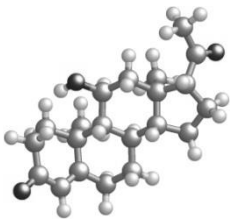

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Valence Shell Electron Pair Repulsion Theory

Opposite charges attract and similar charges repel. As a result of this, negatively charged electrons repel other negatively charged electrons.

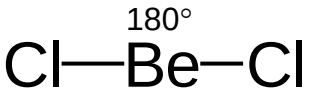
Pairs of electrons in the outer shell (or valence shell) of an atom will repel each other and arrange themselves to be as far apart as possible in three-dimensional space.

To help you see the three-dimensional shape of these molecules and ions, you will probably find it useful to make models of them using modelling clay and cocktail sticks.

Examples:

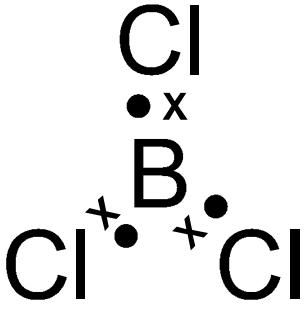
Beryllium chloride – $BeCl_2$

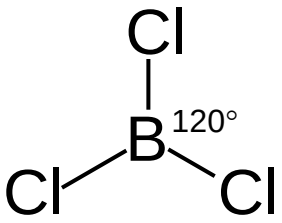
Beryllium has **two** pairs of electrons in its valence shell. The two pairs of electrons repel each other and arrange themselves to be as far apart as possible on opposite sides of the beryllium. $BeCl_2$ is described as a **linear** molecule. The bond angle is 180°.



Boron trichloride – BCl_3

Boron has **three** pairs of electrons in its valence shell. The three pairs of electrons repel each other and arrange themselves to be as far apart as possible in a triangular arrangement. BCl_3 is described as a **trigonal planar** molecule. All of the bond angles are 120°.

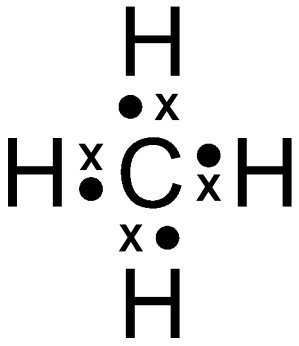


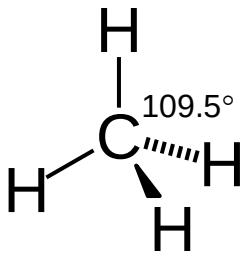


Methane – CH_4

Carbon has **four** pairs of electrons in its valence shell.

CH_4 is described as a **tetrahedral** molecule. All of the bond angles are 109.5°.

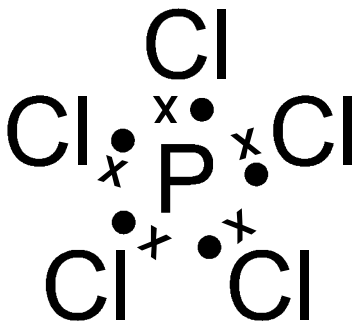


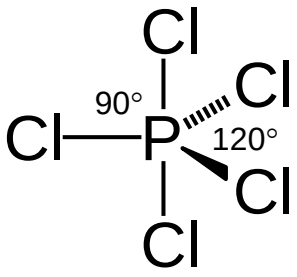


Phosphorus(V) chloride – PCl_5

Phosphorus has **five** pairs of electrons in its valence shell.

PCl_5 is described as a **trigonal bipyramidal** molecule. There are two different bond angles of 90° and 120°.

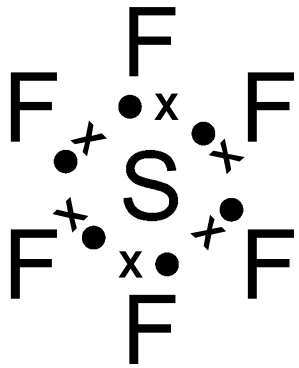


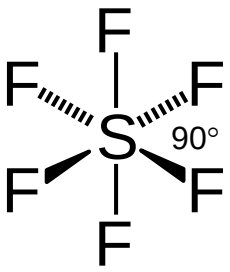


Sulphur(VI) fluoride – SF_6

Sulphur has **six** pairs of electrons in its valence shell.

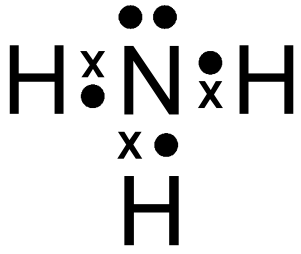
SF_6 is described as an **octahedral** molecule. All of the bond angles are 90°.

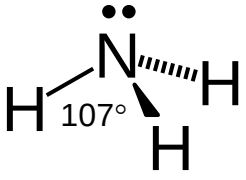




Ammonia – NH_3

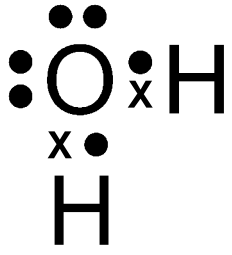
Nitrogen has **four** pairs of electrons in its valence shell. The four pairs of electrons repel each other and take up a tetrahedral arrangement. Because only three pairs of electrons are **bonding pairs** (the fourth pair of is a **lone pair** or **non-bonding pair**) the ammonia molecule is seen to have a **pyramidal** shape. The bond angle in ammonia is 107°.

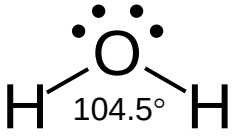




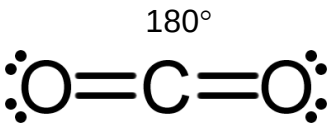
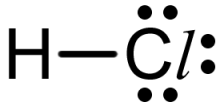
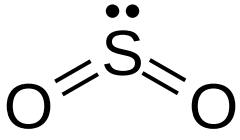
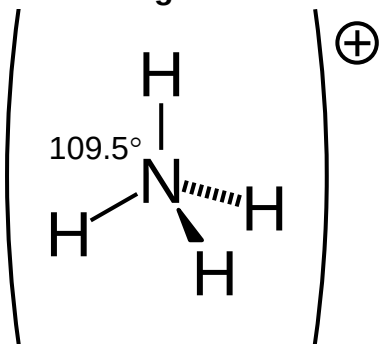
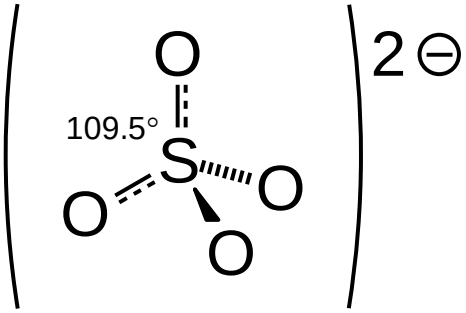
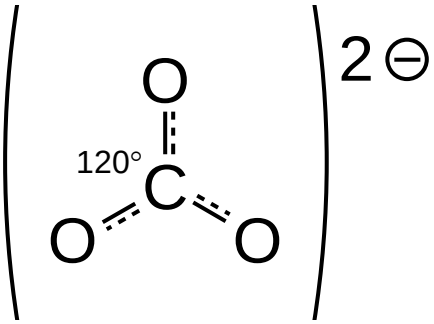
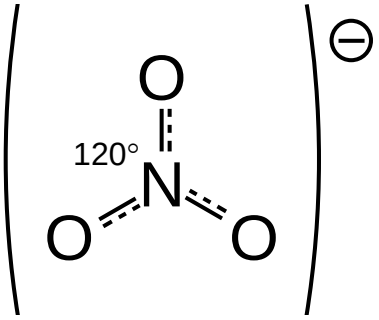
Water – H_2O

Oxygen has **four** pairs of electrons in its valence shell. The four pairs of electrons repel each other and take up a tetrahedral arrangement. Because only two pairs of electrons are **bonding pairs** (the other two pairs of electrons are **lone pairs** or **non-bonding pairs**) the water molecule is seen to have an **angular** or **bent** shape. The bond angle in water is 104.5°.



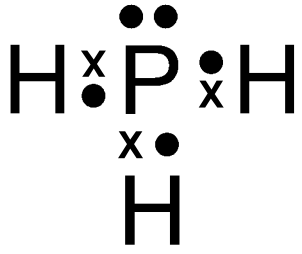


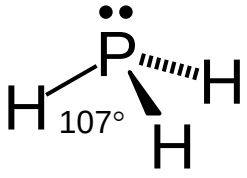
Other examples of molecules and ions that you can consider the shape of are given on the next page…

Carbon dioxide – CO_2 **Linear** **Bond angle = 180°** 	**Hydrogen chloride – HCl** **Linear** 
Sulphur dioxide – SO_2 **Angular** 	**Ammonium ion – NH_4^+** **Tetrahedral** **Bond angle = 109.5°** 
Sulphate ion – SO_4^{2-} **Tetrahedral** **Bond angle = 109.5°** 	**Carbonate ion – CO_3^{2-}** **Trigonal planar** **Bond angle = 120°** 
Nitrate ion – NO_3^- **Trigonal planar** **Bond angle = 120°** 	**<u>Questions</u>** **Predict the shapes of the following molecules:** **PH_3 and H_3O^+** **Answers are given on the next page.**

Answers

PH_3 – Pyramidal – the bond angle will be approximately 107°.





H_3O^+ - Pyramidal – the bond angle will be approximately 107°.