Chapter 6 Ionic compounds 6.3, 6.4

6.1: Intro to Chemical Bonding

A **chemical bond** is a mutual electrical attraction between the nuclei and valence electrons of different atoms that binds the atoms together.

There are two types of bonding:

- **Ionic bonding** is bonding that results from the electrical attraction between anions and cations
- **Covalent bonding** results from the sharing of electron pairs between two atoms

Chemical Bonding

- An electrostatic force of attraction between two atoms, ions, or molecules
- Opposite charges attract and like charges repel.
- Ionic compounds exist as 3-dimensional arrays of ions held together by the force of attraction between the oppositely charged ions.

Formula Unit:

Is used to represent an ionic compound

A formula unit represents the lowest whole number ratio in a compound

- There is no such thing as a molecule of sodium chloride
- ***Ionic compounds exist as a collection of positively and negatively charged ions arranged in repeating 3-D patterns***

Law of Definite Proportions

In samples of any chemical compound, the masses of the elements are always in the same proportions

Example: Magnesium Sulfide:

- 100g sample: breaks down to 43.13g of magnesium and 56.87g of sulfur
- Ratio: 43.13/56.87 = **.7584:1 (Mg:S)**
- ***This proportion remains the same no matter how many grams of MgS you have***

Law of Multiple Proportions

Definition: if two or more different compounds are composed of the same two elements, then the ratio of the masses of the second element combined with a certain mass of the first element is always a ratio of small whole numbers

- Examples:
- CO & CO_2 : 1:1 ratio & a 1:2 ratio
- H_2O & H_2O_2: 2:1 ratio & a 2:2 ratio

Section 6.3: Ionic Bonding

An **ionic compound** is composed of anions and cations combined so that the numbers of positive and negative charges are equal.

- Compounds are comprised of metal-nonmetal bonding
- A **formula unit** shows the lowest whole number ratio of atoms in an ionic compound. (Lowest whole number ratio)
- $CaCl_2$ and NaCl are examples

Ionic Compounds

Ionic Compounds are **neutral**

- Combine a cation and an anion
- Cation + Anion → Neutral ionic compound

$$A^+ + X^- \rightarrow AX$$

The charge of the cation and anion must add up to zero.

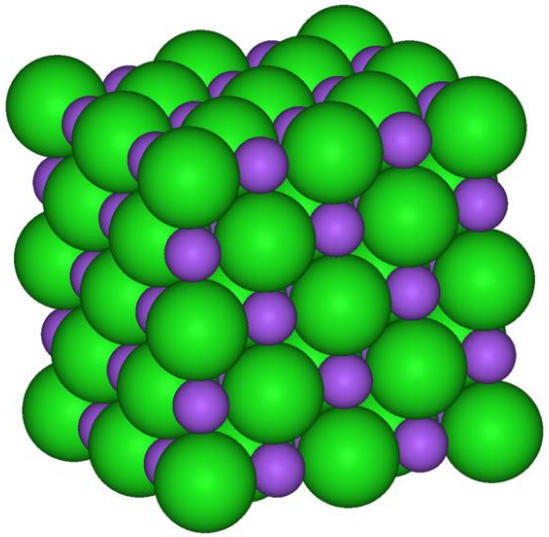
Properties of Ionic Compounds

- Repeating 3D patterns
- Characteristics
  - High melting points
  - Conductivity in molten states
  - Existence in crystalline form
  - Tendency to dissolve in water
  - Produce electrical conductivity when dissolved in water

Coordination Number

Definition – gives the number of ions of opposite charge that surround each ion in a crystal

- Example: NaCl
- Coordination # = 6



Ionic Charges

For "A" Group Metals:

Group **1A**: Alkali metals

- Li, Na, K = 1+

Group **2A**: Alkaline earth metals

- Mg, Ca = 2+

Group **3A**: Other metals

- Al(only metal) = 3+

Ionic Charges:

For "A" Group Nonmetals:

The charge is determined by subtracting 8 from the group number

- Example Group 7A elements
- F : 7- 8 = -1
- Group 7A elements form -1 ions

Ionic Charges:

Group **5A:** Nitrogen family

- N= (5 – 8 = -3)

Group **6A:** Oxygen family

- O, S = (6 – 8 = -2)

Group **7A:** Halogens

- Cl = (7-8 = -1)

Ionic Charges:

Group 0 (really group 8A) and Group 4A usually do not form ions

- Group 8- noble gases
- Group 4A- nonmetals form molecular compounds

Ionic Charges:

Stock system:

- For naming cations with more than one possible charge
- Example: **Iron**
  - Has two possibilities (+2), (+3)
  - Written as Iron(II) ion (Fe^{2+}) and Iron(III) ion (Fe^{3+})

Ionic Charges:

Can also use the root word with a different suffix to designate between multiple charged cations:

- Example: Iron(II): *ferrous* (Fe^{2+})
- Iron(III): *ferric* (Fe^{3+})

Other Ions

Polyatomic ions – ions that are made up of more then one atom

- Behave like atoms
- Tightly bound groups
- Very common & stable in nature
- Have special names:
- Ammonium = NH_4^+

Polyatomic ions:

Most end in *–ite*, or *–ate*

- Exceptions:
  - Ammon*ium* (NH_4^+)
  - Hydrox*ide* (OH^-)
  - Cyan*ide* (CN^-)

Polyatomic ions:

Polyatomic ions with hydrogen:

- Example: HCO_3^-
  - $H^+ \quad + \quad CO_3^{2-}$
  - *Note*: the charge of the new ion is the sum of the charges of the composite ions

Ionic Compounds:

For All Ionic Formulas:

- The positive charge of the cation balances the negative charge of the anion
- **Net ionic charge of formula must = zero**

Writing Ionic Formulas From Names

Ionic Compounds:

Crisscross method:

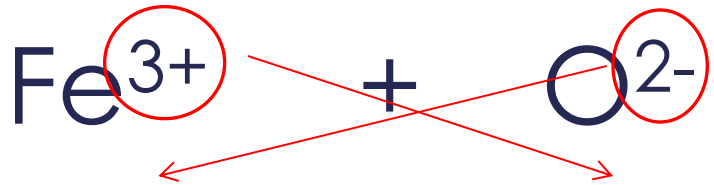
- The numerical charge of each ion is crossed over and used as a subscript for the other ion
- The signs of the numbers are dropped

Rules for Writing Formulas

1. Write the formula of the cation first (usually a metal ion) with the charge
2. Write the formula of the anion with the charge
3. Crisscross the charges so the charge of the cation becomes the subscript for the anion and the charge of the anion becomes the subscript for the cation. (DROP THE SIGNS!)

Binary Ionic Compounds:

- Example: iron (III) oxide



- To write the formula use the crisscross method:

$$Fe_2O_3$$

Ternary Ionic Compounds:

Example: Calcium Nitrate

- Ca^{2+} + NO_3^-

Use crisscross method

$Ca(NO_3)_2$

Parenthesis indicates two nitrate ions

Ternary Ionic Compounds:

Example:

Sodium carbonate

Na^{+1} and CO_3^{2-}

Formula:

Na_2CO_3

Note: If there is more than one of a polyatomic ion, it must be put in parentheses!

Writing Names From Formulas for Ionic Compounds

Binary ionic compounds:

- Composed of only two elements: a non- metallic element and a metallic element
- Ionic charges used to assign **formulas** and **names**

Rules for Naming Binary Compounds

1. Write the name of the cation (usually a metal ion)
   - If the cation is a transition metal, use a Roman numeral for the charge
2. Write the name of the non-metal with an **–ide** ending

Binary compounds

1. $CaBr_2$
   - Calcium Bromide
2. NaCl
   - Sodium Chloride
3. KCl
   - Potassium Chloride

Naming Binary Compounds

Example: CuO

- Copper is a transition metal
- Copper has two possibilities:
  - Copper (I) and Copper (II)
- Since oxygen is -2, Cu is +2
- So the name is **Copper(II) oxide**

Ternary Ionic Compounds:

Ionic compound that contains atoms of three different elements

- Usually contain a polyatomic ion
- Use the same procedure for writing formulas as binary compounds

Ternary Ionic Compounds:

To write the name from the formula:

1. Name the cation first
2. If the cation is a transition metal, use a Roman numeral to indicate the charge
3. Name the polyatomic anion (note: the suffix will be the same as the polyatomic ion!)

Molecular Acids

Molecular Common Acids

Acids: molecular substances that release hydrogen ions when dissolved in water

- They are composed of H^+ ion combined with any anion (negative ion). They are named by modifying the name of the anion.

Naming Common Acids

The cation is always hydrogen

- The formulas have as many hydrogens as needed to make the compound electrically neutral
  - HCl
  - H_2CO_3

Naming Acids

Anion ends with:	Change ending to:
-ate	-ic acid
-ite	-ous acid
-ide	Hydro- ____ -ic acid

I ***ATE*** something ***IC***ky in the cafeteria
I b***ITE*** a delici***OUS*** apple

Writing Formulas

Write formulas exactly like ionic compounds. Use the charges and the crisscross method.

Anion	Formula	Name
Cl^- Chloride ion	HCl	Hydrochloric acid
ClO_3^- Chlorate	$HClO_3$	Chloric acid
ClO_2^- Chlorite	$HClO_2$	Chlorous acid

Six Common Acids:

- Hydrochloric acid: HCl
- Sulfuric acid: H_2SO_4
- Nitric acid: HNO_3
- Acetic acid: $HC_2H_3O_2$
- Phosphoric acid: H_3PO_4
- Carbonic acid H_2CO_3

Memorize these!