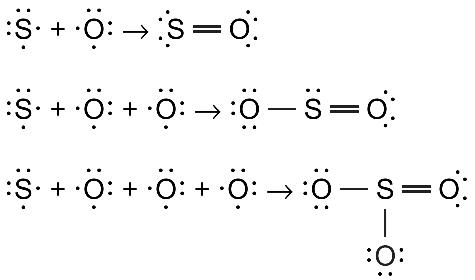
5. Some of the molecular compounds that can be created using oxygen and sulfur include SO, SO_2 , SO_3.



From the examples above, SO contains only multiple bonds.

Applying Inquiry Skills

6. **Experimental Design**
Solubility: Obtain a small amount of compound A. Observe and record its state at the ambient temperature. Add a small quantity of the substance to about 10 mL of distilled water. Stir the mixture with a stirring rod and note whether the chemical dissolves. Many ionic compounds readily dissolve in water.
Conductivity: Obtain a small sample of distilled water in a beaker. Use a low-voltage conductivity apparatus to test the electrical conductivity of the sample. The apparatus should indicate a reading of zero. Test the electrical conductivity of the mixture from the above solubility procedure and record observations. Ionic compounds (many of which dissolve readily in water) form solutions that conduct electricity.
Repeat the procedure for compound B. Molecular compounds (some of which dissolve in water) form solutions that do not conduct electricity.

7. **Experimental Design**
State, Hardness and Brittleness: Obtain a small-sized piece of $NaCl_{(s)}$ in road salt form. Observe and, in a table, record its state at SATP, its hardness, and brittleness.
Solubility: Pour about 10 mL of distilled water into a 50-mL beaker. Add a small quantity of the road salt to the water. Use a stirring rod to stir the mixture. Note whether the road salt dissolves.
Conductivity: Obtain a small sample of distilled water in a beaker. Test the electrical conductivity of the sample. The apparatus should indicate a reading of zero. Test the conductivity of the mixture of sodium chloride and water from the Solubility procedure. Record observations.

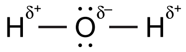
2.4 ELECTRONEGATIVITY, POLAR BONDS, AND POLAR MOLECULES

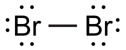
PRACTICE

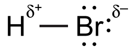
(Page 84)

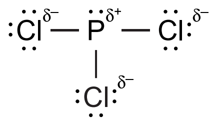
Understanding Concepts

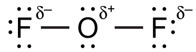
1. To predict whether a chemical bond between two atoms will be ionic, polar covalent, or covalent, we must consider the electronegativities of the elements involved. The absolute value of the difference in electronegativities of two bonded atoms provides a measure of the polarity in the bond: the greater the difference, the more polar the bond. By convention, a difference in electronegativity greater than 1.7 indicates an ionic bond.
2. (a) covalent
(b) covalent
(c) ionic
(d) ionic
(e) covalent
(f) covalent
(g) covalent
(h) ionic
(i) covalent
Si and O would be the most polar of the covalent bonds.
3. (a) H—F
(b) C—O
(c) O—H
(d) P—Cl
(e) N—H
(f) P—O
(g) C—N

4. (a) H_2O 

(b) Br_2 

(c) HBr 

(d) PCl_3 

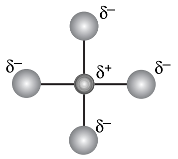
(e) OF_2 

PRACTICE

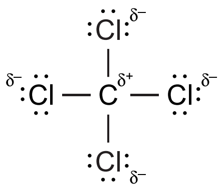
(Page 85)

Understanding Concepts

5. If a molecule that contains polar covalent bonds is quite symmetrical, it lacks oppositely charged ends and is not polar.



or

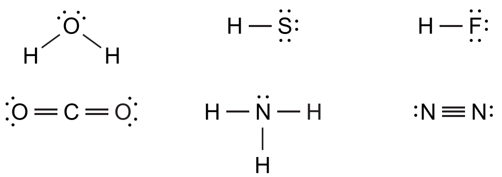


6. While the difference in electronegativity values between carbon and hydrogen results in polar covalent bonds (the difference is 0.4 for each carbon — hydrogen bond), the molecule of methane, $CH_{4(g,)}$ is quite symmetrical, and lacks oppositely charged ends. Therefore, it is not polar.

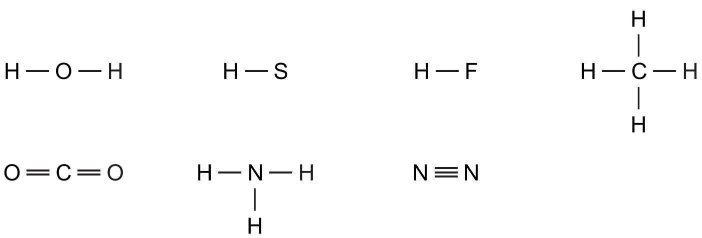
Try This Activity : Molecular Models

(Page 87)

(a)



(b)

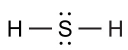


(c) Carbon dioxide required a double bond in order to complete its octet. Nitrogen required a triple bond in order to complete its octet.

(d) Water, hydrogen sulfide, hydrogen fluoride, and ammonia would be expected to be polar.

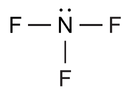
(e) (c) Similar shape to water:

$H_2S_{(g)}$



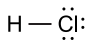
Similar shape to ammonia:

$NF_{3(g)}$



Similar shape to hydrogen fluoride:

HCl



PRACTICE

(Page 88)

Understanding Concepts

7. In ice, the hydrogen bonds between the molecules result in a regular hexagonal crystal structure that forms an open lattice with a great deal of empty space between the molecules. This causes ice to be less dense than liquid water. Thus, as water freezes, the ice floats to the top of the water surface, and as time passes, the lake freezes from the top down.
8. (a) polar
   (b) nonpolar
   (c) polar
   (d) nonpolar
   (e) nonpolar
   (f) nonpolar
9. $PCl_{3(s)}$, $HC_2H_3O_{2(aq)}$, $CCl_{4(l)}$ were classified as nonpolar but contain polar covalent bonds. Due to the symmetrical shape of these molecules, they lack oppositely charged ends and are therefore not polar.
10. A dipole–dipole force describes in general the attractive force acting between polar molecules. A hydrogen bond is a relatively strong dipole–dipole force acting specifically between a positive hydrogen atom of one molecule and a highly electronegative atom (F, O, or N) in another molecule.
11. (a) London dispersion force
    (b) Hydrogen bond
    (c) Hydrogen bond
12. (a) $I_{2(s)}$ is a nonpolar molecule. Thus it is the London dispersion force that exists between all molecules — both polar and nonpolar — that is responsible for the intermolecular attraction between molecules of $I_{2(s)}$.
    (b) $H_2O_{(l)}$ is a highly polar molecule containing an O–H bond. Thus it is the hydrogen bond force — a relatively strong dipole–dipole force between a positive hydrogen atom of one molecule and a highly electronegative atom (F, O, or N) in another molecule — that is responsible for the intermolecular attraction between molecules of $H_2O_{(l)}$.
    (c) $NH_{3(g)}$ is a highly polar molecule containing an N–H bond, and so forms hydrogen bonds with other molecules.

Applying Inquiry Skills

13.**Prediction**

(a) The molecules that will be affected by the charged object are NCl_3 , H_2O, CH_3OH, and H_2O_2. The charged object will have an effect on polar molecules (only) because the polar molecules are slightly charged at each end.

Evidence

(b) Samples 1 to 3 are Br_2, CCl_4, and vegetable oil. Samples 4 to 7 are NCl_3, H_2O, CH_3OH, and H_2O_2.

Analysis

(c) The evidence shows that a charged object will have an effect on a thin stream of liquids that are composed of polar molecules, but will have no effect on liquids composed of nonpolar molecules. The thin stream of liquids composed of polar molecules will be attracted to the charged object. Of the seven sample liquids, only NCl_3, H_2O, CH_3OH, and H_2O_2 are polar, and therefore affected by the charged object.

Synthesis

(d) The polar molecules — NCl_3, H_2O, CH_3OH, and H_2O_2 — are positively charged at one end, and negatively charged at the other because of electronegativity differences. Thus, the end of the polar molecule that has the opposite charge of the charged object will be attracted to the charged object. This is similar to dipole–dipole forces.

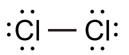
(e) The liquids were affected by both positive and negative charges because the polar molecules of the liquid are positively charged at one end, and negatively charged at the other. If a positively charged object is used, the negatively charged end of the polar molecule will be attracted to the charged object, and if a negatively charged object is used, the positively charged end of the polar molecule will be attracted to the charged object.

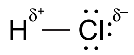
SECTION 2.4 QUESTIONS

(Page 89)

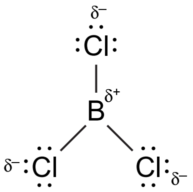
Understanding Concepts

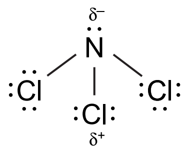
1. Covalent bonds and ionic bonds are the forces that bond atoms and ions together within a compound — the intramolecular forces. These forces are sufficient to explain the existence of molecular and ionic compounds, and to explain many of the properties of ionic compounds, but they aren't sufficient to explain the physical state of molecular compounds. If covalent bonds were the only forces at work, molecular compounds would all be gases, as there would be no attraction between the molecules strong enough to order the molecules into solids or liquids. The concepts of the polar molecule and small charges on atoms that result in intermolecular forces help to explain why these molecular compounds are not all gases at SATP.
2. When the atoms are identical, such as in a chlorine molecule, the electrons are shared equally. However, this is not the case for a compound like hydrogen chloride, where electrons are shared between two different elements. In this situation, the sharing is unequal, as the bonding electrons in the H—Cl bond spend more time near the chlorine atom than near the hydrogen atom. This is because of chlorine's greater attraction for electrons.





3. (a) Both BCl_3 and NCl_3 are molecular compounds. By convention, compounds with bonds that have electronegativity differences less than or equal to 1.7, have covalent-type bonds and are classified as molecular compounds.
   (b) The bonds between B—Cl and N—Cl are similar in that they are both covalent-type bonds and involve the sharing of a pair of electrons. The bonds are different in that the B—Cl bonds are polar covalent bonds due to differences in electronegativities. In this situation, the sharing of electrons is unequal, as the bonding electrons in the B—Cl bond spend more time near the chlorine atom than near the boron atom. This is because of chlorine's greater attraction for electrons. Another difference is that the boron atom in BCl_3 does not have an octet in its valence shell.
   (c) BCl_3 is quite symmetrical and lacks oppositely charged ends. Thus it is not a polar molecule. Intermolecular attractions would be due to the weaker London dispersion forces. NCl_3 is a polar molecule due to having nitrogen at one end. Intermolecular attractions would be due to the stronger dipole-dipole forces.





4. Since a molecule of carbon tetrachloride, $CCl_{4(l)}$n, is quite symmetrical, it lacks oppositely charged ends and is not polar.

2.5 THE NAMES AND FORMULAS OF COMPOUNDS

PRACTICE

(Page 93)

Understanding Concepts

1. Substances were named in a variety of ways. In some cases, the name referred to the use of the compound; in other cases, it incorporated an obvious property, or perhaps referred to the sources of the substance.
2. (a) muriatic acid
   (b) baking soda
   (c) laughing gas
   (d) grain alcohol
3. A binary compound is composed of two kinds of elements.
4. In the formula of a binary ionic compound, the metal cation is always written first, followed by the nonmetal anion. The name of the metal is stated in full and the name of the nonmetal ion has an *-ide* suffix; for example, $NaCl_{(s)}$ is sodium chloride.