

Allotropes of carbon

This resource is part of the **Structure strip** series of resources, designed to support literacy in science teaching. More resources in this series can be found at:

<https://rsc.li/4bQ8d37>

Learning objectives

- 1 Describe the bonding in different allotropes of carbon.
- 2 Explain how the structure and bonding of allotropes of carbon leads to their different properties.

Introduction

Carbon is one of the most versatile elements in the periodic table. It is one of the 'elements of life' present in all living things. Carbon is so special that it has a whole branch of chemistry dedicated to it, this is called organic chemistry.

In this activity, you will look at the structure and bonding of carbon as an element where it forms different macromolecular structures. Different structural forms of the same element are called allotropes.

How to use structure strips

Structure strips are a type of scaffolding you can use to support learners to retrieve information independently. Use them to take an overview at the start of the topic, to activate prior knowledge, or to summarise learning at the end of a teaching topic.

Structure strips have sections containing prompts which are sized to suggest the amount that learners must write. Learners glue the strips into the margin of an exercise book and write their answers next to the sections, in full sentences. When learners have finished using the structure strip, they should have an A4 page set of notes and examples.

Scaffolding

To further support learners to answer the questions you can include a list of keywords or add prompts to the structure strip.

As learners grow in confidence, they may be able to answer the question without the structure strip or attempt the question first and then use the structure strip to improve or self-assess their answer.

Metacognition

This activity supports learners to develop their metacognitive skills in three key areas.

TEACHER NOTES

- **Planning:** the strips provide scaffolding to plan the written response. Learners will decide where to gather information from (textbooks, own notes, revision websites). Ask learners: is the source of information you are using reliable?
- **Monitoring:** learners are prompted by the questions in the structure strip and can check their answer against the prompts. Ask learners: have you covered all of the questions in the space provided? Do you need to change anything to complete the task?
- **Evaluation:** learners can self-assess or ask a peer to check their work against the answers. Ask learners: did you achieve what you meant to achieve? What might you do differently another time?

Follow-up question

Learners should answer this question after they have attempted the structure strip. The structure strip activates the required knowledge which learners can then apply to the question.

Diamond drill bits are used in lots of applications including drilling porcelain, stone and concrete.

- a) State which property of diamond makes it useful for this purpose.
- b) Explain how the structure and bonding in diamond leads to this property.

Keywords

Allotrope, bonding, conductivity, covalent, delocalised, intermolecular, lattice, macromolecular.


Answers

Suggested answers for the structure strip activity are given in the frame on page three.

Follow-up question

- (a) Hardness
- (b) Diamond is a giant structure/lattice/macromolecule. It has four strong covalent bonds per atom.

The answer given here is a very succinct response written with keywords. It is unlikely learners will write such a short, to the point, response on their first attempt but this can be used as a good learning opportunity. Encourage learners to use fewer, better words in subsequent attempts.

Structure strip	Example answer
Bonding in carbon Copy the atomic symbol for carbon. State the number of each subatomic particle in a carbon atom and its electron configuration.	 <p>Atomic symbol as in your usual periodic table (layout dependent on exam board and qualification).</p> <p>6 protons, 6 electrons, 6 neutrons Electron configuration = 2, 4</p>
Explain how carbon forms up to four covalent bonds per atom.	Carbon has four electrons in its outer shell. Each of these electrons can be shared with another atom to form a covalent bond.
Describe the structure of diamond and its key features. State which properties of diamond come from each bonding feature.	<p>Key features (properties in brackets):</p> <ul style="list-style-type: none"> • Giant covalent structure. • Each carbon atom is covalently bonded to four other carbon atoms (these bonds are strong, so diamond is hard and strong). • The carbon atoms have a regular/tetrahedral lattice arrangement (leading to the shininess). • All electrons are used in bonding/no free electrons (diamond does not conduct electricity).
Describe the structure of graphite and its key features. State which properties of graphite come from each bonding feature.	<p>Graphite is formed of layers of hexagonal structures. Each carbon atom forms three bonds. Intermolecular forces occur between the layers.</p> <p>Key features (properties in brackets):</p> <ul style="list-style-type: none"> • Layered structure (makes it slippery). • Each carbon atom has three covalent bonds. • Remaining non-bonding electron is delocalised between the layers (leading to electrical conductivity).
Explain how the structures of graphene and graphite are related.	Graphene is a single layer of graphite. It shares the properties that graphite has of high electron conductivity and strength due to having one delocalised electron per atom and three covalent bonds. It is also flexible and extremely thin because it is a single sheet.
Briefly describe fullerenes and explain how they are different to other carbon structures.	<p>Fullerenes are not giant covalent structures; they are large molecules.</p> <p>Fullerenes are molecules of carbon atoms with hollow shapes such as spheres and tubes. They have structures based on combinations of hexagonal rings of carbon atoms joined by covalent bonds.</p>