Exercise walk-through

2.3
Structure and bonding of carbon (4.2.3.1–4.2.3.3)

AQA · GCSE · Chemistry

Three kinds of strong bond

- All chemical bonds come from the same force: the **electrostatic force** of attraction between opposite charges.
- What changes from one kind of bond to another is where the electrons go.
- **Ionic bonding.** In an **ionic bond** , a metal atom loses its outer electrons and becomes a positive ion; a non-metal atom gains them and becomes a negative ion.
- The opposite ions then attract each other.

Carbon: one element, four structures

- **Diamond** is a **giant covalent structure** in which every carbon atom is bonded to four others. It is very hard, has a very high melting point and does not conduct electricity, because all its outer electrons are in bonds.
- **Graphite** is made of layers of hexagonal rings. Each carbon is bonded to three others, so one electron per atom is delocalised. There are no covalent bonds between the layers, only weak forces, so the layers slide: **graphite** is soft and slippery and is used in pencils and as a lubricant. The delocalised electrons let it conduct electricity.

Carbon: one element, four structures (2)

- **Graphene** is a single layer of **graphite**. It is very strong and conducts electricity, so it is useful in electronics and composite materials.
- A **fullerene** is a hollow molecule of carbon atoms in rings of five, six or seven atoms. The first discovered, buckminsterfullerene (C_{60}), was made in 1985 and is shaped like a football. A **carbon nanotube** is a cylinder-shaped **fullerene** that is very long compared with its width, which makes it strong and useful in electronics and for strengthening materials.

Exercises 2.1·2.2

2.1 How many covalent bonds does each carbon atom form in diamond, and in graphite? [2]



diamond



graphite

2.2 Give **one** use of fullerenes and **one** use of carbon nanotubes. [2]



C_{60}



nanotube

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diamond



graphite

2.1

- diamond: **4**; graphite: **3**

2.2 Give **one** use of fullerenes and **one** use of carbon nanotubes. [2]



C_{60}



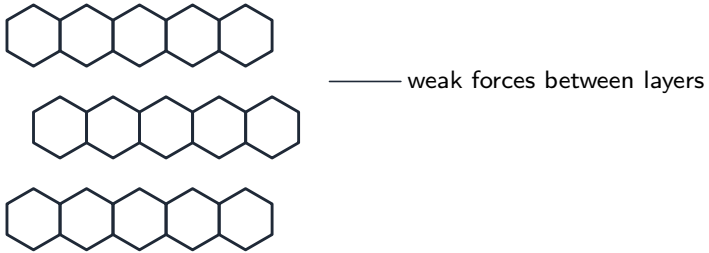
nanotube

2.2

- fullerenes, any one: carrying drugs into the body; lubricants; catalysts
- nanotubes, any one: reinforcing materials such as tennis rackets; electronics

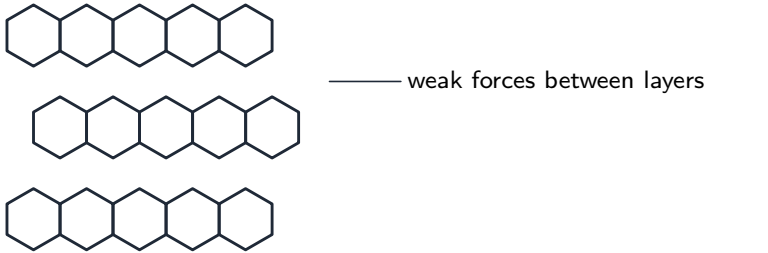
Exercise 3.1

3.1 Explain why graphite conducts electricity but diamond does not. [3]



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3.1

- in graphite each carbon atom forms 3 bonds
- so each atom has one delocalised electron that can move through the layers and carry charge
- in diamond all 4 outer electrons are used in bonds, so there are no free electrons

Exercise 3.2 (a)

3.2 Graphene is a single layer of carbon atoms, 0.34 nm thick. A sheet of graphene with an area of 1 m^2 has a mass of 0.77 mg.

(a) Calculate the mass, in grams, of graphene needed to cover a football pitch of 7000 m^2. [2]



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(a) $0.77 \times 7000 = 5390$ mg; $= \mathbf{5.39}$ g

Exercise 3.2 (b)

3.2 Graphene is a single layer of carbon atoms, 0.34 nm thick. A sheet of graphene with an area of 1 m^2 has a mass of 0.77 mg.

(b) Explain why graphite is soft and is used in pencils. [3]

Exercise 3.2 (b)

3.2 Graphene is a single layer of carbon atoms, 0.34 nm thick. A sheet of graphene with an area of 1 m^2 has a mass of 0.77 mg.

(b) Explain why graphite is soft and is used in pencils. [3]

(b) graphite is made of layers of carbon atoms; there are only weak forces between the layers; so the layers slide over each other and rub off onto the paper

Exercise 3.2 (c)

3.2 Graphene is a single layer of carbon atoms, 0.34 nm thick. A sheet of graphene with an area of 1 m^2 has a mass of 0.77 mg.

(c) Calculate the number of layers in a piece of graphite 0.1 mm thick. (1 mm = 10^6 nm) [2]

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(c) 0.1 mm = 10^5 nm; $10^5 \div 0.34 = \mathbf{2.9} \times \mathbf{10^5}$ layers

Exercise 3.2 (d)

3.2 Graphene is a single layer of carbon atoms, 0.34 nm thick. A sheet of graphene with an area of 1 m^2 has a mass of 0.77 mg.

(d) Compare the structures and properties of diamond, graphite and graphene, and link each to a use. [6]

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(d) points to include:

- diamond: each carbon has 4 strong covalent bonds in a giant structure
- so diamond is very hard with a very high melting point: cutting tools
- graphite: layers of hexagons with weak forces between them, so it is soft: pencils, lubricants
- graphite has delocalised electrons, so it conducts: electrodes
- graphene: one layer of graphite, very strong and light, and it conducts
- graphene is used in electronics and to make strong, light composites

Levels: **5–6** a full, logical answer with correct chemistry and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.