

Exercise walk-through

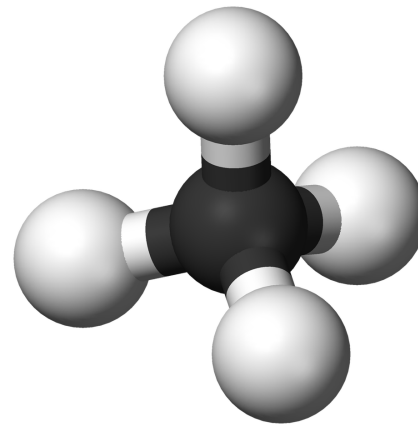
3.5

Shapes of molecules

A-Level Chemistry

What we will cover

- 1 Electronegativity
- 2 Ionic & metallic bonding
- 3 Covalent & coordinate bonds
- 4 Sigma & pi bonds
- 5 Shapes of molecules
- 6 Intermolecular forces



molecules in 3-D

Van der Waals' forces, and when a molecule is polar

Van der Waals' forces

Van der Waals' forces is the general name for all intermolecular forces. There are two main types.

London dispersion

The instantaneous dipole–induced dipole force, or **London dispersion force**. Moving electrons make a brief **instantaneous dipole**, which induces a matching **induced dipole** next door. It acts between **all** molecules.

Permanent dipole

Between molecules that are always polar, because each carries a **permanent dipole**.

Dipole moment

If the bond dipoles in a molecule do **not** cancel, the whole molecule has a **dipole moment** and is polar – which is why CO_2 is not, and H_2O is.

Shape decides polarity: identical bonds arranged symmetrically cancel, however polar each bond is on its own.

Exam tips

- For **shapes**, count bonding pairs and lone pairs, name the shape, then give the exact bond angle (e.g. NH_3 : pyramidal, 107°) – each lone pair lowers the angle by about 2.5° .
- A **dative (coordinate) bond** has both electrons from one atom (e.g. NH_4^+ , H_3O^+); draw the arrow from the lone pair.
- Name the intermolecular force precisely: **hydrogen bonding** needs H bonded to N, O or F; otherwise it is permanent-dipole or induced-dipole (van der Waals). Never call van der Waals forces “bonds”.
- Explain a physical property by stating **which forces are broken**, not just “strong bonds”.

Exercises 2.1·2.2

2.1 State the shape and bond angle of a methane molecule, CH_4 . [2]

2.2 State the shape of an ammonia molecule, NH_3 . [1]

Exercises 2.1·2.2

2.1 State the shape and bond angle of a methane molecule, CH_4 . [2]

2.1

- tetrahedral; 109.5°
-

2.2 State the shape of an ammonia molecule, NH_3 . [1]

2.2

- pyramidal (trigonal pyramidal)

Exercises 3.1·3.2

3.1 What is the bond angle in a carbon dioxide molecule, CO_2 ?

[1]

☐

A 104.5°

B 109.5°

C 120°

D 180°

3.2 Why is the bond angle in water (104.5°) smaller than in methane (109.5°)?

[1]

☐

A water has more bonds

B the two lone pairs on oxygen repel more, squeezing the angle

C oxygen is bigger than carbon

D water has a double bond

Exercises 3.1·3.2

3.1 What is the bond angle in a carbon dioxide molecule, CO_2 ?

[1]

☐

A 104.5°

B 109.5°

C 120°

D 180°

3.1 D

- CO_2 is linear, 180°

3.2 Why is the bond angle in water (104.5°) smaller than in methane (109.5°)?

[1]

☐

A water has more bonds

B the two lone pairs on oxygen repel more, squeezing the angle

C oxygen is bigger than carbon

D water has a double bond

3.2 B

- Oxygen's two lone pairs repel more, squeezing the angle

Exercise 3.3

3.3 (a) Using VSEPR theory, explain the shape of a BF_3 molecule. [2]

(b) Predict the shape and bond angle of an NH_4^+ ion. [2]

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3.3

(a)

- boron has 3 bonding pairs and no lone pairs; they repel equally to a trigonal planar shape, 120°

(b)

- tetrahedral; 109.5° (4 bonding pairs, no lone pairs)

Exercise 3.4

3.4 Explain why ammonia (107°) has a smaller bond angle than methane (109.5°). [2]

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3.4

- ammonia has one lone pair on nitrogen; the lone pair repels the bonding pairs more strongly, squeezing the angle from 109.5° to 107°