

GCSE Combined Science: Trilogy

Worksheet: Graphene and fullerenes

TIME 30 min	TOTAL 29 marks	CALCULATOR Allowed	DIFFICULTY Easy, Medium
-----------------------	--------------------------	------------------------------	-----------------------------------

Topics: Graphene and fullerenes

NAME	CLASS	DATE
-------------	--------------	-------------

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Answer all questions in the spaces provided.
- In all calculations, show clearly how you work out your answer.
- The marks for questions are shown in brackets.

0 1

Graphene and fullerenes are forms of carbon.

0 1 . 1

What is graphene?

Tick (✓) **one** box.

A single layer of graphite

☐

A form of diamond

☐

A polymer of carbon and hydrogen

☐

A compound of carbon and oxygen

☐

[1 mark]

0 1 . 2

What is the molecular formula of Buckminsterfullerene?

Tick (✓) **one** box.

C₆

☐

C₁₂

☐

C₆₀

☐

C₆₀₀

☐

[1 mark]

0 1 . 3

Describe the shape of a Buckminsterfullerene molecule.

[1 mark]

0 1 . 4

Give **one** use of carbon nanotubes.

[1 mark]

0 2

Graphene and fullerenes are forms of carbon.

0 2 . 1

Which statement about graphene is correct?

Tick (✓) **one** box.

It is a single layer of graphite, one atom thick.

☐

It is a hollow sphere of carbon atoms.

☐

It is a tube of carbon atoms.

☐

It has the formula C_{60} .

☐

[1 mark]

0 3

Fullerenes are molecules of carbon atoms with hollow shapes.

0 3 . 1

The structure of fullerenes is based on hexagonal rings of carbon atoms, but fullerenes may also contain rings with other numbers of carbon atoms.

Which numbers of carbon atoms can these other rings contain?

Tick (✓) **two** boxes.

3

☐

4

☐

5

☐

7

☐

8

☐

[2 marks]

0 3 . 2

Give **two** uses of fullerenes.

.....

.....

.....

.....

[2 marks]

0 3 . 3

Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios.

A carbon nanotube has a diameter of 1.5 nm and a length of 3.0 μm .
Calculate the length to diameter ratio of the nanotube. (1 μm = 1000 nm)

.....

.....

.....

.....

.....
[2 marks]

.....

0 4

Graphene, Buckminsterfullerene (C₆₀) and carbon nanotubes are all forms of carbon.

0 4 . 1

Compare the structures of graphene, Buckminsterfullerene and carbon nanotubes, and explain how the structure of each substance makes it useful.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[6 marks]

0 5

Carbon nanotubes are cylindrical fullerenes. A carbon nanotube has a diameter of 1.5 nm and a length of 0.30 mm.

$$1 \text{ mm} = 1 \times 10^6 \text{ nm}$$

0 5 . 1

Give the length of the nanotube in nanometres.

.....

.....

.....

Length = nm

[1 mark]

0 5 . 2

Calculate the ratio of the length of the nanotube to its diameter.

.....

.....

.....

.....

.....

[2 marks]

0 5 . 3

Give **one** use of carbon nanotubes.

.....

.....

[1 mark]

0 6

Graphene is a single layer of graphite. It is only one atom thick.

0 6 . 1

Graphene is useful in electronics.

Explain why, in terms of its structure and bonding.

.....

.....

.....

.....

[2 marks]

0 6 . 2

Graphene is added to other materials to make strong composites.

Explain why graphene is very strong.

.....

.....

.....

.....

[2 marks]

0 6 . 3

Graphite is soft and slippery, but graphene is not.
Suggest why.

[2 marks]

0 7

Graphene oxide is made by treating graphene so that oxygen-containing groups bond to carbon atoms in the layer. Unlike graphene, graphene oxide does not conduct electricity well.

0 7 . 1

Suggest why bonding oxygen-containing groups to the carbon atoms in graphene reduces its electrical conductivity.

[2 marks]

END OF QUESTIONS

Original practice questions written to match the specification. Not produced by, affiliated with or endorsed by AQA.

Mark scheme

GCSE Combined Science: Trilogy · Worksheet: Graphene and fullerenes · 29 marks

Question 1 (4 marks)

01.1 [1 mark]

Correct: A single layer of graphite

01.2 [1 mark]

Correct: C₆₀

01.3 [1 mark]

Answer: a hollow sphere (ball)

- (hollow) sphere / spherical / ball (1)
-

01.4 [1 mark]

Answer: e.g. reinforcing materials such as tennis rackets

- reinforcing materials (e.g. in tennis rackets / bikes) / electronics / nanotechnology (1)
-
-

Question 2 (1 mark)

02.1 [1 mark]

Correct: It is a single layer of graphite, one atom thick.

Question 3 (6 marks)

03.1 [2 marks]

Correct: 5; 7

03.2 [2 marks]

Answer: e.g. delivering drugs into the body; lubricants

- delivering drugs (into the body) (1)
- lubricants (1)
- catalysts (1)
- reinforcing materials (carbon nanotubes) (1)

Any 2 of the points above.

03.3 [2 marks]

Answer: 2000 (2000 : 1)

- $3.0 \mu\text{m} = 3000 \text{ nm}$ (1)
- $3000 \div 1.5 = 2000$ (1)

Notes: An answer of 2 (units not converted) scores 1 mark.

Question 4 (6 marks)

04.1 [6 marks]

Answer: Graphene: a single layer of carbon atoms (one atom thick) in hexagonal rings, each bonded to three others, with delocalised electrons, so it conducts electricity (electronics) and is very strong for its mass (composites). C₆₀: a hollow, spherical molecule of 60 carbon atoms in rings of five and six atoms, used to carry drugs into the body, as lubricants and as catalysts. Carbon nanotubes: cylinders of hexagonal rings with a very high length-to-diameter ratio, very strong and conducting, used to reinforce materials and in electronics and nanotechnology.

Levels of response

- **Level 3 (5–6)** A detailed, coherent answer. Relevant points are accurate, linked in a logical sequence and use correct scientific terms.
- **Level 2 (3–4)** Several relevant points with some linking, but the answer has gaps, errors or lacks detail.
- **Level 1 (1–2)** Simple statements making one or two relevant points, with little or no linking.
- **No marks (0)** Nothing relevant or worthy of credit.

Indicative content

- graphene is a single layer of graphite, one atom thick, with each carbon atom covalently bonded to three others in hexagonal rings
- graphene has delocalised electrons that can move through the layer, so it conducts electricity and is useful in electronics
- graphene's strong covalent bonds make it very strong for its very low mass, so it is useful in composites
- Buckminsterfullerene is a molecule of 60 carbon atoms with a hollow, spherical (cage) shape, made of rings of five and six carbon atoms
- because C₆₀ molecules are hollow and very small, fullerenes can be used to carry drugs into the body; they are also used as lubricants and as catalysts
- carbon nanotubes are cylindrical fullerenes: hexagonal rings of carbon atoms forming very long, thin tubes with a very high length-to-diameter ratio
- nanotubes are very strong along their length and conduct electricity, so they are used to reinforce materials (e.g. in sports equipment) and in electronics and nanotechnology

Notes: Allow 'ball' or 'football shape' for spherical, and 'rolled-up graphene' for nanotubes.

Level 3 (5–6 marks): describes the structures of all three substances and links a structural feature of each to a relevant property or use.

Level 2 (3–4 marks): describes at least two structures with some correct links to uses, or all three structures with few links to uses.

Level 1 (1–2 marks): simple statements about shapes or uses, e.g. 'nanotubes are tubes' or 'graphene is used in electronics'.

Question 5 (4 marks)

05.1 [1 mark]

Answer: 3.0×10^5 nm

- $300\,000 / 3.0 \times 10^5$ (nm) (1)

05.2 [2 marks]

Answer: 2.0×10^5

- $3.0 \times 10^5 \div 1.5$ (1)
- $2.0 \times 10^5 / 200\,000$ (1)

Notes: Allow the ratio written as 200 000 : 1. Allow ECF from the length in nm.

05.3 [1 mark]

Answer: e.g. reinforcing materials such as tennis rackets

- e.g. reinforcing / strengthening materials (e.g. sports equipment), electronics, nanotechnology (1)

Question 6 (6 marks)

06.1 [2 marks]

Answer: Each carbon atom forms three covalent bonds, so one electron from each atom is delocalised. The delocalised electrons can move through the layer, so graphene conducts electricity.

- each carbon atom forms three covalent bonds, so one electron from each carbon atom is delocalised (1)
- the delocalised electrons can move through the layer, so graphene conducts electricity (1)

06.2 [2 marks]

Answer: Each carbon atom is joined to three others by strong covalent bonds in a continuous hexagonal network, so a lot of force is needed to break it.

- each carbon atom is joined to three others by strong covalent bonds (1)
- in a continuous / giant hexagonal network (so many bonds would have to break) (1)

06.3 [2 marks]

Answer: In graphite the layers are held together only by weak forces, so they slide over each other. Graphene is a single layer, so there are no layers to slide.

- in graphite, the layers are held together only by weak forces / there are no covalent bonds between the layers, so the layers slide over each other (1)
- graphene is a single layer, so there are no layers to slide over each other (1)

Question 7 (2 marks)

07.1 [2 marks]

Answer: Electrons that were delocalised are now used to form bonds to the oxygen-containing groups, so fewer delocalised electrons are free to move and carry charge.

- some of the electrons that were delocalised are used in the new bonds to the oxygen-containing groups / the regular layer is disrupted (1)
 - so fewer delocalised electrons are free to move and carry charge (1)
-