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Study Notes on VSEPR Theory

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VSEPR Theory

The main postulates of VSEPR theory are:

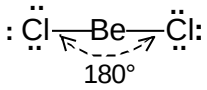
1. The geometry of a molecule can be predicted with the help of the total number of valence shell electron pairs present.
2. If there are only bond pairs present, the molecule will be symmetrical in shape.
3. If lone pairs along with bind pairs are present around the central atom, molecules will be distorted in shape.
4. The relative order of repulsion is:

lp – lp>lp – bp > bp – bp.

Molecules in this theory are divided into two categories, depending on whether the central atom has a lone pair of electrons or not. In this article, we will discuss the molecules in which the central atom has no lone pairs.

(a) AB_2 type molecule

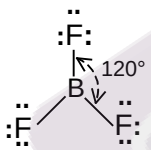
An example of this type of molecule is $BeCl_2$. Its Lewis structure in gaseous state is:



As bonding pairs repel each other, they must be present at opposite ends of a straight line, so that they remain as far apart as possible. Thus, Cl-Be-Cl bond angle is predicted to be 180° and its geometry is **linear**.

(b) AB_3 type molecule

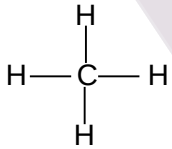
An example of this type of molecule is BF_3. It contains three bonding pairs that are present at the corners of an equilateral triangle having boron at the centre of the triangle.



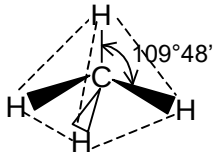
This geometry is known as **trigonal planar** in which the FBF bond angle is around 120°.

(c) AB_4 type molecule

An example of this molecule is Methane (CH_4). Its Lewis structure is

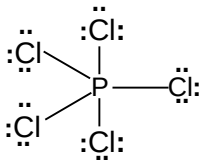


The four bonding pairs in CH_4 are arranged in the form of a tetrahedron. A tetrahedron has four faces, all of which are equilateral triangles. In a **tetrahedral** molecule, the central atom (carbon) is located at the centre and all other four atoms (H) are present at the corners. The HCH bond angles are all 109°48'.

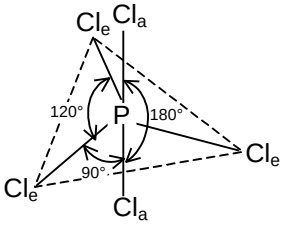


(d) AB_5 type molecule

The general formula AB_5 is represented by the molecule PCl_5. Its Lewis structure in gas phase is:

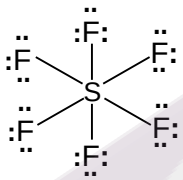


If all the five bonding pairs are arranged in the form of a trigonal bipyramid, repulsion will be minimum. Atoms above and below the triangular plane occupy axial and equatorial positions, respectively. Between two equatorial bonds, bond angle is around 120°, between two axial, bond angle is 180° and between an axial bond and an equatorial bond is 90°.

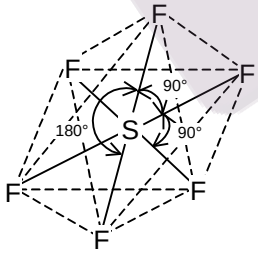


(e) AB_6 type molecule

An example of this type of molecule is SF_6 and its Lewis structure is:



For this molecule, the most stable arrangement is octahedron in which S will be present at the centre of the square base and F atoms will be present at six corners. All bond angles will be of 90° except the one which is between the central atom and the pairs of atoms that are diametrically opposite each other, which is 180°. As all the bonds are equivalent in an octahedral molecule, the terms axial and equatorial cannot be used here.



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