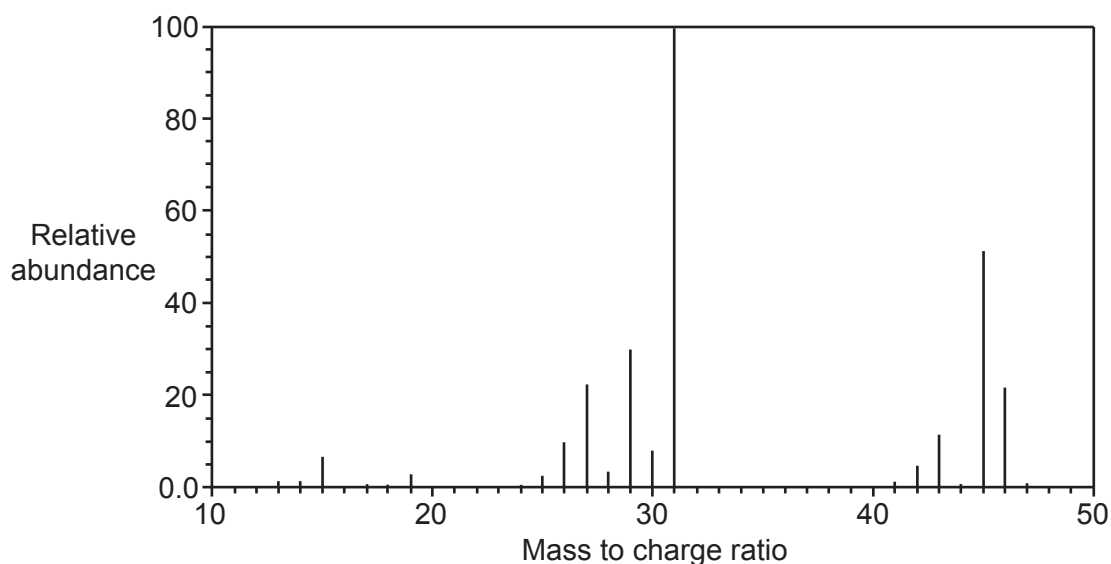


Fig. 21.1

The student also analyses the sample using an infrared spectrometer.

An infrared spectrometer detects covalent bonds in a molecule. Different covalent bonds are detected at different wavenumbers in an infrared spectrum.

Fig. 21.2 shows the infrared spectrum of the ethanol.

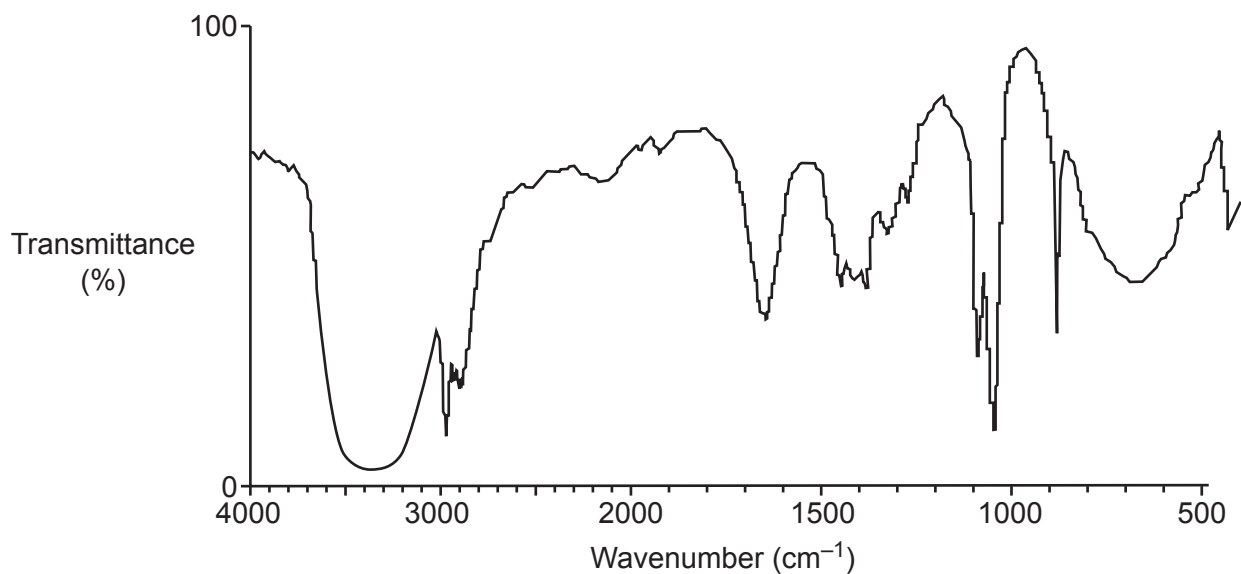


Fig. 21.2

The table shows the wavenumber for different bonds in an infrared spectrum.

Bond	Wavenumber (cm ⁻¹)
C–H	2850–3300
C–C	750–1100
C=C	1620–1680
C=O	1680–1750
C–O	1000–1300
N–H	3360–3500
O–H	3230–3550

(a) Explain how the mass spectrum **and** the infrared spectrum show that the sample is ethanol, C₂H₅OH.

.....

.....

.....

..... [3]

(b) Mass spectrometry and infrared spectrometry are both examples of instrumental methods of analysis.

Describe **two advantages** of instrumental methods of analysis.

1

.....

2

..... [2]

(c) Ethanol, C₂H₅OH, burns in a plentiful supply of oxygen to form carbon dioxide and water.

This is an example of complete combustion.

(i) Write the **balanced symbol** equation for this reaction.

..... [2]

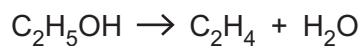
24

- (ii) If there is a limited supply of oxygen, **incomplete combustion** will happen.

Describe a **disadvantage** of incomplete combustion.

..... [1]

- (d) Ethanol, $\text{C}_2\text{H}_5\text{OH}$, can be dehydrated to make ethene, C_2H_4 .



Calculate the atom economy for the production of ethene from ethanol.

(The relative formula mass, M_r , of $\text{C}_2\text{H}_5\text{OH}$ is 46.0 and of C_2H_4 is 28.0).

Atom economy = % [2]

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22 A car manufacturer is designing a new car. They need to decide if the car will have a petrol engine or a diesel engine.

(a) The car manufacturer carries out a **life-cycle assessment** for both types of car.

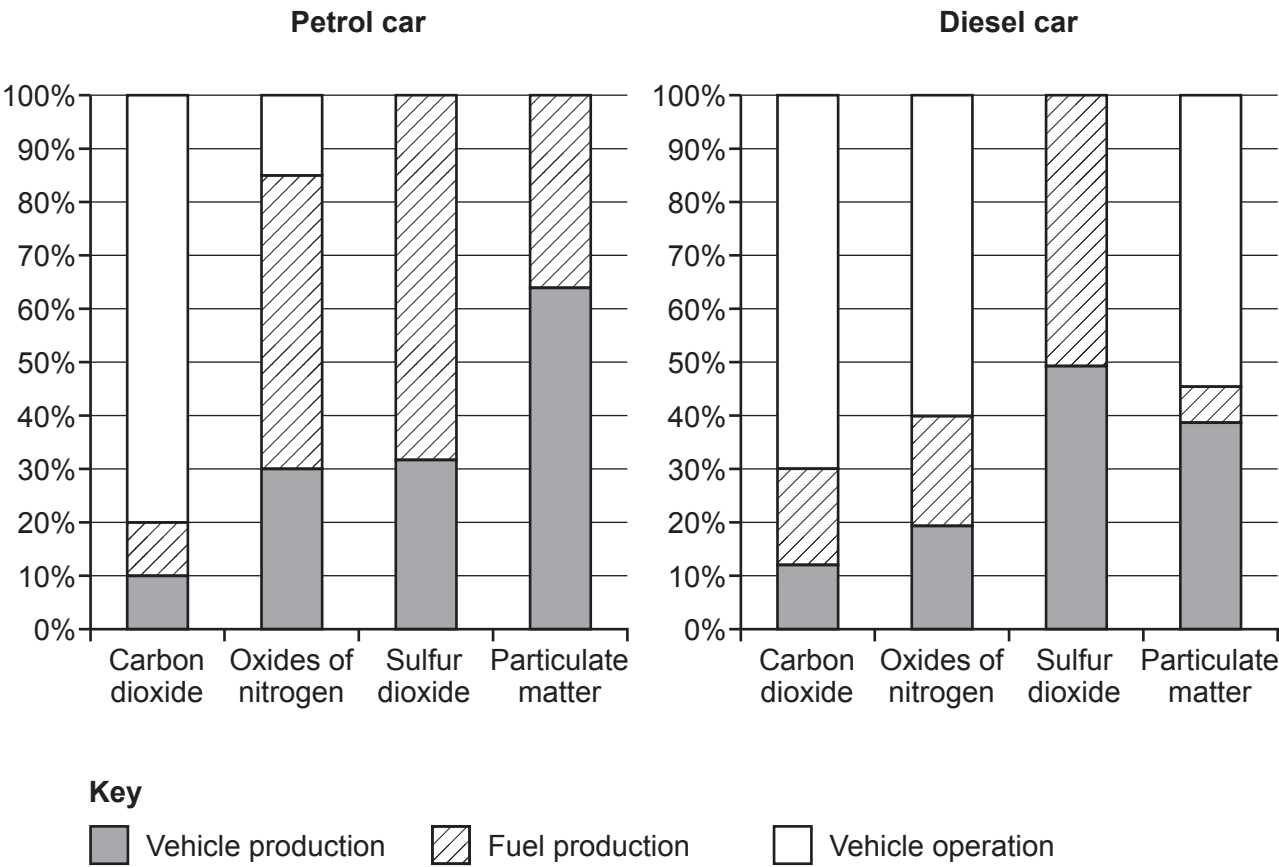
(i) Describe the purpose of a life-cycle assessment.

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

(ii) Describe **two** examples of data, other than waste products and pollution, that could be included in a life-cycle assessment.

1
.....
2
..... [2]

(b) The graphs show the air emission results of a life-cycle assessment for a petrol car and a diesel car.



(i) At which stage are the **most oxides of nitrogen** produced by the **diesel car**?

Tick (✓) **one** box.

Vehicle production	☐
Fuel production	☐
Vehicle operation	☐

[1]

(ii) The car manufacturer estimates that a petrol car produces 29.8 tonnes of carbon dioxide over its lifetime.

A diesel car produces only 20.5 tonnes of carbon dioxide over its lifetime.

Use the graphs to calculate the **mass**, in tonnes, of carbon dioxide produced by the petrol car **and** the diesel car **during vehicle operation**.

Use your answers to calculate the **difference**, in tonnes, in the mass of carbon dioxide produced by the petrol car and the diesel car **during vehicle operation**.

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

Mass of carbon dioxide produced by the petrol car = tonnes

Mass of carbon dioxide produced by the diesel car = tonnes

Difference in mass of carbon dioxide = tonnes
[4]

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).



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