

VSEPR THEORY

Valence Shell Electron Pair
Repulsion Theory

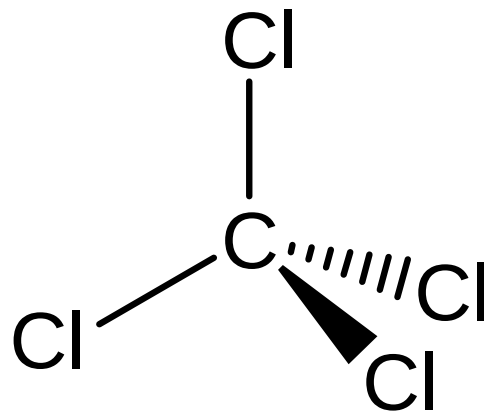
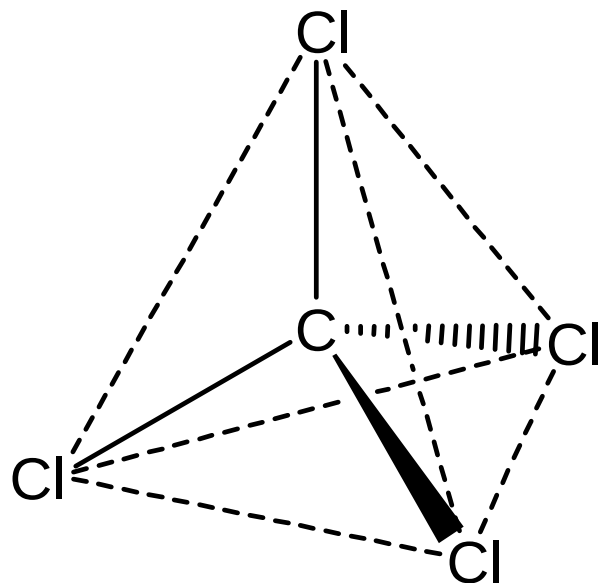
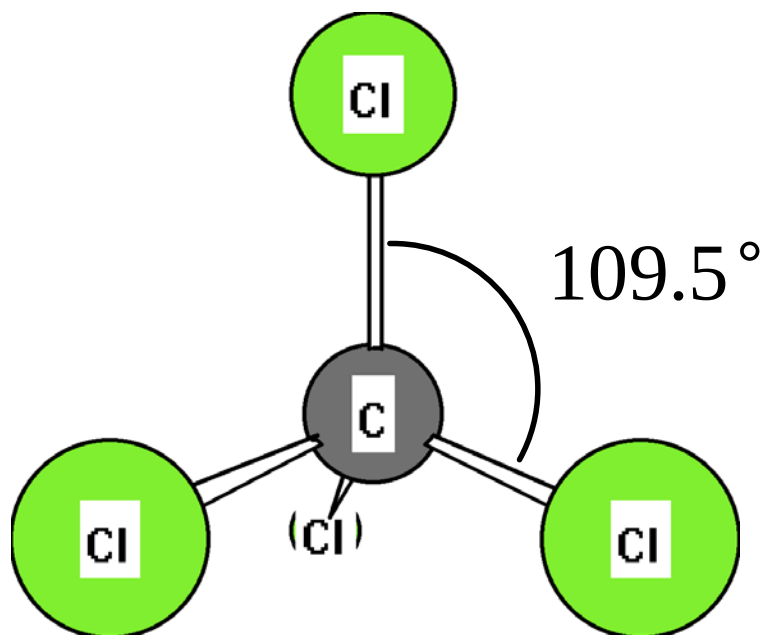
What is the VSEPR Theory?

- The VSEPR Theory is used to predict the shapes of molecules based on the repulsion of the bonding and non-bonding electrons in the molecule.
- The shape is determined by the number of bonding and non-bonding electrons in the molecule.
- In order to determine the shape, the Lewis diagram must be drawn first.
- When determining the shape of a molecule with multiple bonds, treat the multiple bonds as if they were single bonds (i.e. one bonding pair)

Molecules with the central atom surrounded by four bonding pairs (i.e. four atoms)

- If the central atom is placed at the center of a sphere, then each of the four pairs of electrons will occupy a position to be as far apart as possible.
- This will result in the electron pairs being at the corners of a regular tetrahedron, therefore these molecules are said to have a TETRAHEDRAL SHAPE.
- The angle between each bond will be 109.5°

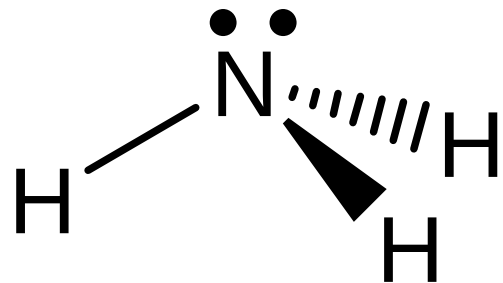
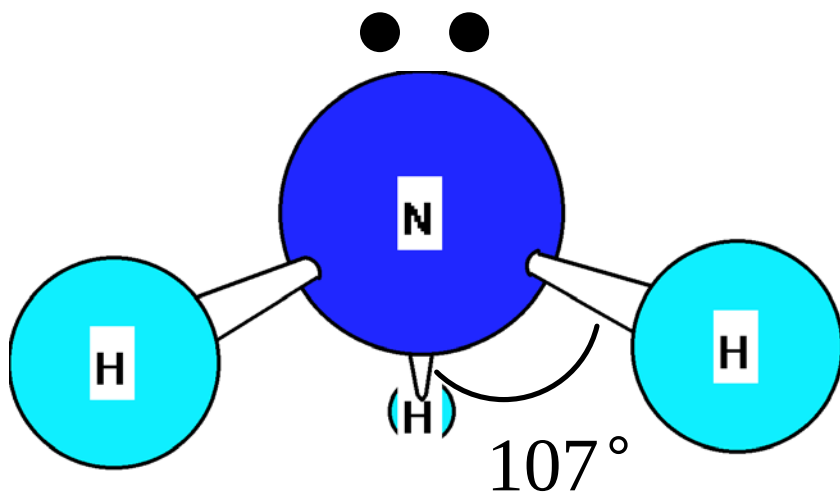
Example CCl_4



Molecules with the central atom surrounded by 3 bonding pairs and 1 non-bonding pair

- Four pairs of electrons will always arrange themselves tetrahedrally around the central atom.
- The shape of the molecule is determined by the arrangement of the atoms not the electrons.
- As a result such molecules will have a TRIANGULAR (TRIGONAL) PYRAMIDAL shape.
- Due to the repulsion, a non-bonding electron pair requires more space than a bonding pair, the angles in these molecules are 107° not 109.5° as in the tetrahedral molecules.

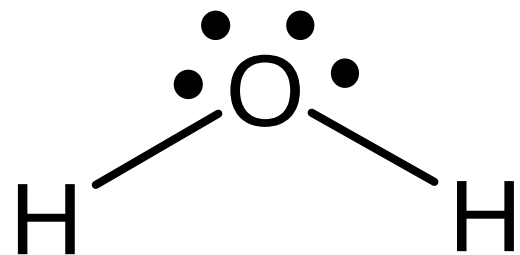
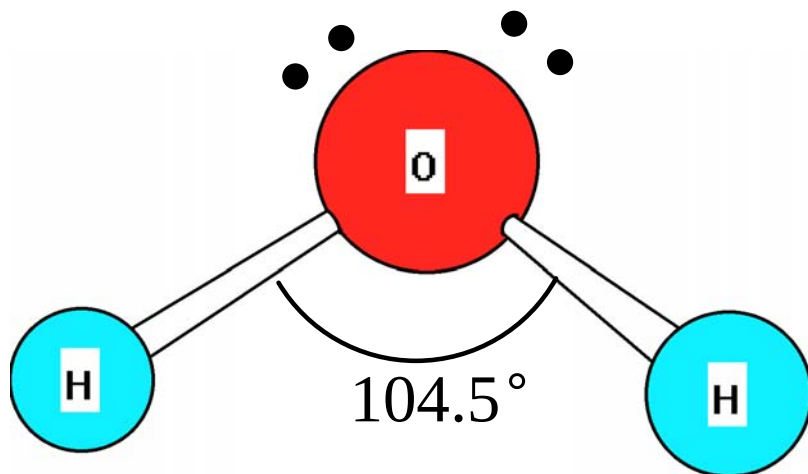
Example NH_3



Molecules with the central atom surrounded by 2 bonding pairs and 2 non-bonding pairs

- The four pairs of electrons will be arranged tetrahedrally but since only 2 pairs are bonding electrons, the surrounding atoms are at 2 corners of the tetrahedron.
- As a result these molecules will have a BENT OR V-SHAPE.
- The repulsion between the non-bonding pairs will result in a bond angle of 104.5° .
- For each pair of non-bonding electrons, the bond angle decreases by 2.5°

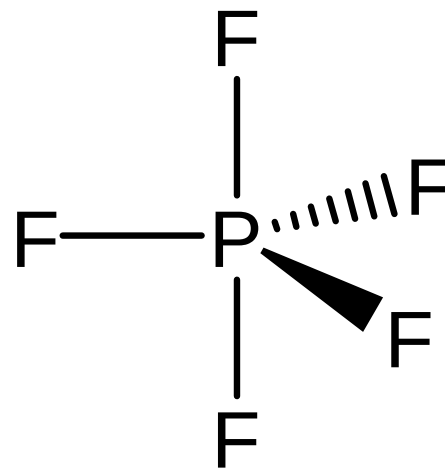
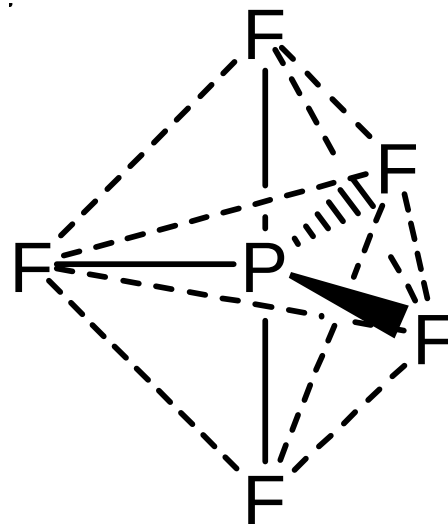
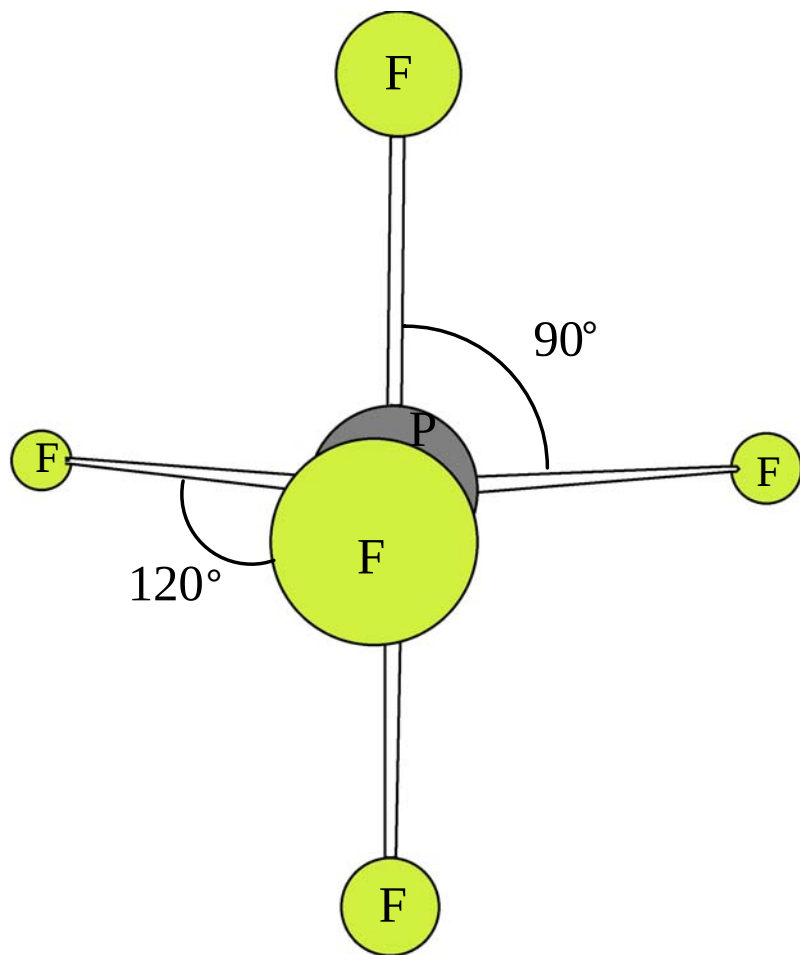
Example H₂O



Molecules with the central atom surrounded by 5 pairs of bonding pairs

- As with the tetrahedral molecules, the electron pairs will arrange themselves as far apart as possible.
- To achieve this, the atoms will arrange themselves in a TRIANGULAR (TRIGONAL) BIPYRAMIDAL SHAPE which consists of 2 pyramids sharing the same base.
- In this type of molecule, the 3 atoms making the base will lie in the same plane with the central atom in the middle of it. The other atoms will be positioned above and below this plane.
- The bond angles within the base will 120° and the bond between the other atoms and the base will be 90° .

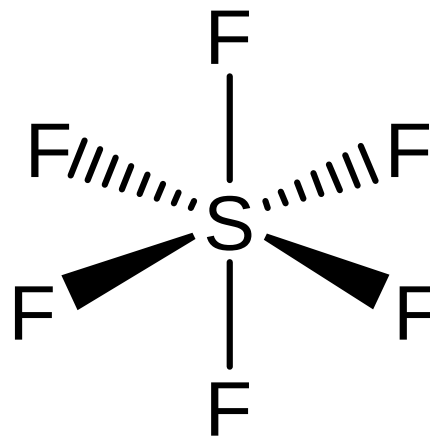
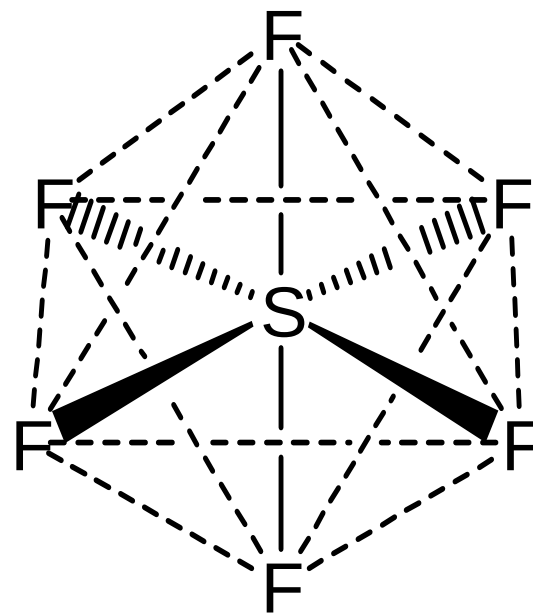
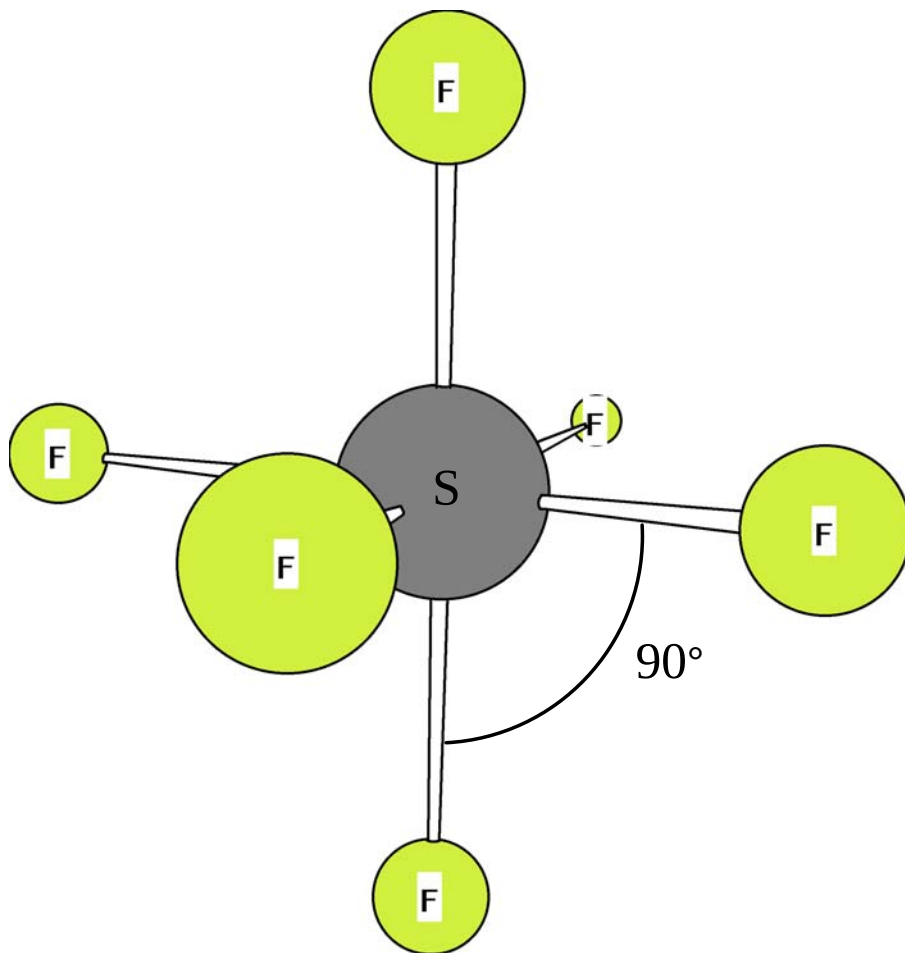
Example PF_5



Molecules with the central atom surrounded by 6 pairs of bonding pairs

- In order for the 6 pairs of electrons to be as far apart as possible in this case, each bonding pair will be at one corner of a REGULAR OCTAGON
- The central atom is at the center of a square plane made up of 4 atoms and the other 2 atoms will be placed above and below the plane.
- All bond angles will be 90°

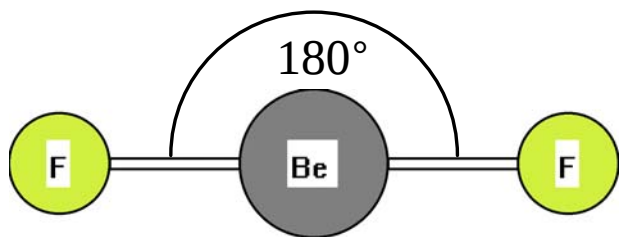
Example SF_6



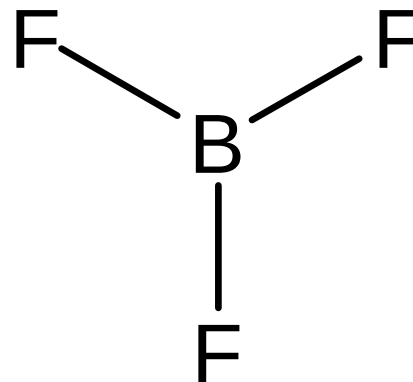
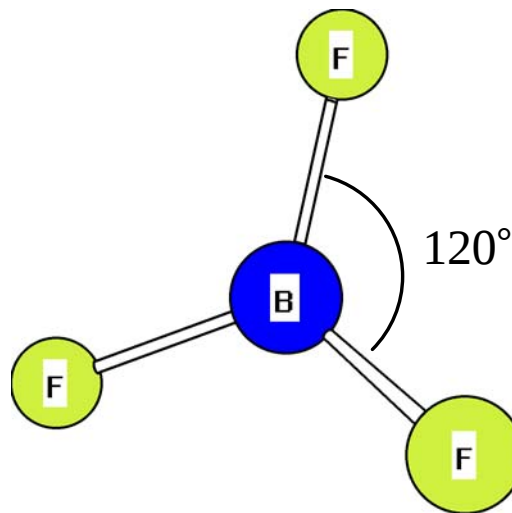
Molecules with the central atom with an incomplete octet

- Molecules that only have 2 bonding pairs on the central atom will have a LINEAR SHAPE with a bond angle of 180°
- Molecules that only have 3 bonding pairs on the central atom will have a TRIANGULAR (TRIGONAL) PLANAR SHAPE with bond angles of 120°

Example BeF_2



Example BF_3



Things to Remember

- In order to predict the shape of a molecule you must draw the Lewis Dot Diagram for the molecule, determine the number of bonding and non-bonding electron pairs and compare this with the chart you have been given (the general shapes must be memorized).