



Cambridge (CIE) A Level Chemistry



Shapes of Molecules

Contents

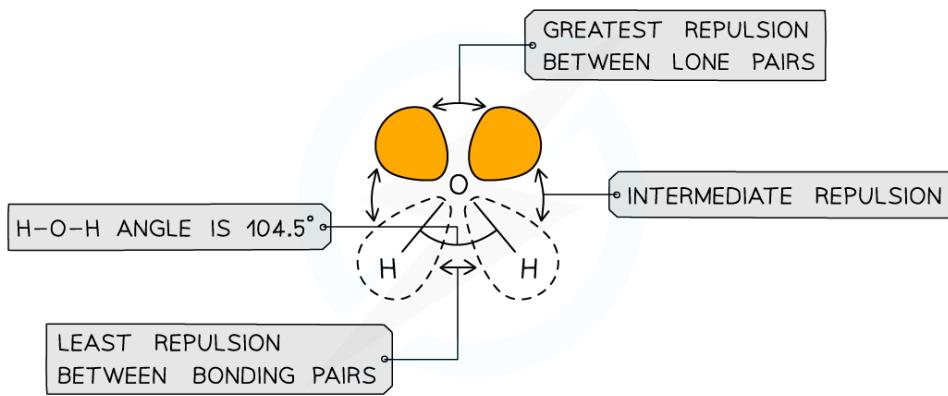
- * Shapes of Molecules



VSEPR Theory

- Bonding and non-bonding electron pairs around a central atom behave like **negatively charged clouds that repel each other**
- To minimise repulsion, these electron pairs arrange themselves as **far apart as possible** in three-dimensional space
- VSEPR theory follows three key rules:
 - All electron pairs (bonding and lone pairs) spread out as far as possible
 - Lone pairs repel more strongly than bonding pairs
 - Multiple bonds behave like a single bond when determining shape
- Using the **valence shell electron pair repulsion theory (VSEPR)**, this allows us to predict:
 - The **shape of the molecule**
 - The **angles between the bonds**
- Each region of electron density around the central atom is called an **electron domain**
 - A domain may contain one, two, or three pairs of electrons

Repulsion between different types of electron pairs



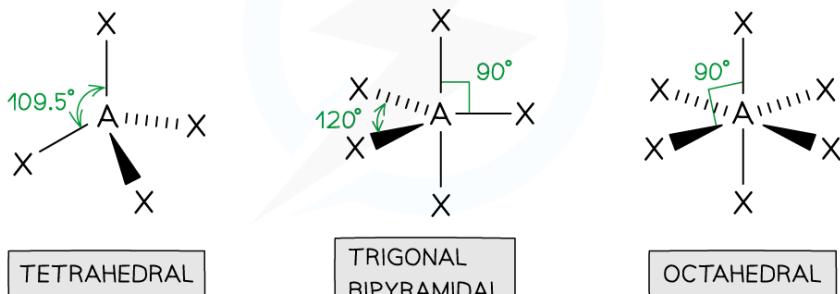
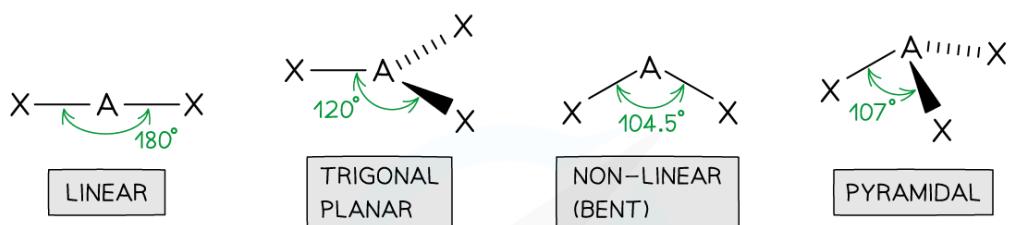
Different types of electron pairs have different repulsive forces

- Molecules can adapt the following shapes and bond angles:

Bond shapes and bond angles



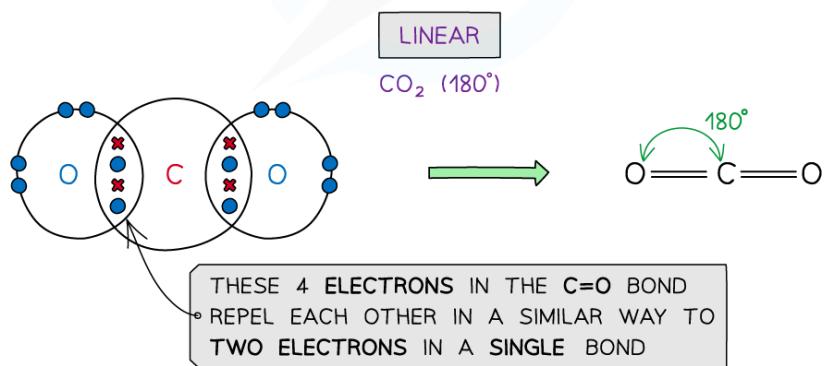
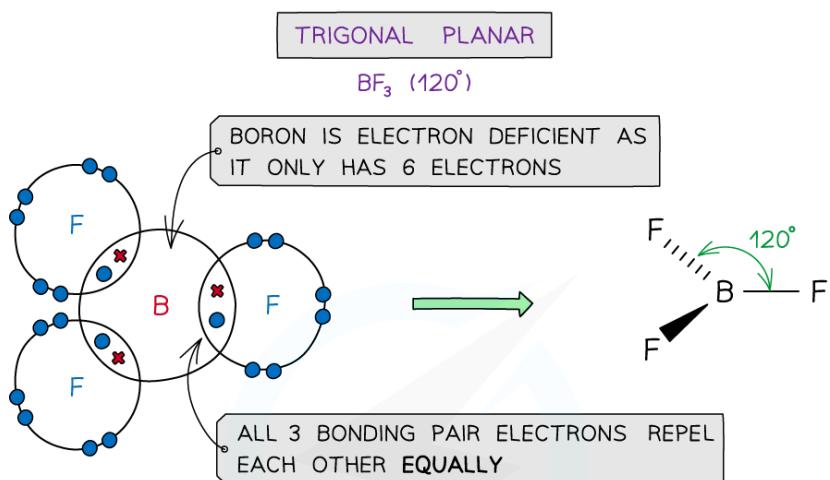
Your notes



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Molecules of different shapes can adapt with their corresponding bond angles

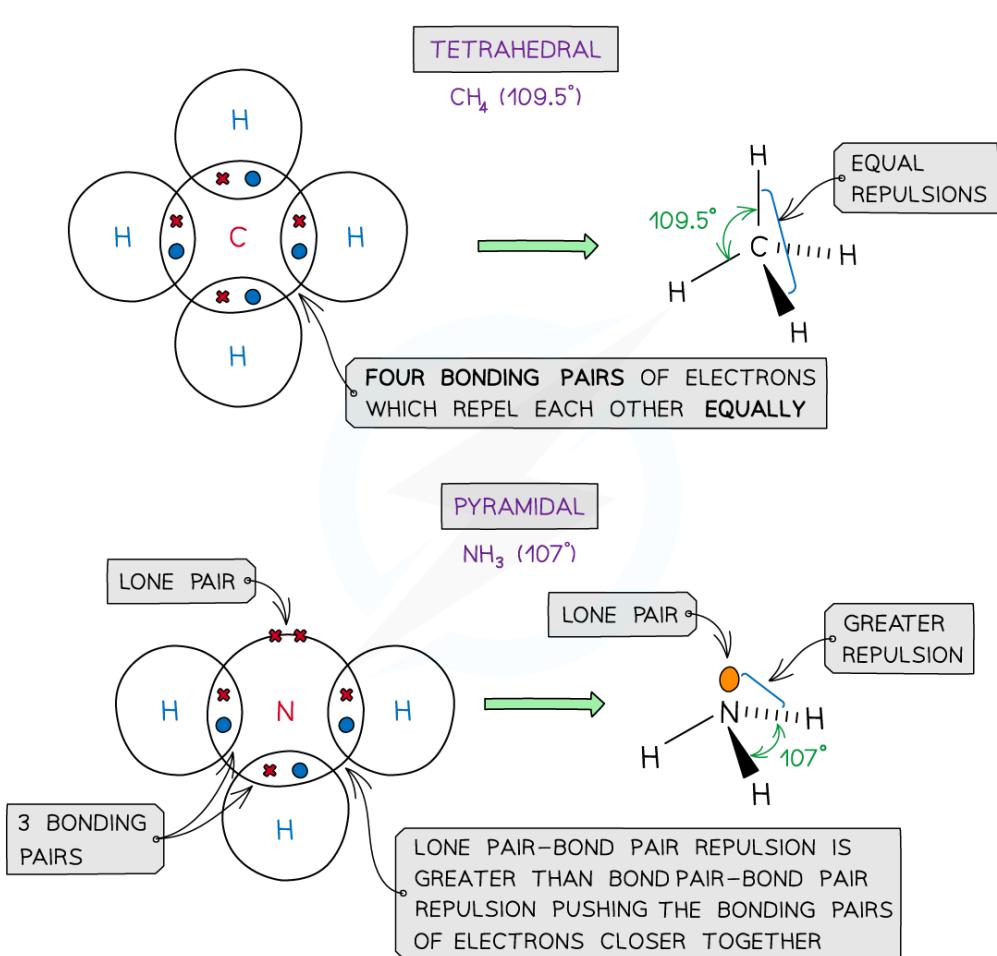
Examples of molecules with different shapes and bond angles



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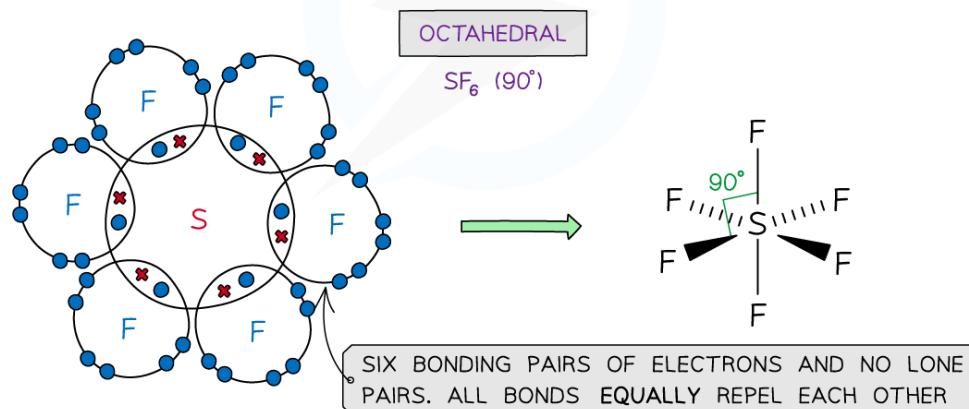
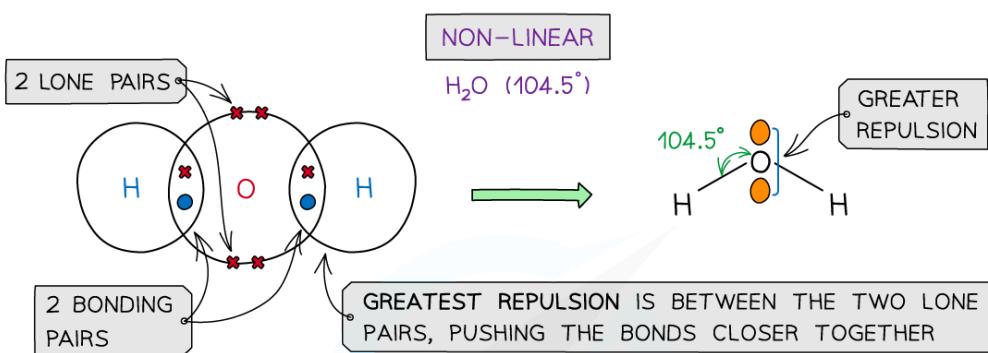
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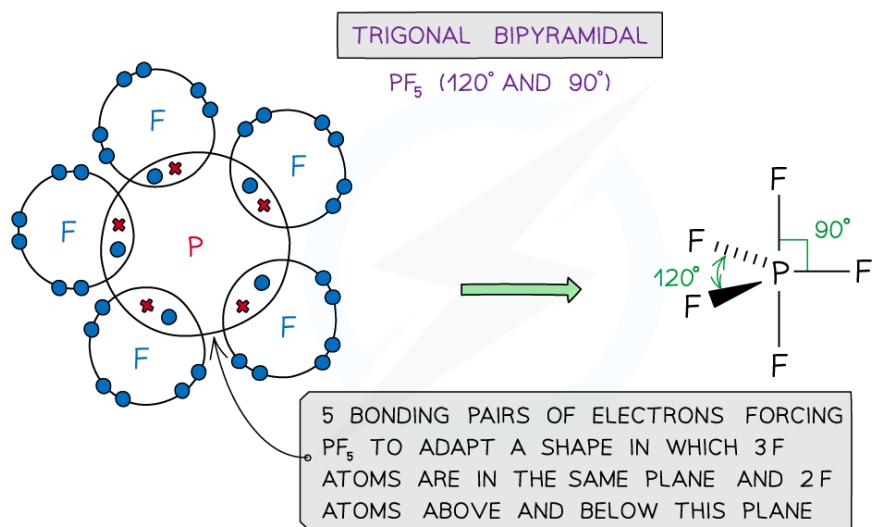
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Each different shape has a specific name and specific bond angle(s)



Worked Example

VSEPR & shapes of molecules



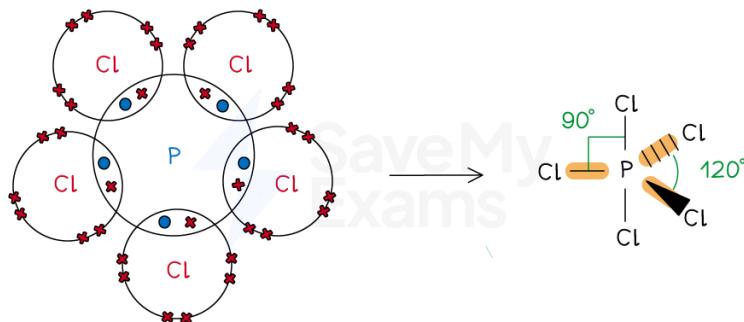
Your notes

Draw the shape of the following molecules and compounds:

1. Phosphorous(V) chloride
2. N(CH₃)₃
3. CCl₄

Answer 1

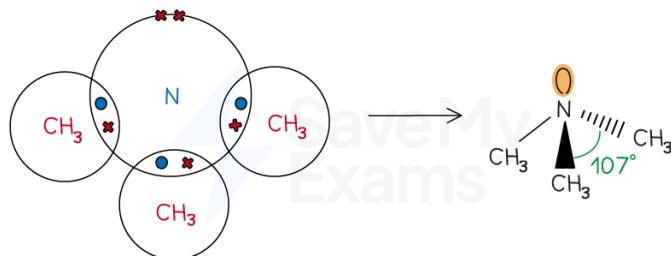
- Phosphorous has a +5 charge so 5 Cl⁻ ions are needed to neutralise the charge
 - Therefore, the phosphorous(V) chloride is PCl₅
- P is in Group 5 and has 5 valence / outer electrons
- Cl is in Group 7 (17) and has 7 valence / outer electrons
- All 5 electrons of phosphorous are used to form single covalent bonds to the 5 chlorines
 - There are no lone pairs
- So, phosphorous(V) chloride has a trigonal bipyramidal shape



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Answer 2

- Nitrogen is in Group 5 and has 5 valence / outer electrons
- The carbon in the -CH₃ groups is in Group 4 and has 4 valence / outer electrons
 - 3 of these electrons are already used in covalent bonds with hydrogen
 - 3 of N's valence / outer electrons are involved in bonding pairs with the carbon from the -CH₃ groups
- This leaves one pair of electrons as a lone pair
- So, N(CH₃)₃ has a pyramidal shape



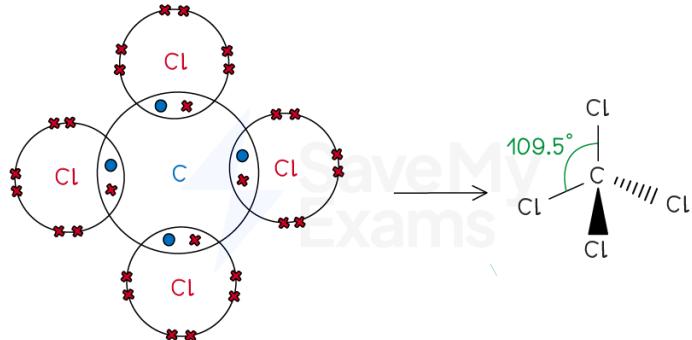
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Answer 3



Your notes

- Carbon is in Group 4 and has 4 valence / outer electrons
- Cl is in Group 7 (17) and has 7 valence / outer electrons
- All 4 valence / outer electrons of carbon are used as bonding pairs with the 4 chlorines
 - There are no lone pairs
- So, the shape of CCl_4 is tetrahedral



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