Naming Covalent and Ionic Molecules

Due: Friday November 21, 2014

Name: _____

Monatomic Ions

Ions are atoms that have either lost or gained electrons. While atoms are neutral, ions are **charged particles**.

- A *loss* of electrons results in a positive ion or **cation** (pronounced "cat-eye-on").
- A *gain* of electrons results in a negative ion or **anion** (pronounced "an-eye-on").

Although ions and elements have similar chemical symbols, they are entirely different substances with different physical properties.

A. Monatomic Ions

In order to determine the charge of *monatomic* ions, you can use the periodic table as a guide:

Group # (Column)	Ion Charge	Examples
1	These elements lose **one** electron to form **+1** ions.	Na^+, Li^+, K^+
2	These elements lose **two** electrons to form **+2** ions.	Mg^{2+}, Ca^{2+}, Ba^{2+}
Groups 3-12	The elements in groups 3-12 are called transition metals. These elements always lose electrons to form **positive** ions (cations) but their charges vary. For example, iron can form a +2 or a +3 ion. *In cases like these, you must be told which ion to use.*	Fe^{2+}, Fe^{3+}
13	These elements lose **three** electrons to form **+3** ion.	Al^{3+}
14	The charges on these ions vary. Carbon and silicon do not form ions. For the rest of the group, you must be given the charge.	Sn^{2+}, Pb^{2+}
15	These elements gain **three** electrons and form **–3** ions.	N^{3-}, P^{3-}
16	These elements gain **two** electrons to form **–2** ions.	O^{2-}, S^{2-}
17	These elements gain **one** electron to form **–1** ions.	F^-, Cl^-, Br^-, I^-
18	These atoms do NOT form ions. Their charge is always **zero**.	He, Ne, Ar, Kr

Naming Ions (Nomenclature):

Simple **cations** are named by saying the element and adding the word "ion."

Na^+ is called "sodium ion"
Mg^{2+} is called "magnesium ion"

Simple **anions** are named by dropping the ending off the element name and adding "ide."

F^- is called "fluoride"
O^{2-} is called "oxide"
N^{3-} is called "nitride"

Note: the charge of a monatomic **anion** is equal to the group number minus 18.

Nomenclature Worksheet 1:
Monatomic Ions

Use a periodic table to complete the table below:

Element Name	**Element Symbol**	**Ion Name**	Ion Formula
1. sodium			
2. bromine			
3. magnesium			
4. chlorine			
5. oxygen			
6. boron			
7. lithium			
8. neon			
9. phosphorus			
10. aluminum			
11. calcium			
12. iodine			
13. nitrogen			
14. cesium			
15. sulfur			
16. fluorine			
17. potassium			
18. barium			
19. hydrogen			
20. helium			

Simple Binary Ionic Compounds

Ionic compounds are compounds formed by the combination of a **cation** and a **anion**. **(Think: "metal plus nonmetal").** Ionic compounds are more commonly known as "salts." Binary ionic compounds are compounds containing only two elements, as demonstrated in the examples below.

When writing formulas for ionic compounds, we use **subscripts** to indicate how many of each atom is contained in the compound. Remember that even though ions have charges, ionic compounds must be **neutral**. Therefore, the charges on the cation and the anion must cancel each other out. In other words, the **net charge** of an ionic compound equals zero.

Example 1:

For a salt containing sodium ion, $\mathbf{Na^+}$, and chloride, $\mathbf{Cl^-}$, the ratio is one to one. The positive charge on the sodium ion cancels out the negative charge on the chloride.

$$\mathbf{(+1) + (-1) = 0}$$

Therefore, the formula for the salt is **NaCl.** (The actual formula is Na_1Cl_1, but chemists omit subscripts of 1).

Example 2:

For a salt containing calcium ion, Ca^{2+}, and chloride, Cl^-, the ratio can't be one to one.

$$\mathbf{(+2) + (-1) = +1}$$

Remember that ionic compounds must be neutral. In order to yield a neutral compound, **two** chlorides must bond to the calcium ion:

$$\mathbf{(+2) + 2(-1) = 0}$$

So, the formula for this salt is $\mathbf{CaCl_2}$.

Nomenclature:

When naming ionic compounds, simply write the *element name* of the metal followed by the *ion name* of the nonmetal. **(Remember: the metal ion (cation) is always written first!)**

NaCl is called "**sodium chloride**," and $CaCl_2$ is called "**calcium chloride.**"

Nomenclature Worksheet 2:
Simple Binary Ionic Compounds

Please complete the following table:

Name of Ionic Compound	Formula of Ionic Compound
1. Sodium bromide	
2. Calcium chloride	
3. Magnesium sulfide	
4. Aluminum oxide	
5. Lithium phosphide	
6. Cesium nitride	
7. Potassium iodide	
8. Barium fluoride	
9. Rubidium nitride	
10. Barium oxide	
11.	K_2O
12.	MgI_2
13.	$AlCl_3$
14.	$CaBr_2$
15.	Na_3N
16.	LiF
17.	Ba_3P_2
18.	Cs_2S
19.	SrF_2
20.	NaCl

Naming Binary Covalent Compounds

Binary covalent compounds come from the combination of two nonmetals (or a nonmetal and a metalloid). These compounds do not involve ions; as a result, they have a slightly different naming system. Chemists use *prefixes* to indicate the number of atoms in each compound. The prefixes are listed in the table below:

# of Atoms	Prefix
1	Mono
2	Di
3	Tri
4	Tetra
5	Penta
6	Hexa
7	Hepta
8	Octa
9	Nona
10	Deca

When naming binary covalent compounds, the first element name is given followed by the second element with an "ide" ending. The first element gets a prefix when there is more than one atom in the compound.* The second element ALWAYS gets a prefix. Here are some examples:

Compound	Name
NO*	Nitrogen Monoxide
N_2O	Dinitrogen Monoxide
NO_2*	Nitrogen Dioxide
N_2O_3	Dinitrogen Trioxide
N_2O_4	Dinitrogen Tetraoxide
N_2O_5	Dinitrogen Pentaoxide

* Notice that the prefix "mono" is omitted in these cases

Prefixes are necessary when naming covalent compounds because the atoms can combine in any whole number ratio. N_2O, for example, cannot simply be called "nitrogen oxide," because there are several other compounds that contain nitrogen and oxygen. We must specify that there are two nitrogen atoms bonded to a single oxygen atom.

When dealing with ionic compounds, there is only one way for a cation and a nion to combine to form a neutral compound. As a result, there is no need to use prefixes. This is why $CaCl_2$ is called "calcium chloride," rather than "calcium dichloride."

Nomenclature Worksheet 6:
Binary Covalent Compounds

Please complete the following table:

Name of *Covalent* Compound	Formula of *Covalent* Compound
1. carbon dioxide	
2. phosphorus triiodide	
3. sulfur dichloride	
4. nitrogen trifluoride	
5. dioxygen difluoride	
	6. N_2F_4
	7. SCl_4
	8. ClF_3
	9. SiO_2
	10. P_4O_{10}

Determine whether the following compounds are **covalent** or **ionic** and give them their proper names.

1. ~~$Ba(NO_3)_2$~~ NaBr
2. CO
3. PCl_3
4. KI
5. CF_4
6. MgO
7. Cu_2S
8. SO_2
9. NCl_3
10. XeF_6

Shortcut for Formula Determination:

Use the following method when asked to determine the formula of an ionic compound:

1. Write the two ions with their charges (metal first).
2. Ignoring the + or – charges, "crisscross" the numbers and make them subscripts.
3. Then, rewrite the formula, dropping the charges.

(See Examples Below)

Example 1:
Write the formula for **calcium chloride**:

1. Write the two ions with their charges (metal first).

Ca^{2+} Cl^-

2. Ignoring the + or – charges, "crisscross" the numbers and make them subscripts:

Ca^{2+} Cl^-

3. Then, rewrite the formula, dropping the charges. In this case, the formula is: **$CaCl_2$**

Example 2:
Write the formula for **magnesium oxide:**

1. Write the two ions with their charges (metal first).

Mg^{2+} O^{2-}

2. Ignoring the + or – charges, "crisscross" the numbers and make them subscripts:

Mg^{2+} O^{2-}

3. Then, rewrite the formula, dropping the charges. The rewritten formula is: Mg_2O_2.
Note: Since the subscripts for the anion and cation are the same, the formula reduces to Mg_1O_1.

Therefore, the correct formula is written as: **MgO**.

Naming Covalent Compounds Worksheet

Write the formulas for the following covalent compounds:

1) antimony tribromide _____

2) hexaboron silicide _____

3) chlorine dioxide _____

4) hydrogen iodide _____

5) iodine pentafluoride _____

6) dinitrogen trioxide _____

7) ammonia _____

8) phosphorus triiodide _____

Write the names for the following covalent compounds:

9) P_4S_5 _____

10) O_2 _____

11) SeF_6 _____

12) Si_2Br_6 _____

13) SCl_4 _____

14) CH_4 _____

15) B_2Si _____

16) NF_3 _____