

Chapter 12 Chemical Bonding

12.1 Characteristics of Chemical Bonds

Key Terms

bonds	bond energy	ionic bond
ionic compound	covalent bond	polar covalent bond
electronegativity	dipole moment	

Summary

Chemical *bonds* hold groups of atoms together. They can be classified into several types. An *ionic bond* is formed when a transfer of electrons occurs to form ions. In a purely *covalent bond*, electrons are shared equally between identical atoms. Between these extremes lies the *polar covalent bond*, in which electrons are shared unequally between atoms.

Electronegativity is the relative ability of an atom in a molecule to attract shared electrons to itself. Electronegativity values have been calculated for most of the elements. The higher an element's electronegativity value, the more strongly the atoms of that element attract the electrons in a chemical bond. As a result, the shared electrons tend to be closer to that element's atoms when they form a bond.

A molecule with a center of positive charge and one of negative charge is said to have a *dipole moment*.

12.2 Characteristics of Ions and Ionic Compounds

Summary

In almost all stable chemical compounds, the atoms tend to achieve the valence-electron formation of one of the noble gases. When a nonmetal and a Group 1, 2, or 3 metal react to form a binary ionic compound, the ions form in such a way that the valence-electron configuration of the nonmetal is completed (by gaining one or more electrons) to achieve the electron configuration of the next noble gas on the periodic table. The valence-electron configuration of the metal is emptied (by giving up one or more electrons) to achieve the electron configuration of the previous noble gas on the periodic table. When two nonmetals react to form a covalent bond, they share electrons in a way that completes the valence-electron configurations of both atoms. Both the nonmetals take on the valence-electron configuration of a noble gas by sharing electrons.

When metals and nonmetals form ionic compounds, the attraction between the oppositely charged cations and anions results in very strong bonds and stable molecules. Polyatomic ions (charge units made up of several atoms) with opposite charges attract each other in the same way. However, the individual atoms that make up the polyatomic ions are held together by covalent rather than ionic bonds.

12.3 Lewis Structures

Key Terms

Lewis structures	duet rule	octet rule
bonding pair	lone pairs (unshared pairs)	single bond
double bond	triple bond	resonance

Summary

Lewis structures are simple diagrams that show the arrangement of the valence electrons in a molecule. Because bonding involves only the valence electrons of atoms, when writing Lewis structures, only the valence electrons are included. When forming stable molecules, hydrogen follows the *duet rule*, which means that each hydrogen atom in H_2 has two shared electrons. In the case of many other atoms, a stable molecule is formed only when one *s* and three *p* orbitals are filled. This requires them to follow the *octet rule*, to be surrounded by eight electrons.

Some molecules require double or triple bonds to satisfy the octet rule. In a *double bond*, two atoms share two pairs of electrons. In a *triple bond*, two atoms share three electron pairs. These bonds can be assigned to the atom pairs in more than one way. As a result, some molecules have more than one possible Lewis structure. This property is called *resonance*.

12.4 Structures of Molecules

Key Terms

molecular (geometric) structure	linear structure
trigonal planar structure	trigonal pyramid
valence shell electron pair repulsion (VSEPR) model	tetrahedral structure

Summary

The *molecular (geometric) structure* of a molecule shows how the atoms are arranged in space. There are three types of planar, or flat, structures. In a bent, or V-shaped, structure, the atoms are arranged in the shape of a V with about a 105° bond angle. In a *linear structure*, all atoms are arranged in a line, that is, with a 180° bond angle. A *trigonal planar structure* has three atoms arranged at 120° bond angles around a central atom. A *tetrahedral structure* is a three-dimensional structure with four atoms arranged at 109.5° bond angles around a central atom. Section 12.4 in the text has illustrations of these bond angles.

The molecular structure of a molecule can be predicted by using the *valence shell electron pair repulsion (VSEPR) model*. The main idea of this model is that the structure around a given atom is determined by minimizing repulsions between electron pairs. The electron pairs around a given atom are positioned as far apart as possible. Whenever two pairs of electrons surround an atom, the molecule has a linear structure, three pairs form a trigonal planar structure, and four pairs form a tetrahedral structure.

In using the VSEPR model for molecules with double and triple bonds, each double and triple bond should be treated the same as a single bond. As a result, the rules for modeling molecular structures for molecules with double and triple bonds are exactly the same as those for molecules with single bonds.

Additional Active Reading Questions

1. Describe the three types of chemical bonds.
2. What is the term for the relative ability of an atom in a molecule to attract shared electrons to itself?
3. What types of atoms do the atoms in stable chemical compounds resemble?
4. Why are ionic compounds so stable?
5. What are Lewis structures?
6. List the four molecular structures and their bond angles.
7. How are repulsions between electron pairs minimized in the VSEPR model?