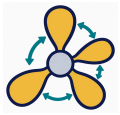
Shapes of Molecules Map

Cambridge International AS & A Level Chemistry · Topic 3 Chemical bonding · Shapes of molecules

1 Electron-pair repulsion 3.5.1

- Count the pairs round the **central atom**
- Pairs **repel**: as far apart as possible
- The arrangement of pairs sets the shape
- A double or triple bond: **one region**
- Name the shape from the **atoms** only



2 Bonding pairs only 3.5.1–3.5.2

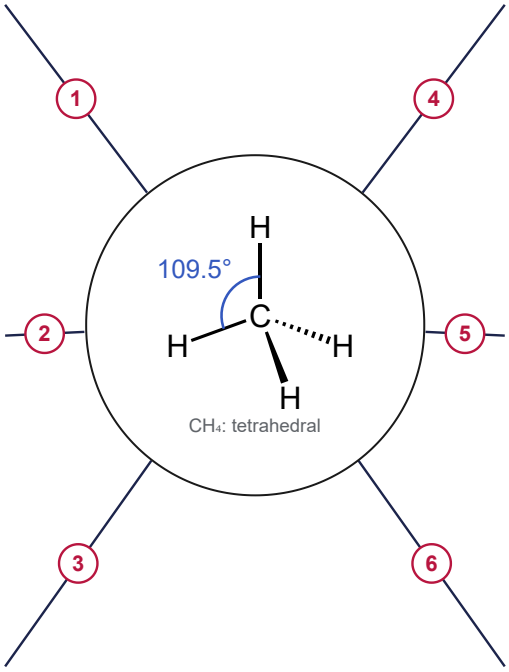
- 2: **linear**, 180° ($BeCl_2$, CO_2)
- 3: **trigonal planar**, 120° (BCl_3)
- 4: **tetrahedral**, 109.5° (CH_4, NH_4^+)
- 5: **trigonal bipyramidal**, 120° and 90° (PCl_5)
- 6: **octahedral**, 90° (SF_6)



3 Lone pairs 3.5.1–3.5.2

- A lone pair is held by one nucleus: repels **more**
- Lone–lone > lone–bond > bond–bond
- About 2.5° less per lone pair
- NH_3: **pyramidal**, 107°
- H_2O: **bent**, 104.5°





4 Five and six pairs 3.5.1–3.5.2

- Period 3 atoms can hold more than 8
- Five pairs: lone pairs go **equatorial**
- SF_4 seesaw; ClF_3 T-shaped (87.5°)
- Six pairs, two lone: **opposite**
- XeF_4 square planar; IF_5 square pyramidal



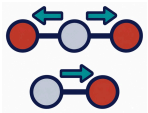
5 Related species 3.5.2

- Adjust the centre's electrons for the **charge**
- Same pairs: **same shape**
- H_3O^+ like NH_3: pyramidal
- NH_2^- like H_2O: bent
- PH_3 like NH_3; H_2S like H_2O



6 Polar molecules 3.6.2

- Polar bonds give bond **dipoles** (δ+ → δ−)
- Polar molecule: an **overall** dipole
- Symmetrical, identical atoms: dipoles **cancel**
- Non-polar: CO_2, BF_3, CCl_4, SF_6
- Polar: H_2O, NH_3, $CHCl_3$, HCl



Electron pairs and shapes

pairs round the central atom; each lone pair closes the angles by about 2.5°

Pairs	Bonding	Lone	Shape	Angle	Example
2	2	0	linear	180°	$BeCl_2$, CO_2
3	3	0	trigonal planar	120°	BCl_3, C_2H_4
4	4	0	tetrahedral	109.5°	CH_4, NH_4^+
4	3	1	pyramidal	107°	NH_3, H_3O^+
4	2	2	bent	104.5°	H_2O, NH_2^-
5	5	0	trigonal bipyramidal	120°, 90°	PCl_5
6	6	0	octahedral	90°	SF_6
6	4	2	square planar	90°	XeF_4

Worked examples

Predicting a shape

- Outer electrons, ± the charge
- Bonds, then lone pairs
- Arrange the pairs; name from atoms

Bond angles

- No lone pairs: the regular angle
- Each lone pair: about 2.5° less
- Double bond: one region

Is it polar?

- Are there polar bonds?
- What is the shape?
- Symmetrical, identical atoms: non-polar

Polar molecules attract each other through permanent dipoles (Intermolecular forces).

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