AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.2.4.1

Sizes of particles and their properties

Past-paper questions

Tier	**Higher**
Question groups	**13**
Available paper years	**2008–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.2.4.1 Sizes of particles and their properties

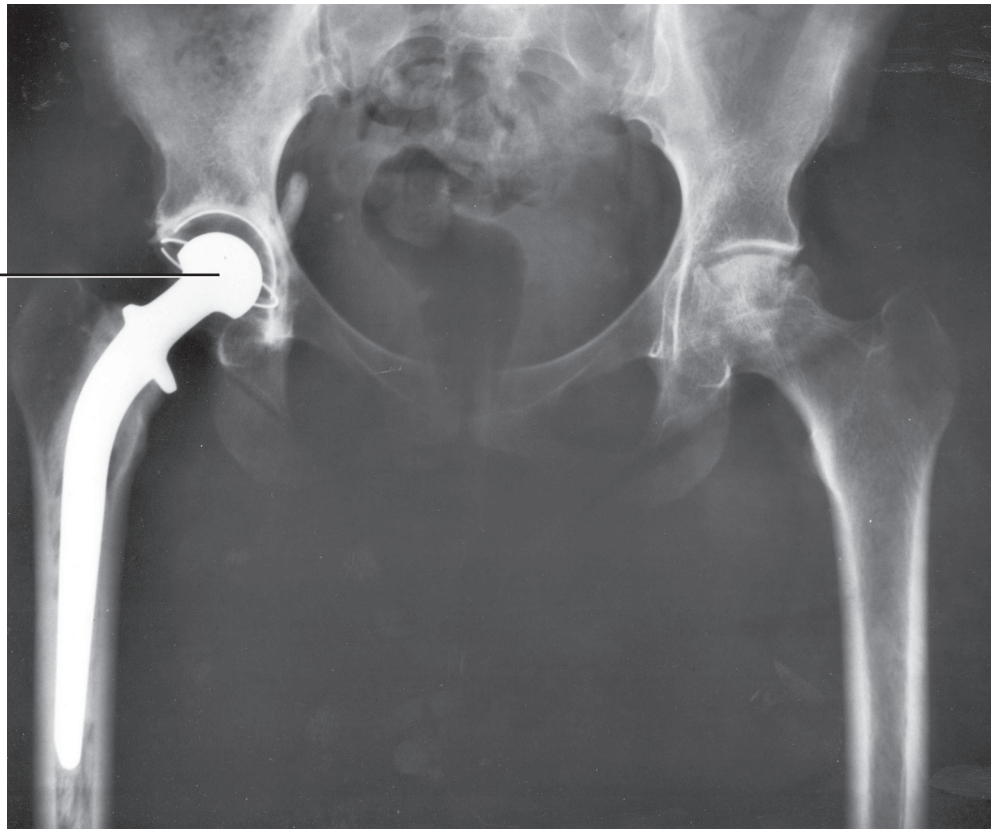
Question 01

2 Read this passage about metals.

Metals are crystalline materials. The metal crystals are normally about 20 000 nm (nanometres) in diameter. The atoms inside these crystals are arranged in layers.

A new nanoscience process produces nanocrystalline metals. Nanocrystalline metals are stronger and harder than normal metals.

It is hoped that nanocrystalline metals can be used in hip replacements.



The use of nanocrystalline metals should give people better hip replacements which last longer.

(a) State why metals can be bent and hammered into different shapes.

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(1 mark)

4.2.4.1 Sizes of particles and their properties

Question 01 · continued

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(b) How is the size of the crystals in nanocrystalline metals different from the size of the crystals in normal metals?

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(1 mark)

(c) Hip joints are constantly moving when people walk.

Suggest and explain why the hip replacement made of nanocrystalline metal should last longer than one made of normal metals.

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(2 marks)

4

4.2.4.1 Sizes of particles and their properties

Question 02

June 2008 | CHY2H | Original Q6 | Legacy

6 Read the article about the use of nanoparticles in sun creams.

Sun creams

Many sun creams use nanoparticles. These sun creams are very good at absorbing radiation, especially ultraviolet radiation. Owing to the particle size, the sun creams spread more easily, cover better and save money because you use less. The new sun creams are also transparent, unlike traditional sun creams which are white. The use of nanoparticles is so successful that they are now used in more than 300 sun cream products.

Some sun creams contain nanoparticles of titanium oxide. Normal-sized particles of titanium oxide are safe to put on the skin. For this reason some chemical companies have assumed that nanoparticles of titanium oxide are also safe without doing further testing.

It is thought that nanoparticles can pass through the skin and travel around the body more easily than normal-sized particles. It is also thought that nanoparticles might be toxic to some types of cell, such as skin, bone, brain and liver cells.

6 (a) Explain why nanoparticles pass through the skin and travel around the body more easily than normal-sized particles of titanium oxide.

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(2 marks)

6 (b) Explain why sun creams containing nanoparticles should be tested further.

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(1 mark)

6 (c) Suggest why some companies that make sun creams might not want to do more tests.

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(2 marks)

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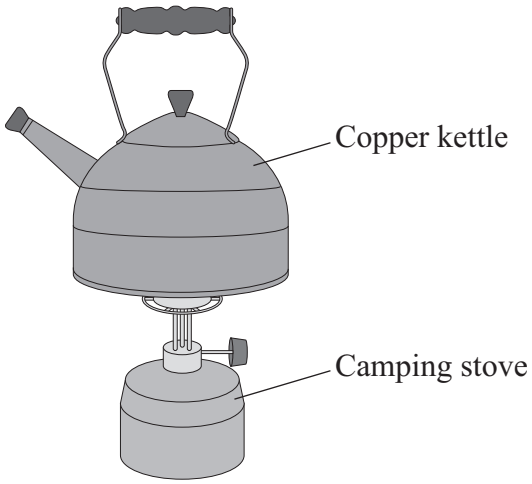
4.2.4.1 Sizes of particles and their properties

Question 03

4 The picture shows a copper kettle being heated on a camping stove.

Copper is a good material for making a kettle because:

- it has a high melting point
- it is a very good conductor of heat.



4 (a) Explain why copper, like many other metals, has a high melting point.
You should describe the structure and bonding of a metal in your answer.

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(4 marks)

4.2.4.1 Sizes of particles and their properties

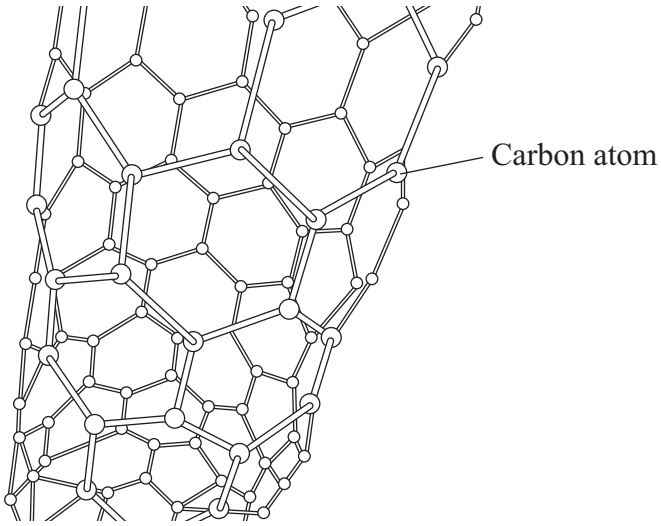
Question 03 · continued January 2010 | CHY2H | Original Q4 | Legacy

for mark

4 (b) An aeroplane contains many miles of electrical wiring made from copper. This adds to the mass of the aeroplane.

It has been suggested that the electrical wiring made from copper could be replaced by lighter carbon nanotubes.

The diagram shows the structure of a carbon nanotube.



4 (b) (i) What does the term 'nano' tell you about the carbon nanotubes?

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(1 mark)

4 (b) (ii) Like graphite, each carbon atom is joined to three other carbon atoms.

Explain why the carbon nanotube can conduct electricity.

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(2 marks)

7

4.2.4.1 Sizes of particles and their properties

Question 04

June 2011 | CHY2H | Original Q1 | Legacy

1 Read the article and then answer the questions.

TOXIC SOCKS?

Silver nanoparticles are added to the fibres used to make some socks. Silver has the special property that it can kill bacteria. As a result there are no unpleasant smells when wearing these socks.



Some scientists are concerned about the use of silver nanoparticles in socks.

The silver can be released from the socks when they are washed. This silver may end up in rivers. Silver in rivers may kill fish.

Scientists found that some makes of socks release the silver more easily than others. Socks in which the silver nanoparticles are trapped in the fibres released very little silver when washed.

1 (a) Suggest why silver stops unpleasant smells when wearing the socks.

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(1 mark)

1 (b) How is the size of silver nanoparticles different from normal sized silver particles?

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(1 mark)

4.2.4.1 Sizes of particles and their properties

Question 04 · continued

1 (c) The silver nanoparticles are more effective at preventing unpleasant smells than normal sized silver particles.

Suggest why.

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(1 mark)

1 (d) The silver nanoparticles should be trapped in the sock fibres.

Use the information in the article to explain why.

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(2 marks)

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4.2.4.1 Sizes of particles and their properties

Question 05

June 2012 | CH2HP | Original Q6 | Legacy

6 This question is about calcium hydroxide.

Ancient artworks and monuments can be protected from acid rain if the surface is sprayed with calcium hydroxide nanoparticles.



6 (a) Calcium hydroxide has the formula $Ca(OH)_2$

Why are there two hydroxide ions for each calcium ion in the formula?

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(1 mark)

6 (b) The calcium hydroxide is used in the form of *nanoparticles*.

What are *nanoparticles*?

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(1 mark)

4.2.4.1 Sizes of particles and their properties

Question 05 · continued

6 (c) A student added water to calcium oxide to make calcium hydroxide.

The equation for the reaction is shown below.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Calculate the maximum mass of calcium hydroxide which could be made from 2.00 g of calcium oxide.

Relative atomic masses (A_r): H = 1; O = 16; Ca = 40.

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Maximum mass of calcium hydroxide = ... g

(3 marks)

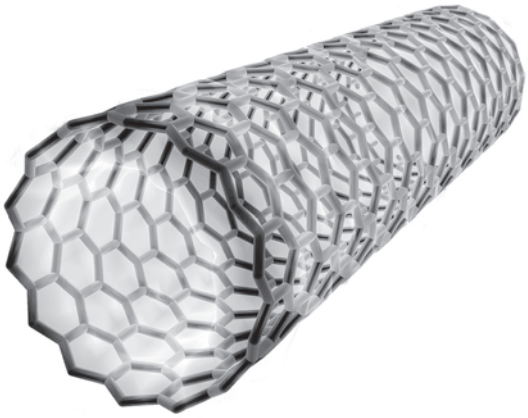
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4.2.4.1 Sizes of particles and their properties

Question 06

June 2014 | CH2HP | Original Q5 | Legacy

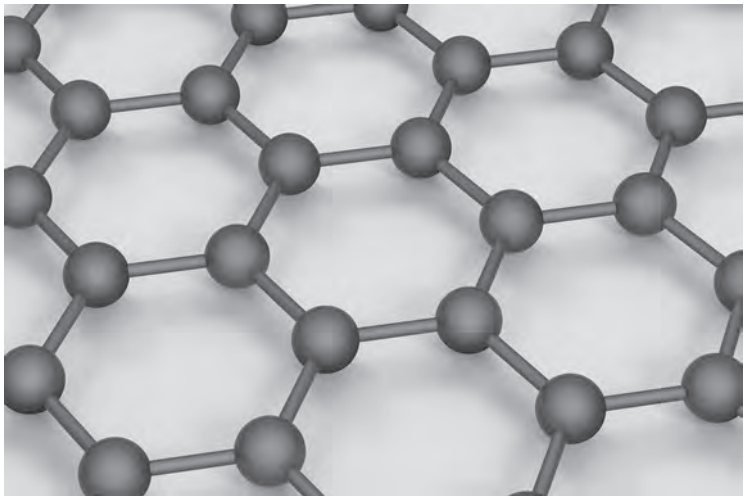
5 Carbon atoms are used to make nanotubes.



Carbon atoms in a nanotube are bonded like a single layer of graphite.

Figure 5 shows the structure of a single layer of graphite.

Figure 5



4.2.4.1 Sizes of particles and their properties

Question 06 · continued

5 (a) Suggest why carbon nanotubes are used as lubricants.

[2 marks]

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5 (b) Explain why graphite can conduct electricity.

[2 marks]

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4.2.4.1 Sizes of particles and their properties

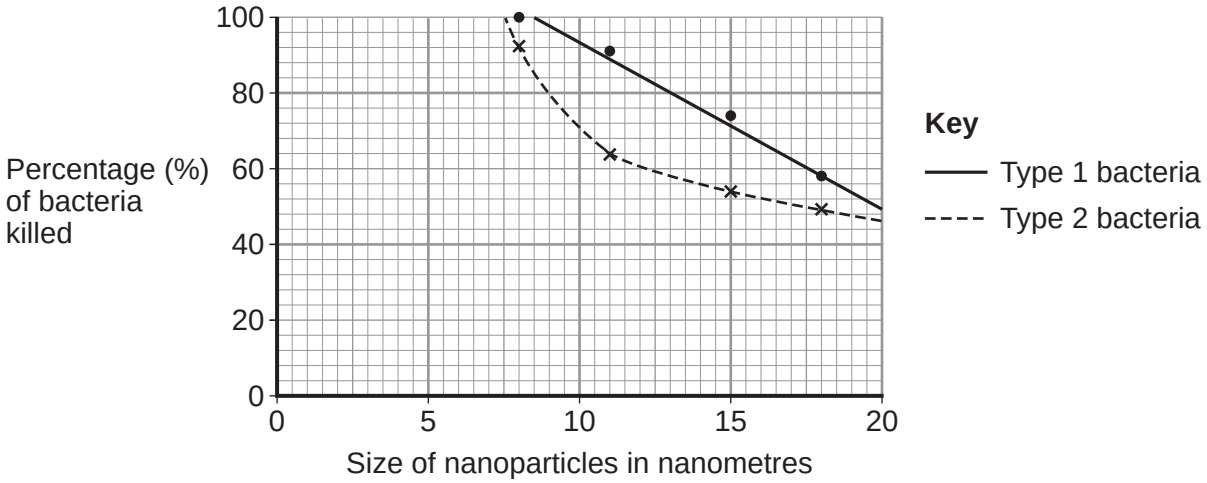
Question 07

June 2014 | CH2HP | Original Q6 | Legacy

6 Magnesium oxide nanoparticles can kill bacteria.

Figure 6 shows the percentage of bacteria killed by different sized nanoparticles.

Figure 6



6 (a) (i) Give **two** conclusions that can be made from **Figure 6**.

[2 marks]

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6 (a) (ii) Points are plotted for only some sizes of nanoparticles.

Would collecting and plotting data for more sizes of nanoparticles improve the conclusions?

Give a reason for your answer.

[1 mark]

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4.2.4.1 Sizes of particles and their properties

Question 07 · continued

6 (b) Magnesium oxide contains magnesium ions (Mg^{2+}) and oxide ions (O^{2-}).

Describe, as fully as you can, what happens when magnesium atoms react with oxygen atoms to produce magnesium oxide.

[4 marks]

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4.2.4.1 Sizes of particles and their properties

Question 08

June 2016 | CH2HP | Original Q3 | Legacy

3 This question is about atoms, molecules and nanoparticles.

3 (a) Different atoms have different numbers of sub-atomic particles.

3 (a) (i) An oxygen atom can be represented as $^{16}_{8}O$

Explain why the mass number of this atom is 16.

You should refer to the numbers of sub-atomic particles in the nucleus of the atom.

[2 marks]

3 (a) (ii) Explain why $^{12}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

You should refer to the numbers of sub-atomic particles in the nucleus of each isotope.

[3 marks]

4.2.4.1 Sizes of particles and their properties

Question 08 · continued

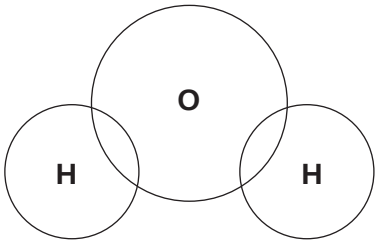
3 (b) Hydrogen atoms and oxygen atoms chemically combine to produce water molecules.

3 (b) (i) Complete **Figure 3** to show the arrangement of the outer shell electrons of the hydrogen and oxygen atoms in a molecule of water.

Use dots (•) or crosses (×) to represent the electrons.

[2 marks]

Figure 3



3 (b) (ii) Name the type of bonding in a molecule of water.

[1 mark]

_____

3 (b) (iii) Why does pure water **not** conduct electricity?

[1 mark]

_____

_____

3 (c) Nanoparticles of cobalt oxide can be used as catalysts in the production of hydrogen from water.

3 (c) (i) How does the size of a nanoparticle compare with the size of an atom?

[1 mark]

_____

_____

3 (c) (ii) Suggest **one** reason why 1 g of cobalt oxide nanoparticles is a better catalyst than 1 g of cobalt oxide powder.

[1 mark]

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_____

11

4.2.4.1 Sizes of particles and their properties

Question 09

June 2017 | CH2HP | Original Q3 | Legacy

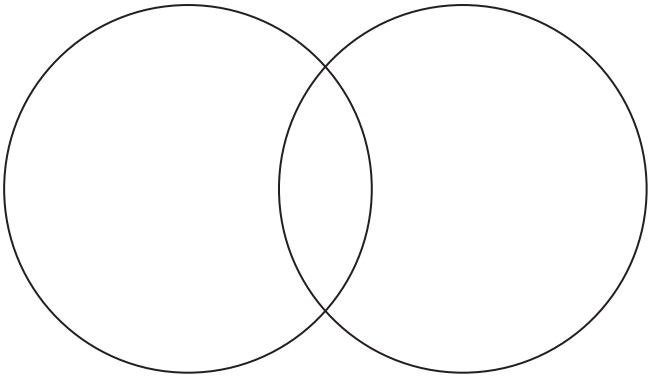
3 This question is about oxygen and substances containing oxygen.

3 (a) (i) Complete **Figure 4** to show the arrangement of the outer shell electrons in an oxygen molecule.

Use dots (•) and crosses (×) to represent the electrons.

[2 marks]

Figure 4



3 (a) (ii) Name the type of bonding in an oxygen molecule.

[1 mark]

_____

3 (a) (iii) Explain why oxygen has a low boiling point.

[2 marks]

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4.2.4.1 Sizes of particles and their properties

Question 09 · continued

3 (b) Magnesium oxide is produced when oxygen reacts with magnesium.

3 (b) (i) **Balance** the equation for the reaction.

[1 mark]

$$Mg + O_2 \longrightarrow MgO$$

3 (b) (ii) Magnesium oxide contains magnesium ions (Mg^{2+}) and oxide ions (O^{2-}).

Describe what happens, in terms of electrons, when magnesium atoms react with oxygen atoms to produce magnesium oxide.

[3 marks]

3 (b) (iii) Magnesium oxide nanoparticles can be made.

What are nanoparticles?

[1 mark]

Question 3 continues on the next page

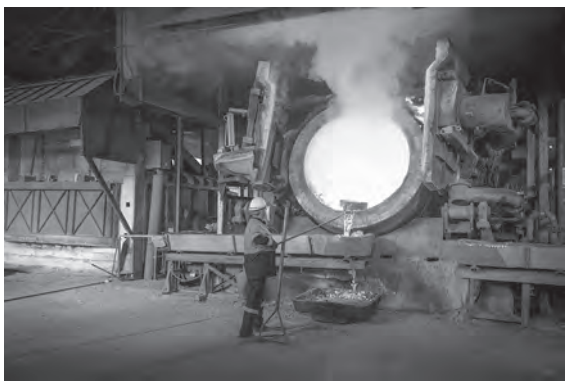
4.2.4.1 Sizes of particles and their properties

Question 09 · continued

3 (c) **Figure 5** shows a furnace lined with silicon dioxide (SiO_2).

The temperature in the furnace is 1500 °C.

Figure 5



Explain, in terms of structure and bonding, why silicon dioxide is used to line furnaces.

[3 marks]

13

4.2.4.1 Sizes of particles and their properties

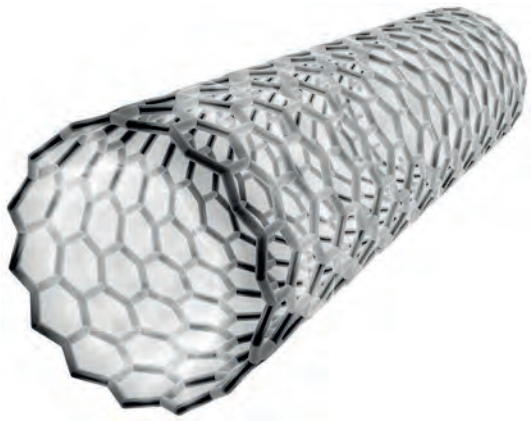
Question 10

June 2019 | 8462/1H | Original Q3

0 3 This question is about materials and their properties.

0 3 . 1 **Figure 3** shows a carbon nanotube.

Figure 3



The structure and bonding in a carbon nanotube are similar to graphene.

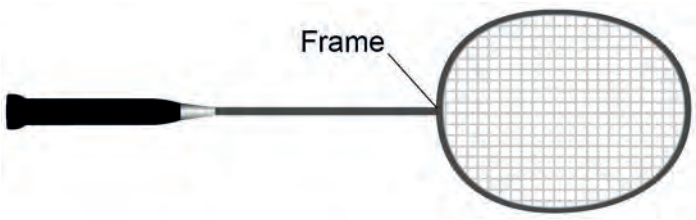
Carbon nanotubes are used in electronics because they conduct electricity.

Explain why carbon nanotubes conduct electricity.

[2 marks]

0 3 . 2 **Figure 4** shows a badminton racket.

Figure 4



4.2.4.1 Sizes of particles and their properties

Question 10 · continued

Table 1 shows some properties of materials.

The materials could be used to make badminton racket frames.

Table 1

Material	Density in g/cm^3	Relative strength	Relative stiffness
Aluminium	2.7	0.3	69
Carbon nanotube	1.5	60	1000
Wood	0.71	0.1	10

Evaluate the use of the materials to make badminton racket frames.

Use **Table 1**.

[4 marks]

4.2.4.1 Sizes of particles and their properties

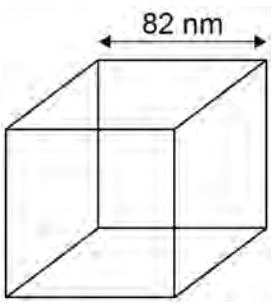
Question 10 · continued

Zinc oxide can be produced as nanoparticles and as fine particles.

0 3 . 3 A nanoparticle of zinc oxide is a cube of side 82 nm

Figure 5 represents a nanoparticle of zinc oxide.

Figure 5



Calculate the surface area of a nanoparticle of zinc oxide.

Give your answer in standard form.

[3 marks]

Surface area = _____ nm^2

0 3 . 4 Some suncreams contain zinc oxide as nanoparticles or as fine particles.

Suggest **one** reason why it costs less to use nanoparticles rather than fine particles in suncreams.

[1 mark]

10

4.2.4.1 Sizes of particles and their properties

Question 11

November 2020 | 8462/2H | Original Q8

0 8 This question is about the rate of the reaction between hydrochloric acid and calcium carbonate.

A student investigated the effect of changing the size of calcium carbonate lumps on the rate of this reaction.

This is the method used.

1. Pour 40 cm^3 of hydrochloric acid into a conical flask.

2. Add 10.0 g of small calcium carbonate lumps to the conical flask.

3. Attach a gas syringe to the conical flask.

4. Measure the volume of gas produced every 30 seconds for 180 seconds.

5. Repeat steps 1 to 4 using 10.0 g of large calcium carbonate lumps.

The student calculated the number of moles of gas from each volume of gas measured.

Table 4 shows the student's results for large calcium carbonate lumps.

Table 4

Time in seconds	Number of moles of gas
0	0.0000
30	0.0011
60	0.0020
90	0.0028
120	0.0034
150	0.0038
180	0.0040

The student plotted the results for small calcium carbonate lumps on **Figure 4**.

0 8 . 1 Complete **Figure 4**.

You should:

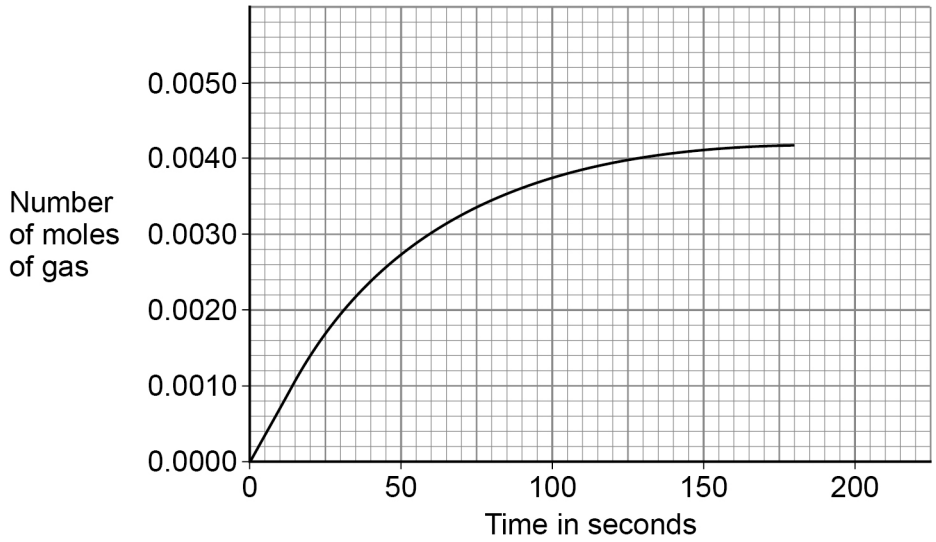
- plot the data for large calcium carbonate lumps from **Table 4**
- draw a line of best fit.

[3 marks]

4.2.4.1 Sizes of particles and their properties

Question 11 · continued

Figure 4



0 8 . 2 Determine the mean rate of reaction for **small** calcium carbonate lumps between 20 seconds and 105 seconds.

Give the unit.

Use **Figure 4**.

[4 marks]

Mean rate of reaction = _____ Unit _____

0 8 . 3 The student concluded that the large calcium carbonate lumps reacted more slowly than the small calcium carbonate lumps.

How do the student's results show that this conclusion is correct?

[1 mark]

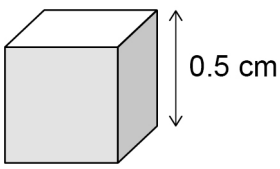
4.2.4.1 Sizes of particles and their properties

Question 11 · continued

The difference in the rates of reaction of large lumps and of small lumps of calcium carbonate depends on the surface area to volume ratios of the lumps.

Figure 5 shows a cube of calcium carbonate.

Figure 5



0 8 . 4 Calculate the surface area to volume ratio of the cube in **Figure 5**.

Give your answer as the simplest whole number ratio.

[3 marks]

Surface area : volume = _____ : _____

0 8 . 5 A larger cube of calcium carbonate has sides of 5 cm

Describe how the surface area to volume ratio of this larger cube differs from that of the cube shown in **Figure 5**.

[1 mark]

12

4.2.4.1 Sizes of particles and their properties

Question 12

June 2023 | 8462/1H | Original Q10

1 0 This question is about titanium dioxide (TiO_2).

1 0 . 1 Self-cleaning windows are coated with a layer of nanoparticles of titanium dioxide.

Titanium dioxide:

- helps sunlight break down dirt particles
- attracts water, so dirt is washed away by rain.

Nanoparticles of titanium dioxide are used instead of fine particles of titanium dioxide for coating self-cleaning windows.

Suggest **two** reasons why.

[2 marks]

1 _____

_____

2 _____

_____

Question 10 continues on the next page

4.2.4.1 Sizes of particles and their properties

Question 12 · continued

10.2 Titanium is extracted from titanium dioxide in a two-stage process.

The equation for the first stage in the process is:

$$TiO_2 + 2\,Cl_2 + 2\,C \rightarrow TiCl_4 + 2\,CO$$

Calculate the volume of chlorine gas needed to react completely with 100 kg of titanium dioxide.

Relative atomic masses (A_r): O = 16 Ti = 48

The volume of one mole of gas = 24 dm^3

[6 marks]

8

Volume = _____ dm^3

4.2.4.1 Sizes of particles and their properties

Question 13

June 2025 | 8462/1H | Original Q5

0 5 This question is about small particles.

Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided.

0 5 . 1 The discovery of the electron led to the plum pudding model of the atom.

Describe the plum pudding model of the atom.

[2 marks]

0 5 . 2 The model of the atom changed again after the alpha particle scattering experiment.

Give **two** conclusions that were made from the alpha particle scattering experiment.

[2 marks]

1

2

0 5 . 3 Niels Bohr made another change to the model of the atom.

What was this change?

[1 mark]

4.2.4.1 Sizes of particles and their properties

Question 13 · continued

0 5 . 4 A helium atom has a radius of 1.4×10^{-10} m.

The nucleus of this atom has a radius of 1.7×10^{-15} m.

How many times larger is the radius of the atom than the radius of the nucleus?

[1 mark]

Tick (✓) **one** box.

~1000 times larger ☐

~10 000 times larger ☐

~100 000 times larger ☐

~1 000 000 times larger ☐

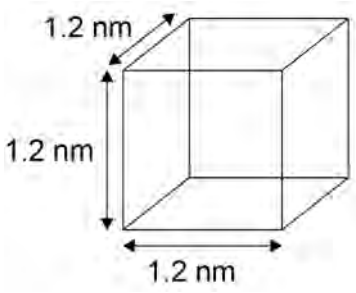
4.2.4.1 Sizes of particles and their properties

Question 13 · continued

Nanoparticles contain a few hundred atoms.

0 5 . 5 **Figure 5** represents a cubic nanoparticle.

Figure 5



Calculate the simplest surface area : volume ratio of the cubic nanoparticle.

[4 marks]

Simplest surface area to volume ratio = _____ : _____

0 5 . 6 Lenses in reading glasses often have a scratch-resistant coating that contains a hard substance.

Nanoparticles of the hard substance are used instead of fine particles of the hard substance.

Explain why nanoparticles are used instead of fine particles.

[2 marks]

12