TYPES OF BONDS

As we have discussed, atoms will gain, lose and share electrons to obtain eight electrons in their outer energy level, the **octet rule**. This process creates bonds between atoms. In this unit we will discuss three types of bonds, ionic, covalent, and metallic. When bonds occur the amount of energy in the system is reduced, however, a more stable system results.

Ionic bonds are formed by the electrostatic attraction between ions. A positively charged ion will be attracted to a negatively charged ion. These bonds tend to form between metals and non-metals. The strength of an ionic bond maybe discussed as **lattice energy**, that is the change in energy that occurs when an ionic solid is separated into isolated ions in the gaseous phase. Ionic bonds result in compounds with several distinguishing characteristics:

1. composed entirely of ionic bonds
2. high melting points
3. brittle – they shatter and cleave
4. most dissolve in water (the ionic bonds will be broken)
5. when in solution they are good conductors

*Review your Lewis Dot Diagrams

As we have learned previously an anion is a negative ion and a cation is a positive ion. In addition, these ions can be described as monoatomic and polyatomic. **Monoatomic** ions are made up of a single element. Monoatomic cations are referred to with the same name as the element. Monoatomic anions are referred to using the –ide suffix. For example an oxygen ion is called an oxide. **Polyatomic** ions are made up of more than one atom and have acquired electrons from an outside source. (*review your polyatomic ions)

Binary ionic compounds are specific compounds that consist of only two elements. To name a binary compound state the name of the cation and then the –ide form of the anion. For example salt (NaCl) is sodium chloride.

When writing formulas you must know the ratio of elements in the compound. This is called an **empirical formula**, for example Al_2O_3 or Li_2O. Formulas for ionic compounds are given in the smallest whole number ratio of the ions. To determine this we use the **criss cross method**. Hint: When using the criss cross method with polyatomic ions enclose the polyatomic ion with parenthesis.

- For example: Write the formula for calcium floride.
  $Ca^{2+}\ F^{1-} \rightarrow Ca^{2+}F^{1-} \rightarrow Ca_1F_2$

- Write the formula for magnesium (II) oxide.
  $Mg^{2+}\ O^{2-} \rightarrow Mg^{2+}O^{2-} \rightarrow Mg_2O_2 \rightarrow MgO$

Practice: Write the formulas for the following ionic compounds.

1. barium chloride _____
2. magnesium phosphate _____
3. lithium iodide _____
4. potassium bromide _____

Covalent bonds exist when atoms share electrons, the electrons occupy the space around both atoms. A covalent bond may be polar or non-polar. A **polar** covalent bond happens when one atom has a significantly higher electronegativity than the other atom. The electrons will spend a greater amount of time around that atom resulting in a slightly negative charge around that atom (δ-) and a slightly positive charge (δ+) around the other atom. For example water is a polar molecule. The oxygen atom has a higher electronegativity that pulls the electrons toward it and away from the hydrogen.

Non-polar covalent bond are those that occur between atoms with similar electronegativities. For example the bond between two atoms of the same element (diatomic) is a covalent bond because the atoms have the same electronegativity. The type of bond formed can be found by determining the difference between electronegativity values for the atoms. See the chart below for interpretation of differences. The greater the difference the more polar the bond is.

Difference in Electronegativity	Type of Bond
0.49 or less	Non-polar covalent
0.50 to 1.99	Polar covalent
2.00 or greater	Ionic

-For example: What type of bond is formed in water (H_2O)?

Hydrogen has an electronegativity of 2.20, and oxygen has an electronegativity of 3.37, the difference is 1.17 thus the bond between oxygen and hydrogen is a polar covalent bond.

O- 3.37
H- 2.20
1.17 Difference – Polar Covalent

-What type of bond is formed in sodium chloride (NaCl)?

Cl – 3.00
Na – 0.96
2.04 Difference – Ionic bond

Practice: Determine the type of bond formed for the following compounds.

1. NH_3

2. CO_2

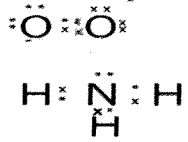
3. CaF_2

4. O_2

We use many different terms to describe covalent compounds. Generally, a group of atoms attached by covalent bonds are referred to as **molecules**. A **molecular substance** would be a substance made up of molecules. When we discuss the formula of a covalent compound we describe the **molecular formula**, and express how many atoms are in a single molecule of the compound. For example sucrose has the molecular formula: $C_{12}H_{22}O_{11}$, however, its empirical formula is CH_2O (1:2:1). Molecules can also be described by their structural formula. A **structural formula** illustrates which atoms are bonded to which. There are three types of structural formulas, Lewis Dot Diagrams, Molecular Shape Formula, and Ball & Stick Models.

1. Lewis Dot Diagrams: this type of diagram is used to illustrate shared electrons.

   For example O_2 and NH_3 would look like:

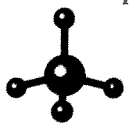


2. Molecular Shape Formulas: this type of formula represents the bonds in a 3-d manner.

   For example H_2O and CO_2 would look like:

3. Ball & Stick Models: this type of model uses actual replicas of atoms to create the compounds.

   For example CH_4 would look like:



methane

Practice: Illustrate the Lewis Dot Diagram and the Molecular Shape Formula for the following compounds.

1. Cl_2

2. H_2O_2

3. CCl_4

There are four types of covalent bonds, a single bond, a double bond, a triple bond, and a coordinate covalent bond. In a **single covalent bond** a single pair of electrons are shared. In a **double covalent bond** two pairs of electrons are shared. In a **triple covalent bond** three pairs of electrons are shared. In a **coordinate covalent bond** one atom donates both of the electrons to be shared.

-For example: What kind of bond is found between the hydrogen and oxygen in water?

Hydrogen only has one electron to share and therefore only forms a single covalent bond.

-What kind of bond occurs between carbon and oxygen in carbon dioxide (CO_2)?

Oxygen requires 2 electrons to be complete and carbon requires four electrons. Each oxygen shares its two electrons with two of carbons. O=C=O

**** There are several exceptions to the octet rule. We have already learned the first exception, hydrogen and helium only require two electrons to fill their outer energy level. A second exception occurs when an atom contains less than an octet. For example, when boron bonds with fluorine (BF_3). Boron forms a 3+ ion, donating 1 electron to each of the attached fluorine. A third exception occurs in atoms like sulfur and phosphorus that end up with more than an octet when they share electrons. The fourth and last exception occurs in molecules with an odd number of electrons. These particular molecules cannot follow the octet rule and are generally unstable and short lived.

Metallic bonds occur in the bonding of pure metals and are very strong bonds. In metallic bonding the valence electrons migrate throughout the crystalline structure and that migration strengthens the structure. The migration also allows better conduction of heat and electricity.

Name: _____ **Period:** ___ **Date:** _____

Homework: Types of Bonds

Complete the following short answer questions.

1. What is ionization?

2. What are the two ways that a bond can form?

3. What is electronegativity?

4. What electrons are involved in a bond?

5. What is any chemical process where there is a loss of electrons is called?

6. When a chemical bond forms the amount of energy in the system (increases/decreases); but the stability (increases/decreases).

Select the best answer for each of the following statements. (a choice may be used more than once)

a. ionic b. non-polar covalent c. polar covalent d. can't tell

_____ 7. Bonding between ions.

_____ 8. Electrons transfer.

_____ 9. Bonding between atoms with very different affinities (attractions) for electrons.

_____ 10. Electrons shared equally.

_____ 11. Unequal sharing.

_____ 12. Bonding between atoms with similar affinities for electrons.

_____ 13. More than 2.0 difference between electronegativities.

_____ 14. Less than 0.4 difference between electronegativities.

_____ 15. Between 0.4 and 2.0 difference in electronegativities.

Complete the following table.

Compound	Type of bond	Lewis Dot Diagram	Molecular Shape Formula
16. H_2S			
17. CsI			
18. $MnCl_2$			
19. $FeCl_3$			
20. HBr			
21. C_2H_6			

Choose the best answer to the following multiple choice questions.

____ 22. Ions that are formed from one atom are known as:
- a. polyatomic ions
- b. monoatomic ions
- c. cations
- d. anions

____ 23. A group of atoms united by covalent bonds is a(n):
- a. cation
- b. octet
- c. ionic compound
- d. molecule

____ 24. Which type of formula best describes how atoms bond in a molcule?
- a. molecular
- b. empirical
- c. structural
- d. chemical

____ 25. An ionic compound has which of the following characteristics?
- a. high melting points
- b. are good conductors in their liquid state
- c. are brittle
- d. all of the above