Chemistry A Ionic Compounds

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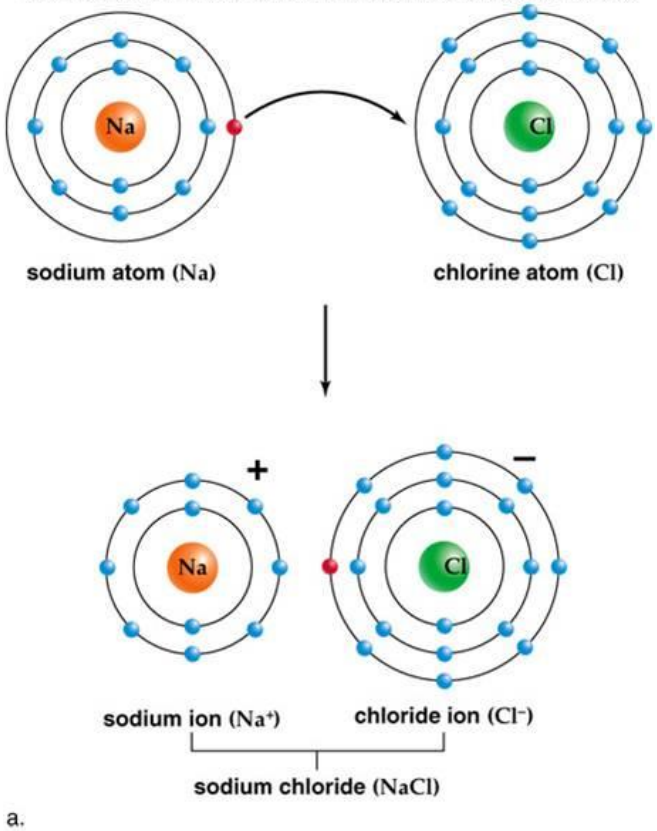


a.

All videos are at www.msu.edu/~bausemic/chem

Ionic Compounds Learning Goals

- 3.1 I can compare and contrast the structure of ionic and covalent compounds and give examples of each.
- 3.2 I can determine the number of atoms in a compound when given the formula.
- 3.3 I can name ionic compounds when given the formulas.
- 3.4 I can write formulas for ionic compounds when given the names.
- 3.5 I can use Roman numerals to name ionic compounds that contain special metals when given the formulas.
- 3.6 I can write formulas for ionic compounds that contain special metals when given the names.
- 3.7 I can write formulas and names for all ionic compounds when given a mixture of those with special metals and those without.
- 3.8 I can compare and contrast the properties (characteristics) of ionic and covalent compounds.
- 3.9 I can draw diagrams to represent ionic bonds.

Worksheet #1: Ionic vs. Covalent Compounds

Learning Target 3.1: I can compare and contrast the structure of ionic and covalent compounds and give examples of each.

An **atom** is the smallest amount of an **element** that has all of the properties of the element. For example, a gold wedding ring contains trillions upon trillions of gold atoms. There is only one element, gold, but the amount of gold is the total number of gold atoms. A compound is a combination of multiple atoms.

A **molecule** is the smallest amount of a **compound** that has all of the properties of the compound. For example, imagine a bucket of pure water (H_2O). The bucket contains only one compound, H_2O, but there trillions upon trillions of water molecules within the bucket.

1. What is the relationship between atoms and elements?

2. What is the relationship between molecules and compounds?

Compounds are held together by **chemical bonds**. There are many different types of chemical bonds. In this packet we will learn about **ionic bonds** and in the next packet we will learn about **covalent bonds**.
Ionic compounds are made of positive ions (metals) and negative ions (nonmetals). The attractions between these oppositely charged ions hold the compound together. Electrons get completely transferred from the metal to the nonmetal ion.
Covalent compounds are made of two nonmetals. These bonds are formed when two or more nonmetal atoms share electrons.

3. What do chemical bonds do?

4. What are ionic compounds made of?

5. What are covalent compounds made of?

6. Which bond shares electrons?

7. Which type transfers electrons?

8. Label each of the following compounds as ionic or covalent:

a. NaCl

b. MgO

c. SO_2

d. $GeCl_4$

e. H_2O (careful!)

BrainPOP: Chemical Bonds

Learning Target 3.1: I can compare and contrast the structure of ionic and covalent compounds and give examples of each.

Watch the video "Chemical Bonds" on brainpop.com
Username- northfarm Password- northfarm2015

1. Atoms are made of _____, _____ and _____.
2. Electrons move around the nucleus in _____.
3. The first shell holds _____ electrons and the second _____.
4. When an atom's outermost shell is completely full it is said to be _____ and won't _____ with other atoms.
5. When an atom's outermost shell is NOT full it is _____ and will try to react with other atoms so that it can have a _____ _____.
6. Hydrogen has _____ electron in its outer shell and wants to have a total of _____. Oxygen has _____ electrons and is looking for _____ more.
7. Oxygen shares a pair of _____ with one hydrogen atom and another pair with another _____. This sharing of electrons is called a _____ bond.
8. _____ bonds happen with one atom _____ an electron from another. The extra electron gives the first atom a _____ _____ and the other atom becomes _____ charged because it lost an electron. These _____ charges of ions attract.
9. On their own, sodium and chlorine atoms have totally different _____ than salt (sodium chloride).
10. Hydrogen and oxygen are both invisible, flammable _____. When they react they form water, a very stable _____.

Worksheet # 2-Naming Ionic Compounds

Learning Target 3.2: I can determine the number of atoms in a compound when given the formula
Learning Target 3.3: I can name ionic compounds when given the formulas.

At this point you have learned approximately 60 of the known elements on the periodic table. These elements will combine to form different compounds. This occurs both in nature as well as in a laboratory. In this packet you will learn how to name these compounds as well as describe them with formulas and diagrams. **A compound is a chemical combination of two or more different elements. It is a substance that has its own definite properties and is represented by a combination of symbols and numbers called a formula.** Remember that ionic compounds contain a metal and a nonmetal.

1. First name the metal.
2. Name the nonmetal, but change the ending to –ide.

The formula below represents potassium oxide. You will notice that there are tiny numbers that appear in the formula. These numbers are called subscripts. **Subscripts tell you the number of each atom in a compound.** For example

K_2O

subscript

Notice that there is no subscript after the oxygen. If a subscript is not written, assume that it is a one. That means that in the above compound there are two potassium atoms and one oxygen atom.

Give the name for the following compounds. Then determine the number of atoms by adding the subscripts.

Formula	Name	# atoms	Formula	Name	# atoms
CsF	Cesium Fluoride	2	NiS		
Rb_2O	Rubidium Oxide	3	$RaBr_2$		
Na_2S			Ag_2O		
$AlCl_3$			$NiBr_2$		
CaO			BaS		
MgS			$SrCl_2$		
K_2Te			CsI		
$CdCl_2$			CdF_2		
ZnO			BaO		
$AuCl_3$			AlI_3		

Worksheet #3: Writing Formulas for Ionic Compounds

Learning Target 3.2: I can determine the number of atoms in a compound when given the formula
Learning Target 3.4: I can write formulas for ionic compounds when given the names.

Ionic compounds contain ions: positive metal ions and negative nonmetal ions. **All compounds are neutral. This means that if we add up all of the positive ions they must equal all of the negative ions. The charge an element has in a compound in called an oxidation number.** The oxidation number is related to the number of electrons in the outermost shell of an atom. In order to write the formulas for compounds of metals and nonmetals you must use the oxidation numbers of each element.

Steps to follow.	Example: sodium oxide
1. Write the symbol for the metal with the oxidation number (or charge) of the metal as a *super*script	Na^{+1}
2. Write the symbol for the nonmetal with the oxidation number (or charge) of the nonmetal as a *super*script	O^{-2}
3. Switch the numbers and write them as *sub*scripts. (Notice that the subscripts do not get a +/-). We will refer to this as "Swap and Drop".	$Na^{+1}O^{-2}$  Na_2 O_1
4. If the subscript is one, you do not need to write it.	Na_2O
5. The subscripts tell you how many of each atom you have in the compound.	2 Na and 1 O combine to make sodium oxide.

Write the correct formula for the following ionic compounds.

Name	Symbols with oxidation #s	Formula (Swap and Drop)	# of atoms (add the subscripts)
potassium chloride	K^{+1} Cl^{-1}	KCl	2
sodium sulfide	Na^{+1} S^{-2}	Na_2S	3
magnesium iodide			
barium oxide			
cadmium sulfide			
aluminum oxide			
calcium nitride			
lithium fluoride			
sodium chloride			
cesium oxide			

Name	Symbols with oxidation #s	Formula (Swap/Drop)	# of atoms (add the subscripts)
nickel oxide			
aluminum bromide			
rubidium sulfide			
cesium sulfide			
beryllium iodide			
zinc telluride			
radium selenide			
sodium phosphide			
potassium iodide			
magnesium nitride			

More Practice with *Learning Target 3.2 and 3.3*

Name the following compounds and determine the number of atoms.

Formula	Name	# atoms (add the subscripts)	Formula	Name	# atoms (add the subscripts)
CsI	Cesium iodide	2	BeSe		
Na_2S	Sodium sulfide	3	RbI		
RaI_2			ZnTe		
Al_2N_3			$SrBr_2$		
CaO			$CoCl_2$		
Li_3P			Ag_2S		
KCl			BaO		
$NiBr_2$			Fr_2O		

Worksheet # 4-Calculating Oxidation Numbers

Learning Target 3.5: I can use Roman numerals to name ionic compounds that contain special metals when given the formulas.

The charge an element has in a compound in called an oxidation number. Many elements only have one possible oxidation number, but other elements have several possible oxidation numbers depending upon what they are combined with and the conditions under which they formed. Both metals and nonmetals may have more than one oxidation number. However, we will learn how to determine the oxidation numbers of the metals in a particular compound.

Remember that the total charge on any compound is zero. Therefore, if we know the oxidation number of one element in a compound we can figure out the oxidation number of the other element in the compound.

Let us first consider the compound with the formula CuCl. We can look on the periodic table and find that the oxidation number of chlorine is –1. We can use this to determine the oxidation of the Cu in CuCl. If the oxidation of Cl is –1 then we know the oxidation number of Cu must be +1. If we add the numbers together we see that they equal 0. This makes the compound neutral. Now lets try some that are a little more challenging.

Example: Bi_2O_3

Now we have 2 Bi and 3 O in this compound. We need to establish some steps to help you.

1. Divide the compound in half.

$Bi_2 \mid O_3$

2. Find the charge of the nonmetal (the element on the right) by looking on your periodic table. It is –2.
3. Multiply the charge by the number of atoms. In this case we have 3. So the charge on all of the oxygen atoms in this compound is –2.

(-2)(3)= -6

$Bi_2 \mid O_3$

4. If the right side of the compound its –6 so the left side of the compound must be +6 (remember it has to equal 0).
5. Since there are 2 Bi we know that both bismuth combined are equal to +6. But we need to know the oxidation number of one bismuth so we need to divide by the number of atoms in the compound.

(+6/2 atoms)=+3 (-2)(3atoms)= -6

$Bi_2 \mid O_3$

For each of the following compounds infer the oxidation number for an individual metal atom. The oxidation number on chlorine is –1 and the oxidation number for oxygen is –2.

Formula	Calculation	Charge of Metal	Formula	Calculation	Charge of Metal
NiO	+2÷1 = **+2** / -2 X 1 = -2 / Ni O	+2	PbO		
HgCl			PbO_2		
W_2O_5			SnO		
La_2O_3			SnO_2		
Sb_2O_3			U_2O_3		

Worksheet #5- Naming Multiple Oxidation Number Metals "Special Metals"

Learning Target 3.5: I can use Roman numerals to name ionic compounds that contain special metals when given the formulas.

Write the name and charges for the seven metals that we use which have multiple oxidation numbers.

Multiple Oxidation Number Metal	Lower Oxidation Number	Higher Oxidation Number
Copper (Cu)	+1	+2
Mercury (Hg)		
Iron (Fe)		
Tin (Sn)		
Lead (Pb)		
Antimony (Sb)		
Bismuth (Bi)		

Roman numerals are used to show which metal ion is in a particular compound. In order to name the following compounds

1) name the metal
2) write the oxidation number as a Roman Numeral in parenthesis
3) name the nonmetal with an –ide ending

Roman Numerals

I=1 II=2 III=3 IV=4 V=5

VI=6 VII= 7 VIII= 8 IX=9 X=10

Only use roman numerals with the 7 metals listed in the table!

Formula	Metal Oxidation Number	Name (use roman numerals)
CuCl	+1	Copper (I) Chloride
$CuCl_2$		
FeO		
Fe_2O_3		
SnS		
SnS_2		
PbO		
PbO_2		
SbF_3		
SbF_5		
$BiBr_3$		
$BiBr_5$		
Hg_2O		
HgO		

Worksheet #6 Writing Formulas for Multiple Oxidation Number Metals

Learning Target 3.6: I can write formulas for ionic compounds that contain special metals when given the names.

Other than the alkali metals (+1) and the alkaline earth metals (+2) most metals can have more than one oxidation number, their oxidation number depends upon what they are combined with and the conditions under which they were formed. We call these multiple oxidation number metals and we will work with seven.

We will now learn to write the formula for compounds that were named using roman numerals. The steps you follow are essentially the same as you did on worksheet #2. The exception is that the Roman Numeral represents the oxidation number for the metal and all you need to look up on the periodic table is the oxidation number of the nonmetal.

Name	Symbols with oxidation #s	Formula (Swap/Drop)	# of atoms (add subscripts)
copper(I) chloride	Cu^{+1} Cl^{-1}	CuCl	2
copper(II) bromide	Cu^{+2} Br^{-1}	$CuBr_2$	3
mercury(I) oxide			
mercury(II) sulfide			
iron(II) sulfide			
iron (III) iodide			
tin(II) fluoride			
tin(IV) oxide			
antimony(III) sulfide			
antimony(V) nitride			
lead(II) sulfide			
lead(IV) oxide			

Worksheet #7- Putting it all together: Ionic Compounds

Learning Target 3.7: I can write formulas and names for all ionic compounds when given a mixture of those with special metals and those without.

The following set contains a mixture of compounds. Some will require roman numerals and others will not.

1) Indicate which compounds have a special metal and will therefore need a roman numeral (RN).
2) Name each compound. For compounds with a "RN" be sure to calculate the oxidation number and use the roman numerals to name it.

Formula	RN?	Name	# of atoms (add subscripts)
Bi_2S_3	Yes	bismuth (III) sulfide	5
KCl	No	potassium chloride	2
Al_2O_3			
FeO			
RaI_2			
Na_3P			
Cu_3N			
Be_3As_2			
Rb_2Se			
SrTe			

Write the formulas for the following compounds.

Name	Symbols with oxidation #s	Formula (Swap/Drop)	# of atoms (add subscripts)
iron(II) nitride	$Fe^{+2}N^{-3}$	Fe_3N_2	5
barium bromide			
antimony(III) oxide			
potassium chloride			
tin(IV) sulfide			
aluminum iodide			

Worksheet #8: Describing Ionic Bonds

Learning Target 3.8: I can compare and contrast the properties (characteristics) of ionic and covalent compounds.

The ionic bond is formed by the attraction between oppositely charged ions. Ionic bonds are formed between metals and nonmetals. Remember that metal atoms lose one or more valence electrons in order to achieve a stable electron arrangement. When a metal atom loses electrons it forms a positive ion or **cation**. When nonmetals react they gain one or more electrons to reach a stable electron arrangement. When a nonmetal atom gains one or more electrons it forms a negative ion or **anion**. The metal cations donate electrons to the nonmetal anions so they stick together in an ionic compound. This means that **ionic bonds are formed by the complete transfer of one or more electrons.**

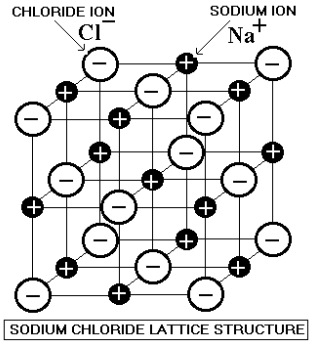
A structure with its particles arranged in a regular repeating pattern is called a **crystal**. Because opposite charges attract and like charges repel, the ions in an ionic compound stack up in a regular repeating pattern called a crystal lattice. The positive ions are pushed away from other positive ions and attracted to negative ions so this produces a regular arrangement of particles where each ion is surrounded by ions of the opposite charge. Each ion in the crystal has a strong electrical attraction to its oppositely charged neighbors so the whole crystal holds together as one giant unit. We have no individual molecules in ionic compounds, just the regular stacking of positive and negative ions.

9. Define the following terms:
   a) ionic bond –

   b) cation –

   c) anion –

   d) crystal –



SODIUM CHLORIDE LATTICE STRUCTURE

The following paragraph describes the properties (characteristics) that describe ionic bonds. At room temperature ionic compounds are high melting point solids. They are usually white except for compounds of the transition metals that may be colored. They are brittle (break easily). They do not conduct electricity as solids, but do conduct electricity when melted or dissolved in water.

10. List several properties of ionic compounds:

11. When can electricity to be conducted in an ionic bond?

Worksheet #9: Describing Covalent Bonds

Learning Target 3.8: I can compare and contrast the properties (characteristics) of ionic and covalent compounds.

A covalent bond is formed between nonmetal atoms. The nonmetals are connected by a shared pair of valence electrons. Remember, nonmetals want to gain valence electrons to reach a stable arrangement. If there are no metal atoms around to give them electrons, nonmetal atoms share their valence electrons with other nonmetal atoms. Since the two atoms are using the same electrons they are stuck to each other in a neutral particle called a molecule. **A molecule is a neutral particle of two or more atoms bonded to each other.** Molecules may contain atoms of the same element such as N_2, O_2, and Cl_2 or they may contain atoms of different elements like H_2O, NH_3, or $C_6H_{12}O_6$. Therefore, covalent bonding is found in nonmetallic elements and in nonmetallic compounds.

Covalent bonds are **intramolecular forces**; that is, **they are inside the molecule and hold the atoms together to make the molecule**. Covalent bonds are strong bonds and it is difficult and requires a lot of energy to break a molecule apart into its atoms. However, since molecules are neutral one molecule does not have a strong electrical attraction for another molecule. **The attractions between molecules are called intermolecular forces** and these are weak forces.

The following paragraph describes the properties (characteristics) that describe covalent bonds. Covalent substances have low melting points and boiling points compared to ionic compounds or metals. At room temperature, covalent substances are gases, liquids or low melting point solids. They do not conduct electricity as solids or when molten and usually do not conduct when dissolved in water.

1. Define the following terms:
   a) covalent bond –

   b) molecule –

   c) intramolecular force–

   d) intermolecular force–

2. List several properties of covalent compounds.

Worksheet #10: Drawing Ionic Bonds

Learning Target 3.9: I can draw diagrams to represent ionic bonds.

Remember: *Ionic bonds form between POSITIVE IONS and NEGATIVE IONS. Ionic bonding is when one of the atoms is donating an electron(s) (the cation) and one of atoms is accepting an electron(s) (the anion). The electrons are not shared, the anion gains an electron(s) to achieve a full valence and the cation loses an electron(s) to achieve a full valence.*

Diagram the ionic bonding process from neutral atoms to ions showing the valence electrons and indicating with arrows the direction in which the electrons are going. Write your final answer in the box.

Ex: sodium nitride (Na_3N)

1. sodium chloride (NaCl)

2. barium oxide (BaO)

3. magnesium chloride ($MgCl_2$)

4. calcium chloride ($CaCl_2$)

5. potassium fluoride (KF)

6. sodium oxide (Na_2O)

7. aluminum chloride ($AlCl_3$)

8. rubidium oxide (Rb_2O)

Worksheet #11: Ionic Compounds Review Sheet

LT 3.2, 3.3, 3.5 and 3.7 In the following table go through and "RN" all of the compounds, which contain special metals. Then write the name of the following compounds using roman numerals ONLY when a special metal is present.

Formula	RN?	Name	# of atoms (add the subscripts)	Formula	RN?	Name	# of atoms (add the subscripts)
Fe_2S_3	Yes	iron (III) sulfide	5	Rb_3N			
NaCl	No	sodium chloride	2	FeP			
Bi_2O_5				Mg_3As_2			
PbO				Ca_3N_2			
BaF_2				Hg_2S			

LT 3.4, 3.6 and 3.7 Write the formulas for the following compounds.

Name	Symbols with oxidation #s (optional)	Formula (Swap & Drop)	Name	Symbols with oxidation #s (optional)	Formula (Swap & Drop)
iron(III) sulfide	$Fe^{+3}S^{-2}$	Fe_2S_3	potassium chloride		
francium iodide			bismuth(V) arsenide		
copper(II) nitride			strontium selenide		
beryllium phosphide			lithium telluride		
radium fluoride			tin(IV) oxide		
antimony(V) oxide			aluminum bromide		

Worksheet #11 Continued

LT 3.9 Draw diagrams for the following compounds.

a) potassium iodide (KI)

b) calcium iodide (CaI_2)

c) aluminum fluoride (AlF_3)

d) magnesium nitride (Mg_3N_2)

e) sodium oxide (Na_2O)

f) calcium bromide ($CaBr_2$)

Learning Target 3.1 Short Answer Question: Describe the difference between the structures of ionic and covalent compounds.

(Use the following terms: metal, non-metal, share, transfer, electrons, opposite charge, attraction)

Learning Target 3.8 Short Answer Question: Describe the different between the properties of ionic and covalent compounds.

(Use the following terms: solid, liquid, gas, high/low melting point, brittle, conduct electricity)