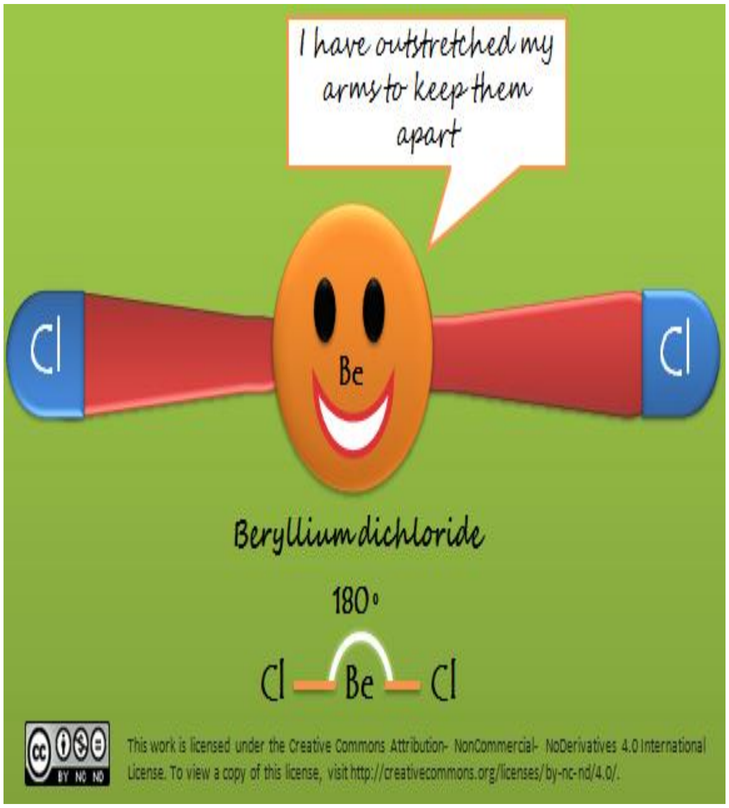
WHAT WILL BE THE SHAPE OF A MOLECULE?

Two different elements combine together and form an entirely different molecule. This fact has surprised us and it has puzzled scientists too. Whenever they came closer to solve one mystery, the next question arose and in an effort to solve the mystery of molecules, scientists have given different theories. Each theory tried to solve this mystery but left few unanswered questions and then scientists proposed a new theory. We will try to reveal its mystery in this post and the coming posts. With each successive theory we will be able to understand these molecules more closely.

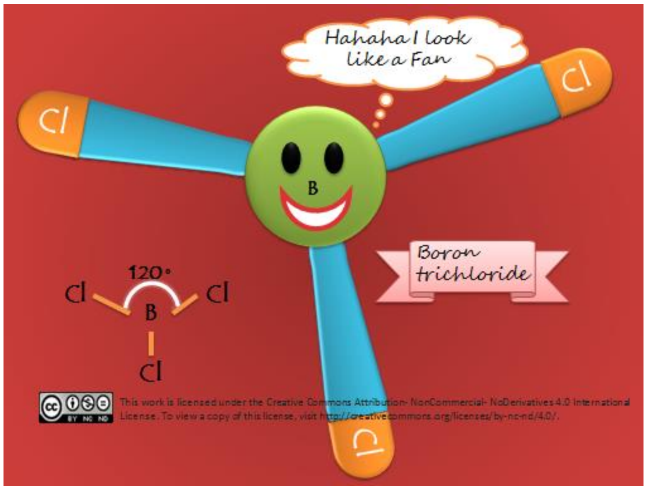
Covalent molecules are more mysterious than ionic molecules because in covalent molecules bonding electrons are shared between bonded atoms and they also share a bit of atomic orbital. We will discuss covalent and ionic molecule in different posts. Here we will discuss covalent molecules.

In covalent molecules there is one central atom which is surrounded by atoms of other elements. Central atom acts like the king who governs the shape of the molecule. Valence electrons help central atom to make bond with other elements and bonding electrons keep them bonded together. These valence electrons of central atom and bonding pairs play an important role in deciding the shape of a molecule.

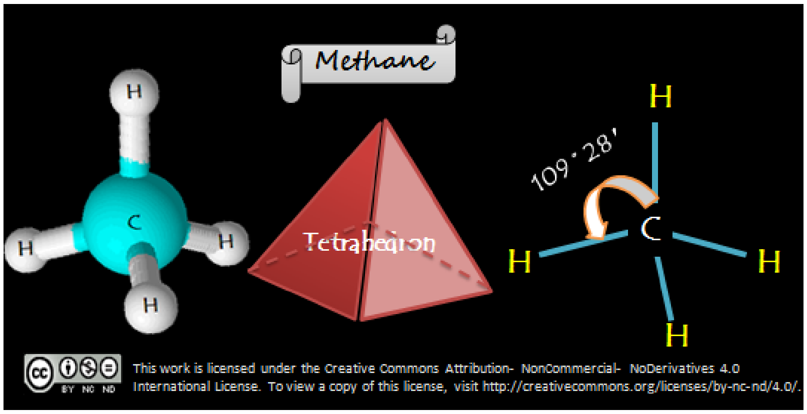
Let’s take an example of a simple (three atomic) molecule $BeCl_2$. I guess you will be able to name it correctly, Beryllium dichloride. In $BeCl_2$ molecule Be is the central atom, it has 2 bonding pair of electrons. Each bonding pair repel other and struggle to go far away from each other. If you imagine Be atom with the arms of ‘bonding pairs’ you must be able to guess the position in which they can be placed at maximum distance. Yes, you guessed correct; when Be atom fully stretches its arms, both bonding pairs are far way from each other. That's why the shape of $BeCl_2$ molecule is linear and the angle of Cl-Be-Cl is 180°.



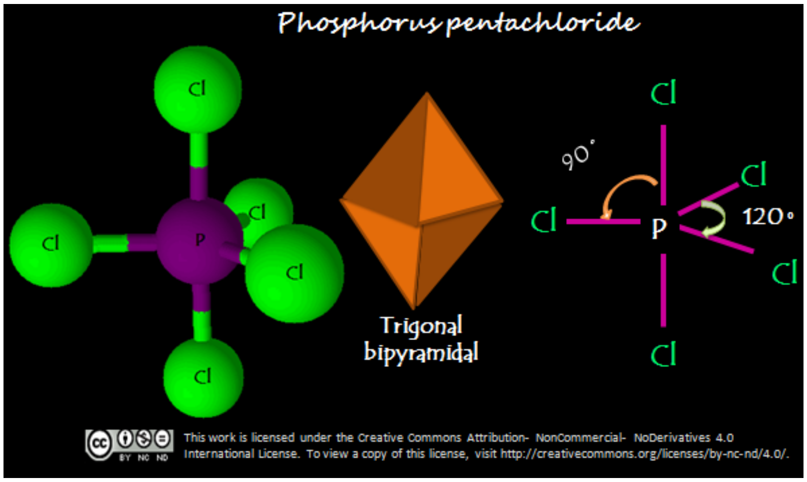
Let's take another example of (four atomic) molecule BCl_3. Its name is Boron trichloride. Its central atom is Boron and it has 3 bonding pairs. Now imagine B atom with 3 arms, all of them repelling each other. Can you guess, what will be the possible arrangement in which they have maximum distance between them? Yes, in a triangular arrangement where each bonding pair stays apart from each other. That's why the shape of BCl3 molecule is triangular planer and the angle of Cl-B-Cl is 60°.



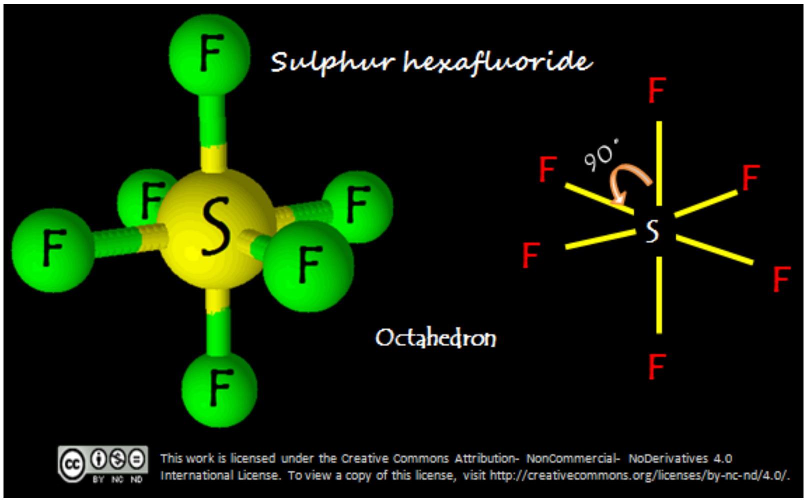
Let's take another example of (five atomic) molecule CH_4. Its name is Carbon tetrahydride and it is known as Methane. Carbon is the central atom in this molecule and it has 4 bonding pairs. Now you have to arrange 4 arms in the space at maximum distance. If you guessed square, it isn't the correct answer. Imagine a tetrahedron arrangement. Tetrahedron is a three dimensional shape that has equilateral triangles as its four faces. When you place carbon at the centre of the tetrahedron and place H at each vertex, you will be able to place them farthest away from each other. The shape of the CH_4 molecule is tetrahedron and angle between H-C-H is $109°28'$.



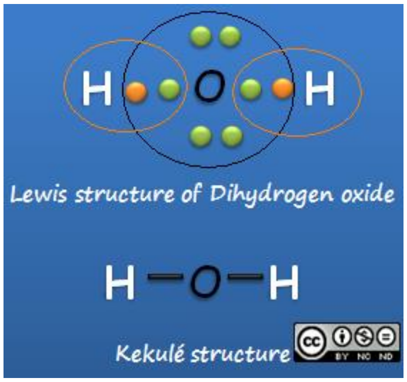
Take another example of six atomic molecule PCl_5. Its name is Phosphorus pentachloride. Phosphorus is the central atom in this molecule and it has 5 bonding pairs. Now think about the possible arrangement for these 5 bonding pairs. If we fix 2 pyramids by their base we will get 5 vertices and we can place Cl at each vertex and central atom P can be placed at the centre of the common surface of the two pyramids. That's how you can proof the shape of PCl_5 molecule is trigonal bipyramidal which has 3 angles Cl-P-Cl is of 120° and 2 angles Cl-P-Cl is of 90°



Take another example of seven atomic molecule SF_6. Its name is Sulphur hexafluoride. Sulphur is the central atom in this molecule and it has 6 bonding pairs. Now think about the possible arrangement for these 6 bonding pairs. If we fix 2 square pyramids by their base we will get 6 vertices and we can place F at each vertex and central atom S can be placed at the centre of the common surface of two square pyramids. That's how you can proof the shape of SF_6 molecule is octahedron (it has 8 faces) which has all angles F-S-F is of 90°.



All the examples we have discussed above are based on Sidgwick-Powell Theory. This theory reviewed the structure of known molecules. In this theory approximate shape of molecules can be predicted from the number of bonding pair of electrons but it is limited to the molecules which have only single bonds.



Let's try to predict the shape of H_2O molecule. You might say it must be linear like $BeCl_2$. But actually its shape is bent. Why your prediction went wrong? Examine the molecule of H_2O what makes it different from $BeCl_2$. Oxygen also has 2 bonding pair but it also has 2 lone pairs.

Sidgwick-Powell Theory didn't explain shape of molecules which has lone pairs. In 1957 Gillespie and Nythol improved this theory and gave a new theory "Valence shell electron pair repulsion (VSEPR)" theory" to predict molecular shape and bond angles more exactly. In the next post we will solve the mystery of the shape of H2O molecule with the help of VSEPR theory.

Source : http://chemistrynotmystery.blogspot.in/2014/08/what-will-be-shape-of-molecule.html