Unit 9: Molecular Geometry and Bonding Theories

Polarity

In this worksheet, you will be using the VSEPR model to observe polarity as well as molecular geometry in molecules.

Practice Questions:

1. Classify each of the following molecules as polar or nonpolar: ammonia, sulfur dioxide, beryllium fluoride, and sulfur trioxide.

2. Define polar molecule and polar bond. What is the difference between the two?

3. Are hydrocarbons generally polar or nonpolar?

4. For what type of bonding is polarity and molecular geometry relevant?

5. Describe molecular polarity in terms of electron distribution.

6. Which geometries based on the VSEPR model are nonpolar and which are inherently polar?

7. Discuss polar bonds and polar molecules using carbon tetrafluoride as a model.

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ANSWER KEY:

1. Classify each of the following molecules as polar or nonpolar: ammonia, sulfur dioxide, beryllium fluoride, and sulfur trioxide.

Ammonia is a polar molecule as it is a nitrogen bonded to three hydrogens along with one lone pair on the nitrogen. This makes it have trigonal pyramidal geometry which has an uneven distribution of electrons (asymmetrically bonded) and therefore polar.

Sulfur dioxide is a polar molecule as it is a sulfur atom with two bonded oxygens and one lone pair. This makes it have a bent shape which has an asymmetrical distribution of electrons (Asymmetrically bonded) and therefore polar.

Beryllium fluoride has a linear geometry as it consists of two fluorine atoms on either side of the beryllium. This makes it nonpolar as its electrons are evenly distributed throughout the molecule.

Sulfur trioxide is nonpolar as it has trigonal planar geometry as well as even distribution of electrons.

2. Define polar molecule and polar bond. What is the difference between the two?

A polar molecule is one that has a positive and a negative pole. This comes from asymmetrical bonds which can be caused by lone electron pairs. When there are lone electron pairs present on the central atom, there is increased electron repulsion which can push certain atoms away from the central atom. This leads the molecule to become asymmetrical and thus have a region that is more positive and a region that is more negative (generally has more affinity for electrons). A polar bond is between two atoms and results from one atom being more electronegative which makes that atom be more negative. A molecule can have multiple polar bonds and still be nonpolar as long as the bonds/electrons are symmetrical.

3. Are hydrocarbons generally polar or nonpolar?

Hydrocarbons are generally nonpolar and this is because they consist of a carbon skeleton bonded to hydrogens with an even distribution of electrons. The central carbon atoms usually display tetrahedral geometry with four hydrogens attached to a carbon atom. This geometry as well as the even electron distribution of electrons would make hydrocarbons nonpolar.

4. For what type of bonding is polarity and molecular geometry relevant?

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How electrons are shared and bonded in a molecule is what creates polarity and molecular geometry. Polarity is determined by how evenly electrons are shared or distributed while molecular geometry is the shape of a molecule given its electron sharing. Therefore, polarity and molecular geometry are only relevant when discussing covalent bonding which is the sharing of electrons to make bonds.

5. Describe molecular polarity in terms of electron distribution.

For a molecule to be polar, it must have electrons being shared unevenly between the atoms bonded (asymmetrically bonded). This usually involves an electronegative atom pulling the electrons towards itself which causes that side to be slightly negative. The existence of lone pairs on the central atom of molecules also causes electron repulsion which is a factor in the geometry of the molecule, and thus its electron distribution.

6. Which geometries based on the VSEPR model are nonpolar and which are inherently polar?

Geometries that have an even distribution of electrons (symmetrical bonds) and are therefore nonpolar covalent include: linear, trigonal planar, tetrahedral, trigonal bipyramidal, octahedral, and square planar ONLY assuming that all substituents are the same. When molecules with these geometries have more than one type of atom as a substituent, they can be polar molecules. The rest are inherently polar as they have uneven electron distribution (asymmetric bonds) due to their lone electron pairs. Uneven electron distribution simply means that one side of the central atom may have more electrons which can increase repulsion and make one side more negative than the other. The reason that certain geometries are not inherently nonpolar is that depending on the types of atoms involved, more electronegative atoms can cause a “symmetrical” molecular geometry to be polar.

7. Discuss polar bonds and polar molecules using carbon tetrafluoride as a model.

Carbon tetrafluoride has a tetrahedral geometry as well as an even electron distribution between its four fluorine atoms. This makes it symmetrical and a nonpolar molecule. However, an individual C-F bond is considered polar as the fluorine atom is extremely electronegative and would be slightly more negative than the carbon. However, in a tetrahedral arrangement, the entire molecule becomes nonpolar.