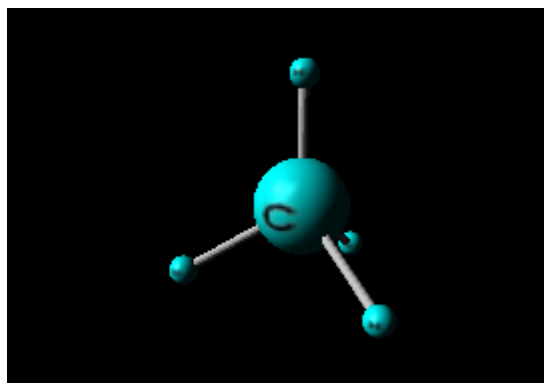


Section 9.4: The VSEPR Model for Molecules with Four Charge Clouds

Consider CH₄: The total number of valence electrons is $4 + 4 = 8$. The Lewis dot structure satisfying both the duet and octet rules, and the C-atom having a formal charge of zero is:



Look at the central atom.

- (a) All bonds from the central atom are called charge clouds.
- (b) If there are any lone pairs of electrons on the central atom, then they are also considered as charge cloud.

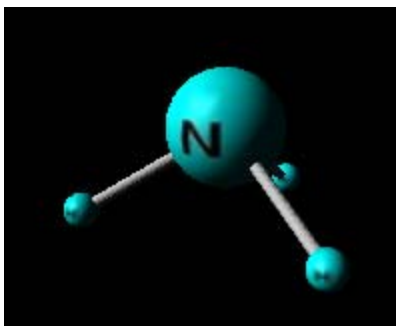
Hence, in CH₄ there are four charge clouds.

Rule: In a molecule where there are four charge clouds around the central atom, the arrangement of the electron pairs is “Tetrahedral.”

In a tetrahedral geometry, the bond angles from the central atom are 109.5° . In general, for a molecule AB₄, where A is the central atom, the molecular geometry is “Tetrahedral”.

Another molecule having this geometry is SiCl₄.

Consider NH₃: The total number of valence electrons is $5 + 3 = 8$. The Lewis dot structure satisfying both the octet and duet rules and the N-atom having a formal charge of zero is:



Look at the central atom.

- (a) All bonds from the central atom are called charge clouds.
- (b) If there are any lone pairs of electrons on the central atom, then they are also considered as charge cloud.

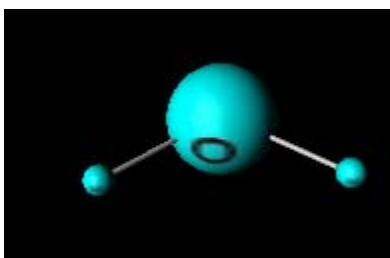
Thus, the N-atom has four charge clouds.

The general formula for a molecule of this type would be AB_3E . E represents a lone pair of electrons on the central atom A.

Rule: In a molecule where there are four charge clouds around the central atom, the arrangement of electron pairs is “Tetrahedral.”

However, when there are three bonds and one lone pair in four charge clouds, the molecular geometry is “Trigonal Pyramidal.” In a trigonal pyramidal geometry the bond angles from the central atom are a little less than 109.5° . Other molecules having this geometry are PF_3 , ClO_3 , etc.

Consider H_2O : The total number of valence electrons is $2 + 6 = 8$. The Lewis dot structure satisfying both the octet and duet rules, and the O-atom having a formal charge of zero is:



Look at the central atom.

- (a) All bonds from the central atom are called charge clouds.
- (b) If there are any lone pairs of electrons on the central atom, then they are also considered as charge cloud.

Thus, the O-atom has four charge clouds.

The general formula for a molecule of this type would be AB_2E_2 . E represents a lone pair of electrons on the central atom A.

Rule: In a molecule where there are four charge clouds around the central atom, the arrangement of electron pairs is “Tetrahedral.”

However, when there are two bonds and two lone pairs in four charge clouds, the molecular geometry is “Bent or V-shaped.” In a bent or V-shaped geometry the bond angles from the central atom are less than 109.5° .

Other molecules having this geometry are OF_2 , SCl_2 , etc...

Summary

| Molecule | Total # of Charge Clouds | # of Bonds | # of Lone Pairs | Arrangement of Charge Clouds | Geometry | Bond Angle |
|-----------|--------------------------|------------|-----------------|------------------------------|--------------------|------------|
| AB_4 | 4 | 4 | 0 | Tetrahedral | Tetrahedral | 109.5 |
| AB_3E | 4 | 3 | 1 | Tetrahedral | Trigonal Pyramidal | <109.5 |
| AB_2E_2 | 4 | 2 | 2 | Tetrahedral | Bent or V-shaped | <109.5 |

All these concepts can be applied in predicting the geometry of polyatomic ions