

Cambridge (CIE) A Level Chemistry



Your notes

Shapes of Molecules

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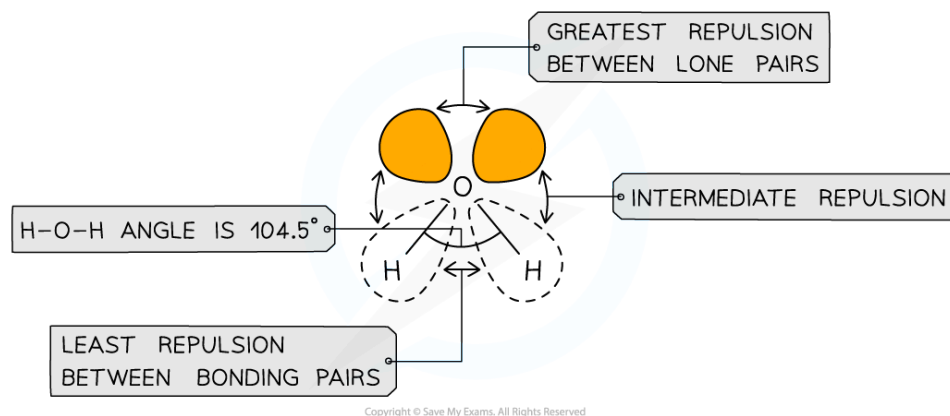
* Shapes of Molecules



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:
 1. **All electron pairs (bonding and lone pairs) spread out as far as possible**
 2. **Lone pairs repel more strongly than bonding pairs**
 3. **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



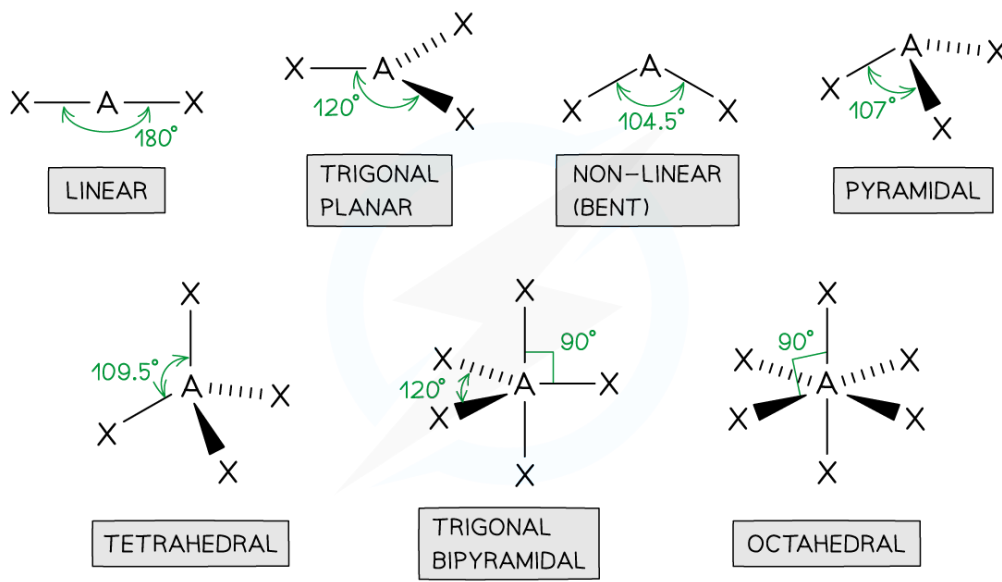
Different types of electron pairs have different repulsive forces

- Molecules can adopt the following shapes and bond angles:

Bond shapes and bond angles



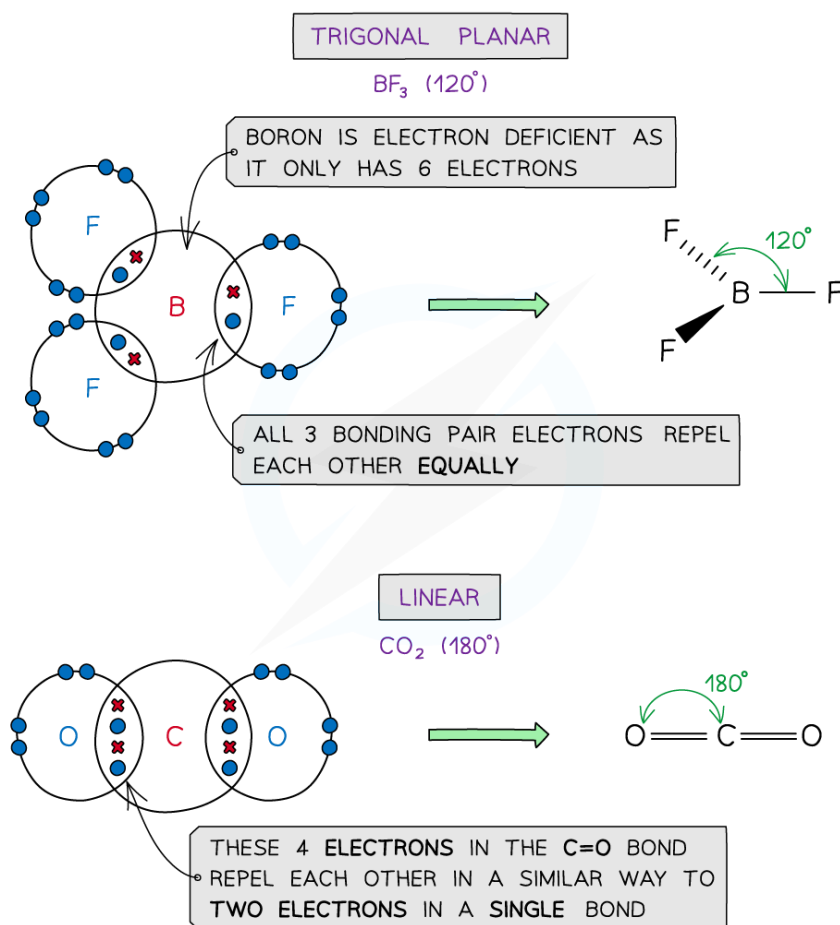
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Molecules of different shapes can adapt with their corresponding bond angles

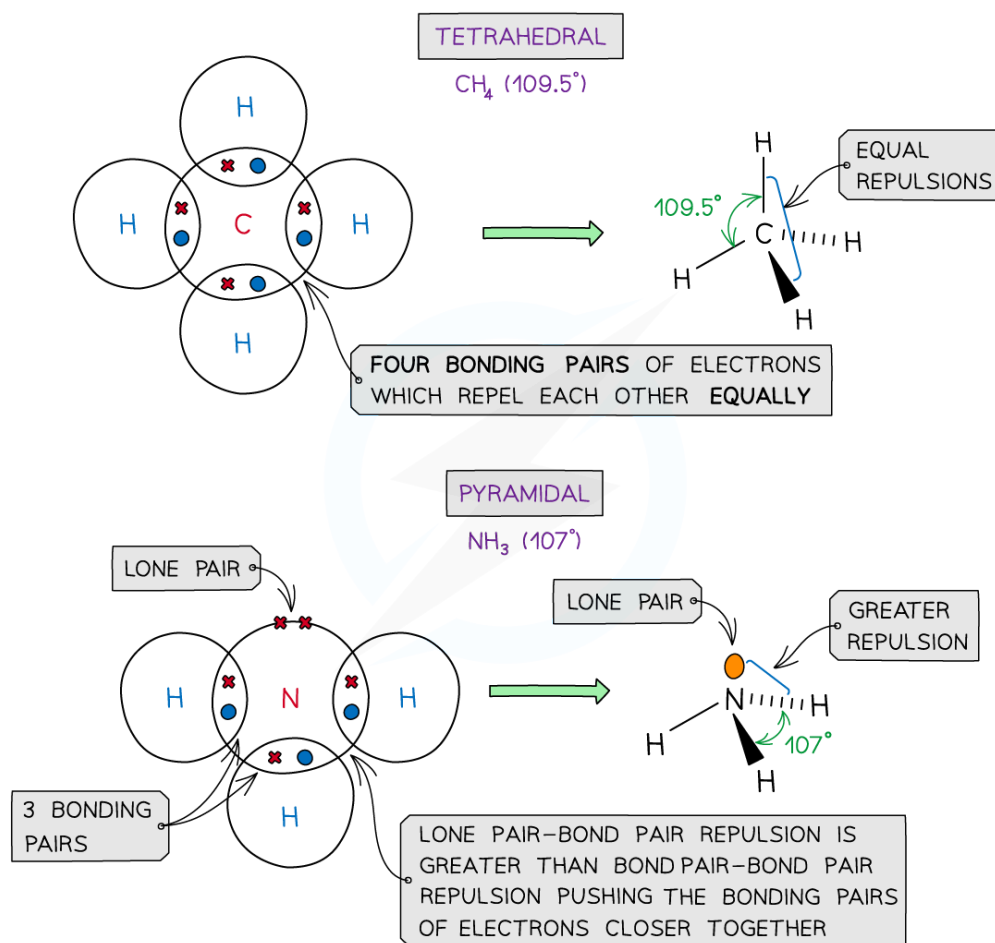
Examples of molecules with different shapes and bond angles



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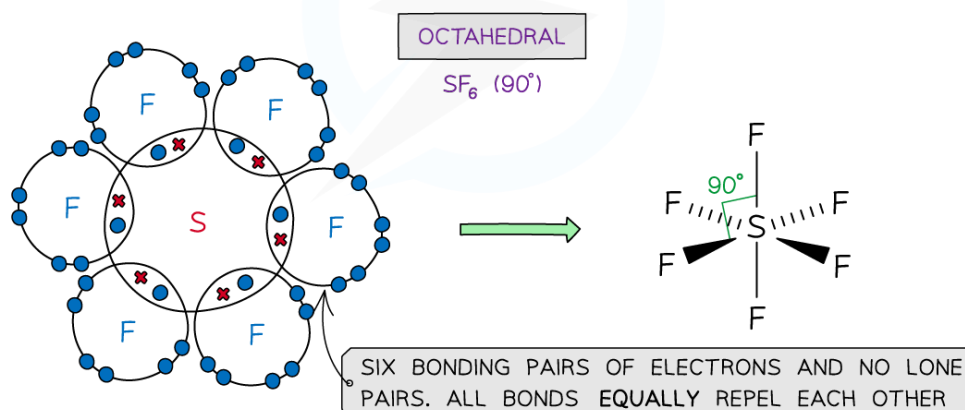
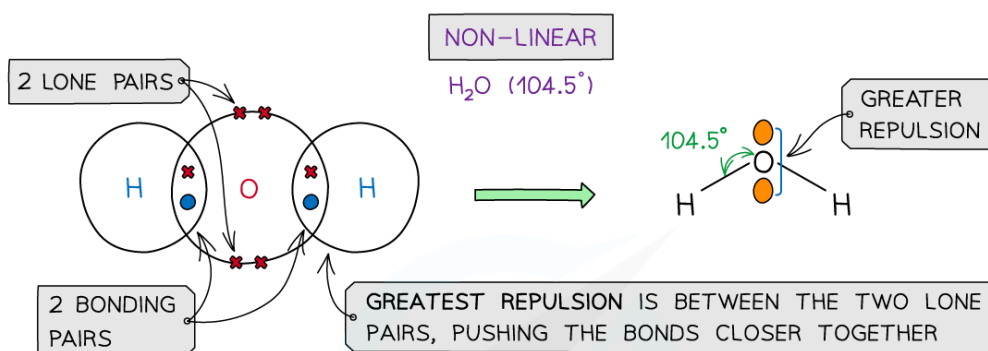


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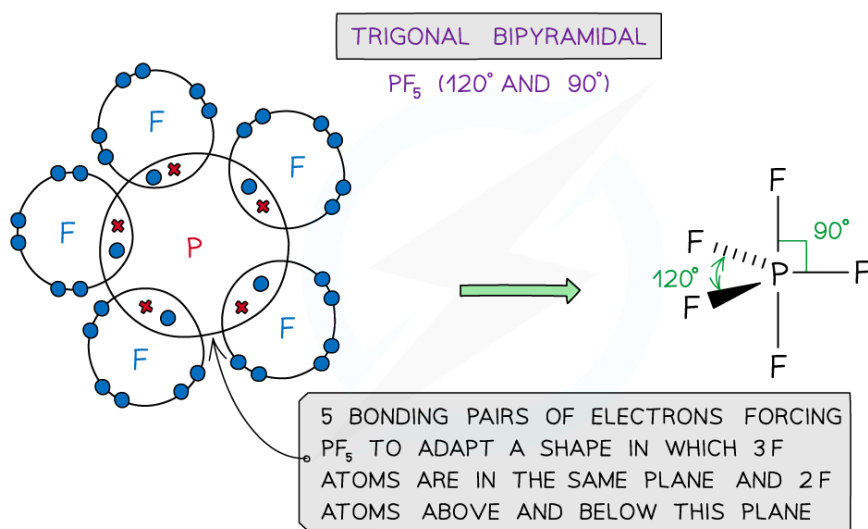




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Each different shape has a specific name and specific bond angle(s)



Worked Example

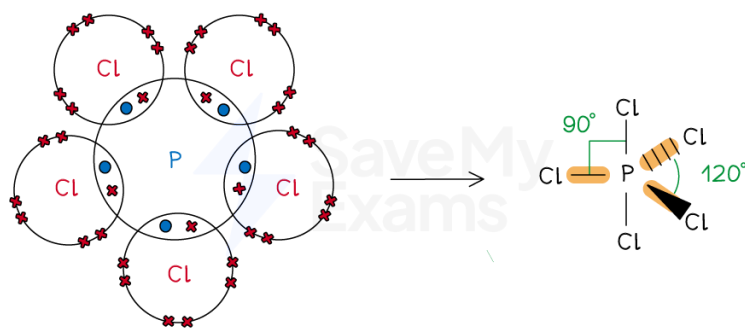
VSEPR & shapes of molecules

Draw the shape of the following molecules and compounds:

1. Phosphorous(V) chloride
2. $\text{N}(\text{CH}_3)_3$
3. CCl_4

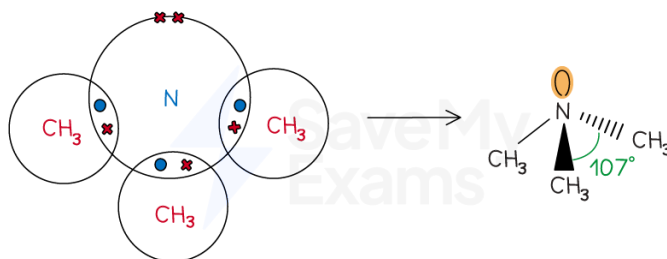
Answer 1

- Phosphorous has a +5 charge so 5 Cl^- ions are needed to neutralise the charge
 - Therefore, the phosphorous(V) chloride is PCl_5
- 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



Answer 2

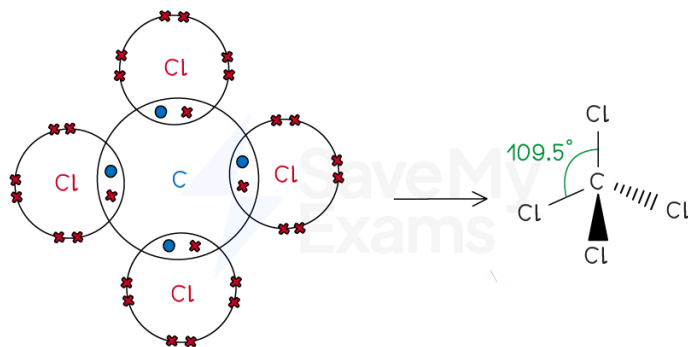
- Nitrogen is in Group 5 and has 5 valence / outer electrons
- The carbon in the $-\text{CH}_3$ groups is in Group 4 and has 4 valence / outer electrons
 - 3 of these electrons are already used in covalent bonds with hydrogen
- 3 of N's valence / outer electrons are involved in bonding pairs with the carbon from the $-\text{CH}_3$ groups
 - This leaves one pair of electrons as a lone pair
- So, $\text{N}(\text{CH}_3)_3$ has a pyramidal shape



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Answer 3

- 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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