

How atoms share electrons in covalent bonds

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to count shared electrons, predict formulae from outer electrons, read dot-and-cross diagrams and graphs, and explain physical properties in terms of structure. They suit GCSE and IGCSE students, O Level, WAEC and KCSE learners, and Class 9-10 students. Work from easiest to hardest. Show every count and give units where there are any.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C2

Problem 1 Define the bond (easy)

Wanjiru is revising for her Class 9 chemistry test.

1. Define a covalent bond.
2. State which type of element usually forms covalent bonds.
3. State how many electrons are shared in one single bond.

Problem 2 How many bonds? (easy)

Atoms try to reach a full outer shell. Hydrogen has 1 outer electron, oxygen 6, nitrogen 5, carbon 4 and chlorine 7.

1. Work out how many electrons each atom needs to gain a full outer shell (hydrogen needs a total of 2, the others a total of 8).
2. State how many covalent bonds each atom usually forms.

Problem 3 Counting shared electrons (easy)

Some molecules have double or triple bonds.

1. Oxygen, O_2 , has one double bond. State how many electrons are shared.
2. Nitrogen, N_2 , has one triple bond. State how many electrons are shared.
3. Carbon dioxide, CO_2 , has two double bonds. State how many electrons are shared in total.

Problem 4 Sort the substances (easy)

Mei tests four substances. Chlorine is a gas at 25 °C. Silicon dioxide (sand) melts at 1710 °C. Iodine easily turns to vapour when warmed. Diamond is the hardest natural material.

1. Classify each substance as simple molecular or giant covalent.
2. Give one reason for each of your choices.

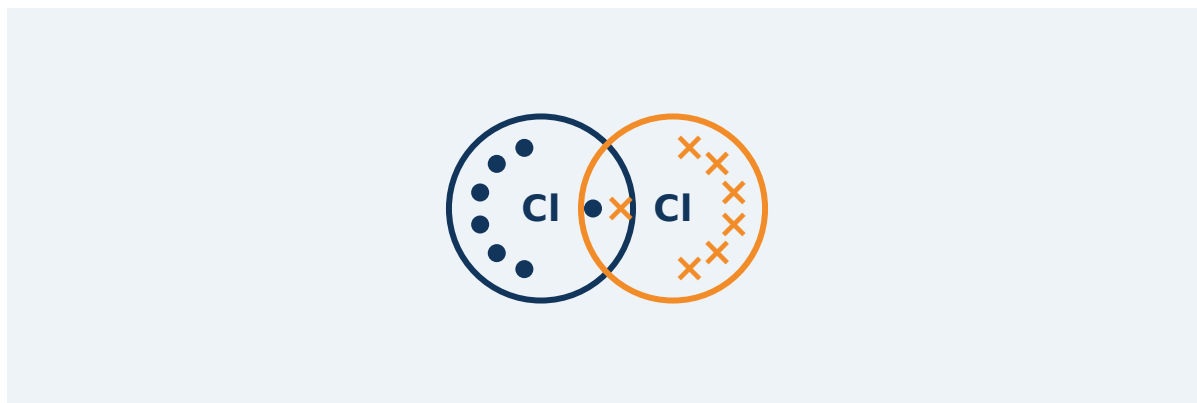
Problem 5 Why no current? (easy)

Kofi tests a block of wax and a graphite rod in a circuit with a lamp. The lamp lights only with the graphite.

1. State why the wax does not conduct electricity.
2. Explain why graphite does conduct electricity.

Problem 6 Reading a diagram (easy)

The diagram shows two chlorine atoms bonded to make a chlorine molecule, Cl_2 .



Dot-and-cross diagram of Cl_2 .

1. State the number of shared pairs.
2. State the number of lone pairs on each chlorine atom.
3. State the total number of outer electrons around each chlorine atom.

Problem 7 Uses of carbon (easy)

Match the use to the structure. Write one sentence for each.

1. Diamond is used on the tips of rock drills.
2. Graphite is used in pencil leads.
3. Graphite is used as a dry lubricant in locks.

Problem 8 Hydrogen chloride (medium)

Hydrogen chloride, HCl , is a gas that dissolves in water to make hydrochloric acid. Hydrogen has 1 outer electron and chlorine has 7.

1. State the number of shared pairs in a molecule of HCl .
2. State the number of lone pairs on the chlorine atom.
3. Explain why the molecule has the formula HCl rather than H_2Cl .

Problem 9 Predict the formula (medium)

Aarav predicts formulae of compounds made with hydrogen or chlorine. Phosphorus has 5 outer electrons, silicon has 4 and sulfur has 6.

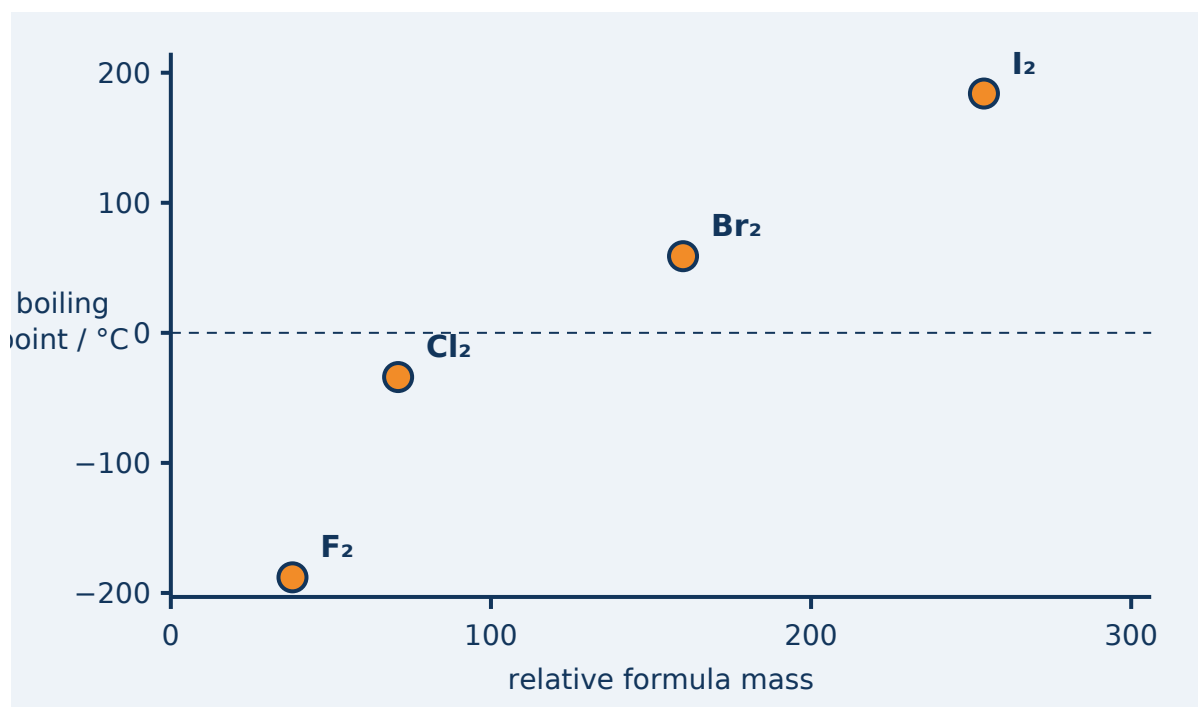
1. Predict the formulae of the compounds of phosphorus with hydrogen, silicon with chlorine,

and sulfur with hydrogen.

2. State the number of lone pairs on the central atom in each compound.

Problem 10 Boiling points of the halogens (medium)

The graph shows the boiling points of four halogens plotted against their relative formula mass.



Boiling point against relative formula mass.

1. Read the boiling point of bromine from the graph.
2. Describe the trend shown.
3. Explain the trend using forces between molecules.
4. State which halogens are gases at 25 °C.

Problem 11 Carbon dioxide and sand (medium)

Solid carbon dioxide (dry ice) changes to gas at $-78\text{ }^{\circ}\text{C}$. Silicon dioxide (sand) melts at $1710\text{ }^{\circ}\text{C}$.

1. Explain the difference in terms of structure and bonding.

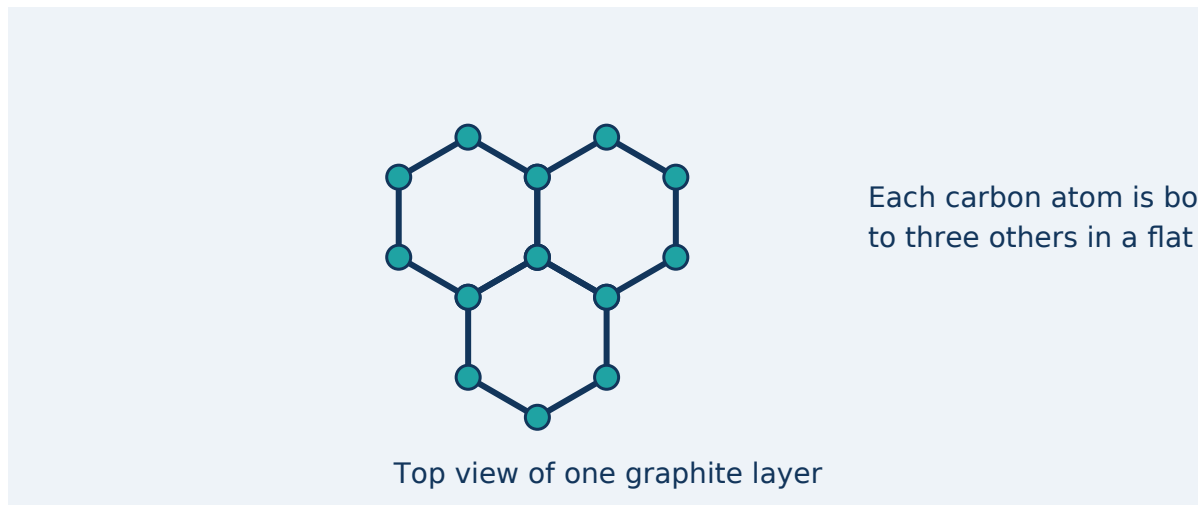
Problem 12 Counting bonds in hydrocarbons (medium)

Hydrocarbons contain only carbon and hydrogen. Ethane has the formula C_2H_6 and ethene has the formula C_2H_4 . In ethane all bonds are single. In ethene the two carbon atoms are joined by a double bond.

1. Count the covalent bonds in one molecule of ethane.
2. Count the shared pairs in one molecule of ethene.
3. Calculate the number of shared electrons in one molecule of ethene.

Problem 13 Diamond versus graphite (medium)

The diagram shows the top view of one layer of graphite.



One layer of graphite.

1. State how many bonds each carbon atom forms inside the layer.
2. Explain why graphite is soft.
3. Explain why graphite conducts electricity while diamond does not.

Problem 14 Four unknown solids (medium)

Bilal records data for four solids: A melts at 44 °C and never conducts. B melts at 801 °C and conducts only when molten. C melts at 1710 °C and never conducts. D melts at 1085 °C and conducts both as solid and liquid.

1. Classify each solid as simple molecular, giant covalent, ionic or metallic.
2. Explain your choice for A and C.

Problem 15 Spot the errors (medium)

Diego writes three statements in his notes.

1. Water boils at 100 °C because strong O-H covalent bonds break.
2. Diamond conducts electricity because each carbon forms four bonds.
3. Methane has a low boiling point because its C-H bonds are weak.
4. Correct each statement.

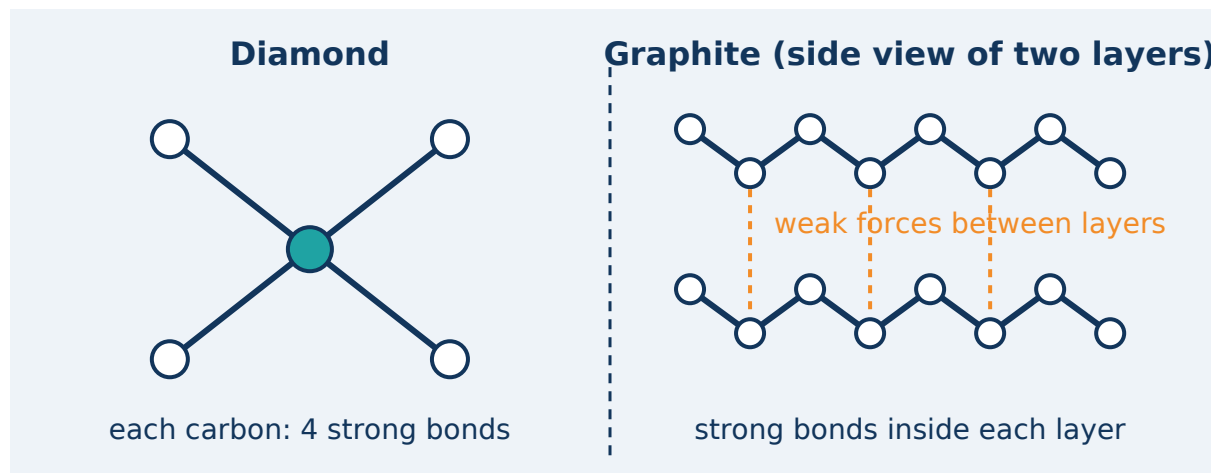
Problem 16 Bonds in a diamond (hard)

A small diamond contains 5.0×10^{21} carbon atoms. Each carbon is bonded to four others, and each bond joins two atoms.

1. Explain why the number of bonds is not $4 \times 5.0 \times 10^{21}$.
2. Calculate the number of covalent bonds in the diamond.
3. A piece of graphite also has 5.0×10^{21} carbon atoms and each atom forms three bonds in its layer. Calculate the number of bonds in the layers.

Problem 17 Graphite in detail (hard)

Emma investigates graphite for a project about electrodes.



Diamond and graphite.

1. Use the diagram to explain how the structure of graphite differs from diamond.
2. Explain why graphite has a high melting point even though it is soft.
3. Explain why a graphite electrode could be used in place of a metal in an electrolysis cell.

Problem 18 Silicon carbide (hard)

Silicon carbide, SiC, is used on grinding wheels. It melts at about 2700 °C, is very hard and does not dissolve in water. Both silicon and carbon have 4 outer electrons.

1. Suggest the type of structure it has.
2. State the number of bonds each atom forms.
3. Explain each of the three properties using your answer.

Problem 19 Hydrogen cyanide (hard)

Hydrogen cyanide has the formula HCN. Its atoms are joined in the order H-C-N, with a triple bond between carbon and nitrogen. Hydrogen has 1 outer electron, carbon 4 and nitrogen 5.

1. Calculate the total number of outer electrons in the molecule.
2. State the number of shared pairs.
3. State the number of lone pairs and where they are.
4. Show that every atom has a full outer shell.

Problem 20 Boiling points of alkanes (hard)

Chiamaka collects boiling points of five hydrocarbons: methane –162 °C, ethane –89 °C, propane –42 °C, butane –1 °C and pentane 36 °C.

1. Calculate the increase in boiling point from each substance to the next.
2. Explain why the boiling point rises as the molecules get larger.
3. State whether butane and pentane are gases or liquids at 25 °C.
4. Hexane is the next member. Predict its boiling point as a range between 60 °C and 80 °C

and justify your range.