Allotropes of carbon

Student activity • desk activity

YEAR 10 / LESSON 24 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

How can the same element form hard diamond, soft graphite and molecular C_{60}?

Build small structural fragments and compare them with a C_{60} reference model. Connect bonding, arrangement and electron mobility to properties. Diamond and graphite are extended covalent structures; C_{60} consists of discrete molecules. A fragment with exposed edges is a model, not a complete crystal.

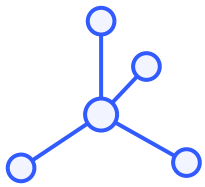
Equipment

- Student booklet, pencil and teacher-displayed RSC carbon reference
- Per pair: 24 reusable modelling nodes and 30 pre-cut blunt connectors, or paper circles/lines
- Two paper hexagonal-sheet outlines and a tetrahedral model or kit reference; one shared C_{60} reference image/model

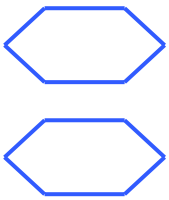
Desk activity only. Use pre-cut blunt modelling pieces and keep small parts out of mouths. Keep the workspace clear; no chemicals, flames or electrical supply are required.

Course coverage: 1.49–1.51: giant covalent structures; diamond, graphite and C_{60} properties; why covalent substances do not usually conduct electricity and the graphite exception.

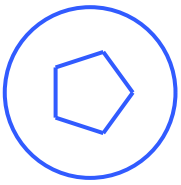
Different structures • schematic fragments



Diamond: 4 neighbours



Graphite: separate layers



C_{60}: one cage

Not to scale or complete networks. No covalent connectors join the graphite layers. A full C_{60} cage has 60 vertices; the icon is symbolic.

Method and reasoning

Read the whole sequence before starting

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1. Read the reference cards. Identify whether each structure is an extended network or separate molecules. Write “allotrope” as a different structural form of the same element.

2. Use a central model node and four neighbours to represent a tetrahedral diamond environment. Extend one branch if materials allow. Label the four bonds around the central atom; the real network continues in three dimensions.

3. Make two small hexagonal graphite-sheet fragments with three neighbours around an interior atom. Place the sheets one above the other on separate paper mats. Do not add bond sticks between layers.

4. Slide one sheet relative to the other and explain the model. Strong covalent bonds are within sheets; weaker attractions are between them. If a stand is used, label it as support, not a chemical bond.

5. Examine the C_{60} reference: a closed cage of 60 carbon atoms with pentagons and hexagons. Sketch several separate cages to represent the molecular solid; do not join cages into a diamond-like network.

6. Complete the property table, linking each claim to a structural reason. For graphite, distinguish electrons that can move along sheets from the fixed carbon-atom framework.

7. Critique one model: identify an incomplete edge, an exaggerated gap or a missing electron representation. Explain why flexible model sticks do not prove real diamond is flexible.

Cleanup

• Keep your evidence and corrections. Count and return reusable model pieces; recycle unwanted paper. No chemical waste is produced.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Diamond: each carbon has four covalent bonds in a tetrahedral network. Graphite: each carbon bonds to three neighbours in a sheet, with an electron per carbon contributing to delocalisation. C_{60}: each carbon has three neighbours in a 60-atom cage; cages are separate molecules. At this level, pure C_{60} is a poor electrical conductor compared with graphite; electron delocalisation within a cage is not a conducting path through the whole solid.

Allotrope / structure	Hardness / bonding explanation	Electrical behaviour / reason
Diamond: extended 3D network		
Graphite: extended sheets		
C_{60}: separate cage molecules		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Define allotrope and explain why diamond and graphite are both carbon.

2. Explain diamond’s hardness and its high temperature requirement for disrupting the structure.

3. Explain graphite’s softness without saying the bonds within its sheets are weak.

4. Explain why graphite conducts electricity and diamond normally does not.

5. Compare bonding within and between C_{60} cages; explain why C_{60} is not a giant covalent structure.

6. Identify two misleading features of your models and correct the interpretations.