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

**J260/06** Chemistry (Higher Tier)

## Thursday 17 May 2018 – Morning

### Time allowed: 1 hour 45 minutes

*703593526*

**You must have**
- the Data Sheet (for GCSE Chemistry B (inserted))
- a ruler (cm/mm)

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

*J260006*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| First name | | | | | | | | | |
| Last name | | | | | | | | | |
| Centre number | | | | | | Candidate number | | | | |

**INSTRUCTIONS**
- The Data Sheet will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

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

Answer **all** the questions.

**1** The elements in Group 7 (Group 17) of the Periodic Table are called the halogens.

**(a)** Each element has a different state and colour at room temperature.

Draw lines to connect each **element** with its correct **state** and **colour** at room temperature.

| State | Element | Colour |
|---|---|---|
| | | Green |
| Solid | Chlorine | |
| | | Dark grey |
| Liquid | Bromine | |
| | | Pink |
| Gas | Iodine | |
| | | Red/brown |

**[3]**

**(b)** **Table 1.1** shows what happens when some halogens react with hydrogen.

| Element | Reaction with hydrogen |
|---|---|
| **Bromine** | Reacts steadily when heated. |
| **Fluorine** | Explodes at room temperature. |
| **Iodine** | Reacts slowly when heated. |

**Table 1.1**

**(i)** Describe the trend in reactivity of the Group 7 elements with hydrogen.

.....

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

**(ii)** A mixture of chlorine and hydrogen explodes when a small spark is added.

Does this fit the trend of the reactivity of the other Group 7 elements with hydrogen?

Explain your reasoning.

.....

.....

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

**(c)** The halogens also react with reactive metals.

**(i)** Potassium reacts with bromine to form potassium bromide.

Balance the symbol equation for this reaction.

.....K + $Br_2$ → .....KBr

**[1]**

**(ii)** Other metals also react with bromine to form metal bromides.

The formula of the metal bromide depends on the number of electrons in the outer shell of an atom of the metal.

Complete **Table 1.2** which shows the products formed when different metals react with bromine.

| Metal | Periodic Table Group | Number of electrons in outer shell of atom of metal | Ion formed by metal | Formula of metal bromide |
|---|---|---|---|---|
| **Potassium** | 1 | 1 | $K^+$ | KBr |
| **Magnesium** | 2 | | | |
| **Aluminium** | 3 | | | |

**Table 1.2**

**[3]**

**2** Most cars are fitted with catalytic converters.

Harmful gases from the car engine react together in the converter to form less harmful gases.

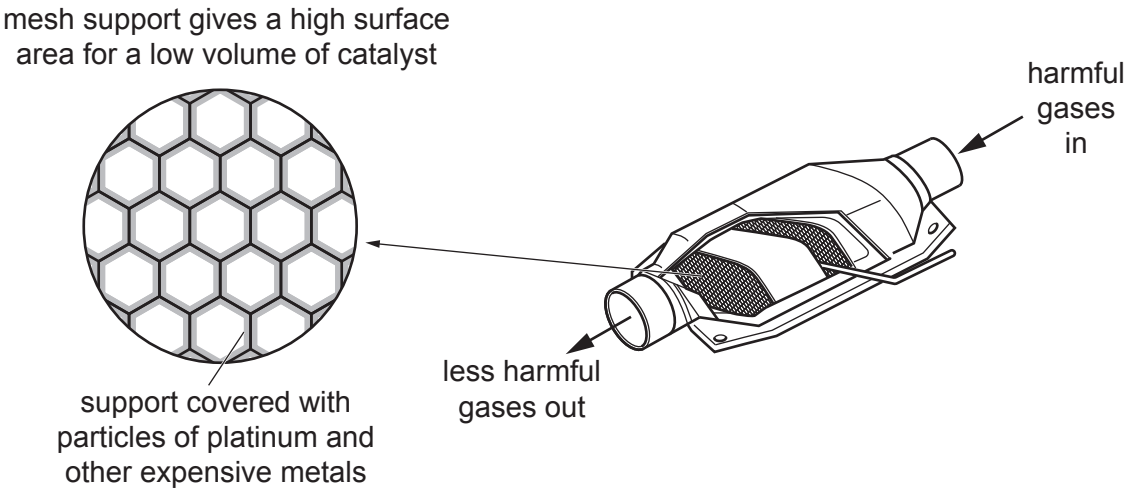
**(a)** The catalyst in the converter increases the rate of the reactions between the gases.

Use ideas about energy to explain how catalysts increase the rate of a reaction.

.....

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

**(b)** Platinum and other very expensive metals are used as catalysts in the converter.
Very small particles of the metals are spread in a thin layer over a support.
This means that a very low volume of metals is needed to give a very high surface area.




Suggest the advantages of using a low volume of catalyst with a high surface area.

Low volume .....

.....

High surface area .....

.....

**[2]**

**(c) (i)** The surface area to volume ratio of a particle of a catalyst can be calculated by using this formula:
surface area to volume ratio = surface area of particle ÷ volume of particle

The table shows the particle size and surface area to volume ratio for fine and coarse powders.

| Particle | Fine powder | Coarse powder |
|---|---|---|
| **Size (nm)** | 500 | 5000 |
| **Surface area to volume ratio ($nm^{-1}$)** | 0.012 | 0.0012 |

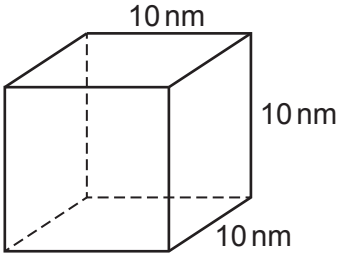
How is the surface area to volume ratio of a particle related to its size?

.....

.....

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

**(ii)** Catalysts are now made from nanoparticles. A nanoparticle in a catalyst is shown in the diagram.




Calculate the surface area to volume ratio of the nanoparticle.
Assume that it is a cube with sides of 10 nm.

Surface area to volume ratio of the particle = ..... $nm^{-1}$

**[4]**

**3** Many compounds found on Earth and other planets contain hydrogen.

**(a)** Water is a compound of hydrogen with oxygen. It is found in very large amounts in the Earth's seas.

Water is added to the sea when ice caps melt.

In sunlight, plants use water for photosynthesis to make glucose.

**(i)** Which statements are **true only for melting**, which are **true only for photosynthesis** and which are **true for both**?

Put a tick (✓) in one box in each row.

| | **True only for melting** | **True only for photosynthesis** | **True for both** |
|---|---|---|---|
| It is a physical change. | | | |
| It is a chemical change. | | | |
| New substances are formed. | | | |
| It involves an energy change. | | | |

**[2]**

**(ii)** Use the particle model to explain why the ice caps are a fixed shape but water in the sea can flow and change shape.

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

**(b)** Water, methane and ammonia are compounds of hydrogen with other elements.

Some scientists think that life on other planets could be based on methane or ammonia instead of water.

The table shows some properties of water, methane and ammonia.

| Compound | Formula | Melting point (°C) | Boiling point (°C) |
|---|---|---|---|
| **Water** | $H_2O$ | 0 | 100 |
| **Methane** | $CH_4$ | –182 | –164 |
| **Ammonia** | $NH_3$ | –78 | –33 |

**(i)** Which statements about water, methane and ammonia are **true** and which are **false**?

Put a tick (✓) in one box in each row

| | True | False |
|---|---|---|
| Water has the lowest melting point. | | |
| Methane has the weakest forces between its molecules. | | |
| The boiling point of methane is higher than the melting point of ammonia. | | |
| Water has the highest relative formula mass. | | |

**[2]**

**(ii)** The average surface temperature of Earth is 14 °C.
The average surface temperature of Mars is –55 °C.

Use the data in the table to predict the state of ammonia on each planet.

Explain your answer.

.....

.....

.....

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

**4** Indigestion may be caused by excess acid in the stomach. Kai and Jane investigate indigestion tablets.

The active compound in each tablet is calcium carbonate which reacts with excess acid.

**(a)** Kai and Jane react solid calcium carbonate with dilute hydrochloric acid.

The products of the reaction are calcium chloride, carbon dioxide and water.

This is the equation for the reaction.

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

Kai says that after the reaction, the mass of products must equal the mass of the reactants.

Jane predicts that the mass will decrease during the reaction.

Explain why they are **both** correct.

Kai .....

.....

Jane .....

.....

**[2]**

**(b)** Jane does an experiment to find out the total mass of carbon dioxide made when one indigestion tablet reacts with dilute hydrochloric acid.

Describe how Jane could do her experiment.

Include a list of the apparatus she could use and the measurements she should record.
You may include a diagram in your answer.

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

**(c)** Jane repeats her experiment four times.

Here are her results.

| **Experiment** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Mass of carbon dioxide made (g)** | 0.22 | 0.18 | 0.24 | 0.17 |

**(i)** What is the range of Jane's results?

Range = ..... **[1]**

**(ii)** Calculate the mean value for the mass of carbon dioxide made.

Give your answer to **2** decimal places.

Mean value = ..... g **[3]**

**(d)** The label on the tablets says that each tablet contains 500 mg of calcium carbonate.

**(i)** Jane works out that there are 0.005 moles of calcium carbonate in 500 mg.

Show by calculation that she is right.

**[2]**

**(ii)** Jane reacts 0.005 moles of calcium carbonate with dilute hydrochloric acid.

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

Calculate the mass of carbon dioxide made in the reaction.

Mass of carbon dioxide = ..... g **[2]**

**5*** The table shows the type of bonding and the melting points of the chlorides and oxides of the elements in Period 3 of the Periodic Table.

| | **Period 3 chlorides** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Formula** | $NaCl$ | $MgCl_2$ | $AlCl_3$ | $SiCl_4$ | $PCl_3$ | $SCl_2$ | $Cl_2$ |
| **Bonding and structure** | ionic | | simple covalent | | | | |
| **Melting point (°C)** | 801 | 712 | 193 | –68 | –92 | –80 | –101 |
| | **Period 3 oxides** | | | | | | |
| **Formula** | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_4O_6$ | $SO_2$ | $Cl_2O_7$ |
| **Bonding and structure** | ionic | | | giant covalent | simple covalent | | |
| **Melting point (°C)** | 1275 | 2800 | 2045 | 1700 | 24 | –72 | –92 |

Describe the pattern shown by the melting points of the chlorides and oxides. Use ideas about bonding and structure to explain why the melting points are different.

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

**6** Mia is investigating vitamin tablets. She reads the label on a bottle of vitamin tablets and it says that the tablets contain other ingredients.

**(a)** The tablets are a formulation.

What is the difference between a formulation and a pure substance?

.....

.....

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

**(b)** The other ingredients in the tablet include coloured dyes.

Mia uses chromatography to separate the dyes.
She starts by crushing a tablet and mixing it with water.

She finds that some of the ingredients in the tablet dissolve in the water but the dyes do not.

**(i)** How can she tell that the dyes have **not** dissolved in the water?

.....

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

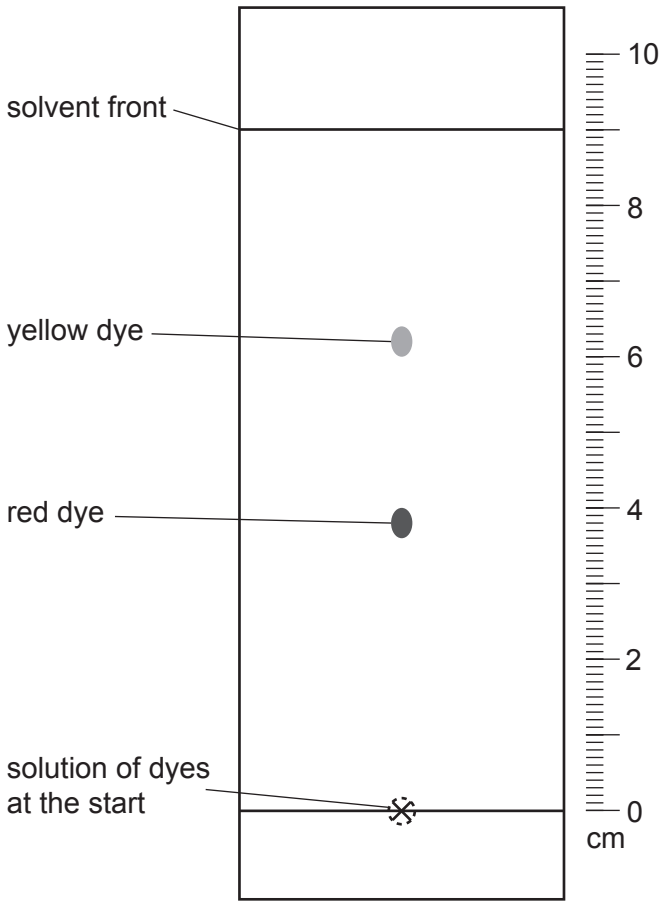
**(ii)** What should she do to make a solution of the dyes?

.....

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

**(c)** Mia takes a solution of the dyes and does a chromatography experiment.

Here are her results.




**(i)** Use the scale given on the diagram to complete the table of results.

| | **Distance moved by solvent (cm)** | **Distance moved by dye (cm)** |
|---|---|---|
| **Red dye** | | |
| **Yellow dye** | | |

**[2]**

**(ii)** Mia uses this formula to calculate the $R_f$ value of each dye:

$$R_f = \frac{\text{distance moved by the dye}}{\text{distance moved by the solvent}}$$

How could she use the $R_f$ values of the dyes to check that they are the dyes listed in the tablet ingredients?

Tick (✓) **two** boxes.

Repeat the same experiment and compare $R_f$ values. ☐

Compare the $R_f$ values when different solvents are used. ☐

Compare the $R_f$ values with a reference table of known dyes. ☐

Do an experiment to find the $R_f$ value for pure samples of the listed dyes. ☐

**[2]**

**(iii)** Mia does a chromatography experiment for a green dye.
This dye has an $R_f$ value of 0.52.

After the experiment the solvent front has travelled 8 cm from the start line.

How far from the start line does the green dye travel?

Distance = ..... cm **[2]**

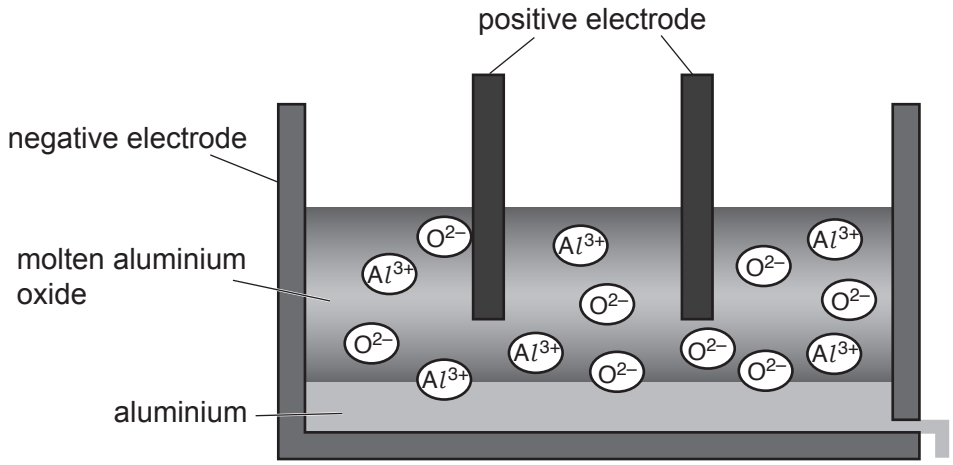
**(d)** Explain why it was **not** necessary to use a locating agent in this experiment.

.....

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

**7** Aluminium is extracted from aluminium oxide by electrolysis.

Aluminium oxide, $Al_2O_3$, is an ionic compound.




**(a)** The aluminium oxide must be molten in this process so that it conducts electricity.

Explain why aluminium oxide conducts electricity when it is liquid but not when it is solid.

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.....

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

**(b)** **(i)** Complete the table to show the product and half equation at the positive electrode.

| **Electrode** | **Name of product** | **Half equation** |
|---|---|---|
| **Negative** | aluminium | $Al^{3+} + 3e^- \rightarrow Al$ |
| **Positive** | | |

**[3]**

**(ii)** Complete the following sentence by putting a (ring) around the correct words:

The reaction at the negative electrode is **oxidation / reduction** because

electrons are **gained / lost**. **[1]**

**(c)** Alex does an experiment to find out if he can make aluminium at room temperature.
He starts by making a solution of aluminium sulfate.

He reacts solid aluminium oxide with dilute sulfuric acid to make a solution of aluminium sulfate in water.

Complete and balance the chemical equation for this reaction.
Include the state symbols.

aluminium oxide + sulfuric acid → aluminium sulfate + water

..... (s) + .....$H_2SO_4$ (aq) → $Al_2(SO_4)_3$ (.....) + $3H_2O$ (.....)

**[2]**

**(d)** Alex passes electricity through the dilute solution of aluminium sulfate he has made.
He expects aluminium to form at the negative electrode.

He finds that a gas forms at the negative electrode instead of aluminium. He tests the gas with a lighted splint and it gives a squeaky pop.

**(i)** Explain why aluminium is **not** formed at the negative electrode.

.....

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

**(ii)** Name the gas that forms at the negative electrode and explain why this gas is produced during the electrolysis.

.....

.....

.....

.....

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

**8** The Haber Process manufactures ammonia by reacting nitrogen with hydrogen.

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

**(a)** Explain why this reaction cannot produce a yield of 100%.

.....

.....

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

**(b)** The table shows the yield of ammonia at different conditions of temperature and pressure.

| | **Percentage yield of ammonia at equilibrium** | | | | |
|---|---|---|---|---|---|
| | **Temperature (°C)** | | | | |
| **Pressure (atm)** | **100** | **200** | **300** | **400** | **500** |
| **10** | – | 51 | 15 | 4 | 1 |
| **25** | 92 | 64 | 27 | 9 | 3 |
| **50** | 95 | 74 | 40 | 15 | 6 |
| **100** | 97 | 82 | 53 | 25 | 11 |
| **200** | 98 | 89 | 67 | 39 | 18 |
| **400** | 99 | 95 | 80 | 55 | 32 |

**(i)** Describe the effect of changing the temperature and the pressure on the **percentage yield** of ammonia produced.

Temperature .....

.....

Pressure .....

.....

**[2]**

**(ii)** Which temperature and pressure would together give the highest yield?

Temperature = ..... °C

Pressure = ..... atm **[1]**

**(iii)** The conditions chosen for the manufacture of ammonia are 400–450 °C and 200 atmospheres pressure.

For each condition, give a reason why it is chosen rather than the one that gives the highest yield.

Temperature .....

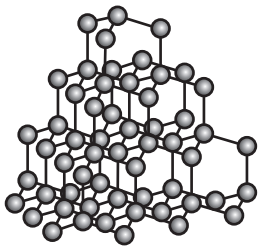
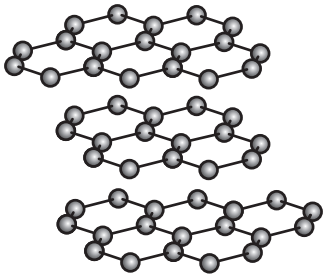
.....

Pressure .....

.....

**[2]**

**9** Diamond and graphite are allotropes of carbon.

| | **Diamond** | **Graphite** |
|---|---|---|
| **Structure** |  |  |
| **Hardness** | very hard | soft, flakes easily |
| **Electrical conductivity** | does not conduct | high |

**(a)** Describe two similarities and two differences between the **structures** of diamond and graphite.

Similarities:

1 .....

.....

2 .....

.....

Differences:

1 .....

.....

2 .....

.....

**[4]**

**(b)** Use ideas about structure and bonding to explain why the hardness and electrical conductivity of diamond and graphite are different.

Hardness .....

.....

.....

Electrical conductivity .....

.....

.....

**[4]**

**10** pH values can be used to compare the acidity of different acids.
The pH of an acid can be measured by reading the display on a pH meter.

**(a)** Describe a different way that the pH of an acid can be measured.

.....

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

**(b)** Ling tests the pH of solutions of a strong acid and a weak acid. Both acids have the same concentration.
She finds that the strong acid has a much lower pH.

Explain why the strong acid has a lower pH than the weak acid.

.....

.....

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

**(c)** The table shows information about three different acid solutions.

Complete the table for the three solutions.

| Acid solution | Concentration of solution (mol / $dm^3$) | pH | Concentration of hydrogen ions (mol / $dm^3$) | Type of acid |
|---|---|---|---|---|
| **1** | 0.1 | 1 | $1 \times 10^{-1}$ | strong |
| **2** | 0.01 | 2 | $1 \times 10^{-2}$ | ..... |
| **3** | 0.1 | 5 | ..... | weak |

**[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).