Name:

Atoms, Ions, and Compounds

Part I: A. Electron Dot Structures

When atoms of metals in groups 1, 2, or 3 react with atoms of nonmetals in groups 15, 16, and 17, the metals lose electrons and the nonmetals gain electrons in their valence shells. We can predict the number of electrons lost or gained by analyzing the electron dot structures of the atoms. In an electron dot structure, the valence electrons are represented as dots around the symbol of the atom. For example, aluminum, electron arrangement 2-8-3, has three valence electrons and an electron dot structure with three dots. Chlorine, electron arrangement 2-8-7, has seven valence electrons and an electron dot structure with seven dots.

Main group metals (Group A elements) with 1, 2, or 3 valence electrons lose their valence electrons. For example, an aluminum atom loses its three valence electrons. Because Al loses three electrons to reach stability, it acquires an ionic charge of 3+. It is now an aluminum ion with a new electron arrangement of 2,8, which means that it is stable. Positive ions keep the same name as the element.

	Aluminum atom	Aluminum ion	
Symbol	Al	Al^{3+}	
Electron arrangement	2-8-3	2-8	(Electrons lost)
Number of protons	13 p	13 p	(Same)
Number of electrons	13 e -	10e -	(Three fewer electrons)
Net ionic charge	0	3+	

Al^{+3}

When nonmetals with 5, 6, or 7 valence electrons combine with metals, they gain electrons to become stable, and form negatively charged ions. For example, a chlorine atom gains one valence electron to become stable with an electron arrangement of 2-8-8. With the addition of one electron, chlorine become a chloride ion with an ionic charge of 1-. When naming binary compounds (two different elements), the name of the negative ion ends in -ide.

	Chlorine atom	Chloride ion	
Symbol	Cl	Cl^-	
Electron arrangement	2-8-7	2-8-8	(Electron added)
Number of protons	17 p	17 p	(Same)
Number of electrons	17e -	18 e -	(One more electron)
Net ionic charge	0	1-	

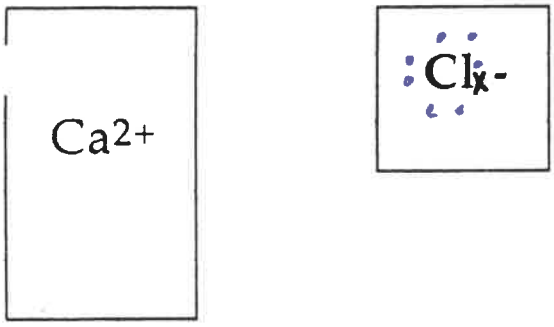
On the next page write the electron structures for atoms and their ions. Write the symbol, ionic charge, and name of each ion.

B. Writing ionic Formulas

The group number on the periodic table can be used to determine the ionic charges of elements in each family of elements. (Just drop the 1 before 13, 14,15, 16 and 17 to determine the number of valence electrons) . Nonmetals only form ions if they combine with a metal.

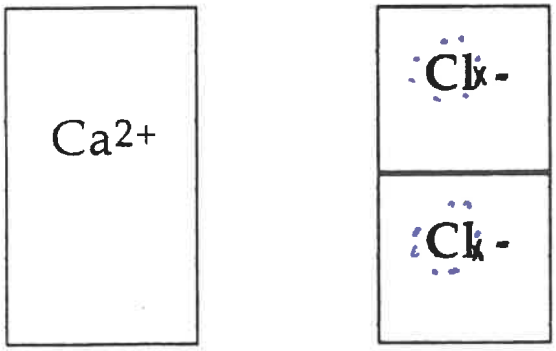
Group number	1	2	13	14	15	16	17
Valence electrons	1e -	2e -	3 e-	4 e-	5 e-	6 e-	7 e-
Change	lose	lose	lose	none	gain	gain	gain
Ionic charge	1+	2+	3+	none	3 -	2 -	1 -

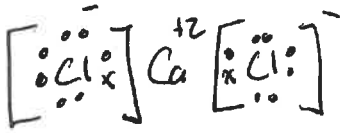
In an ionic formula, the total loss and gain of electrons is equal. The overall net charge is zero. This means that the total amount of positive charge must be made equal to the total amount of negative charge. To balance charge, we determine the smallest number of positive and negative ions that give an overall charge of zero (O). We can illustrate the process by showing the ions Ca^{2+} and Cl^- as geometric shapes that represent the amount of ionic charge.



The charge is balanced by using two Cl^- ions to match the shape of the Ca^{2+}. Charge balance occurs with one(1) calcium ion and two (2) chloride ions. This is shown as subscripts in the formula $CaCl_2$. The subscript 1 for Ca is understood. Note that only the symbols are written in the formula, not their ionic charges.

Balancing the amount of ionic charge



$= CaCl_2 =$ 

The brackets around the non-metal show it has Gained electrons

Draw the e⁻ Dot structures, write the formula & name them

1. lithium and iodine Formula _____ Name _____	2. calcium and iodine Formula _____ Name _____	3. magnesium and sulfur Formula _____ Name _____
4. sodium and oxygen Formula _____ Name _____	5. aluminum and chlorine Formula _____ Name _____	6. aluminum and phosphorus Formula _____ Name _____
7. calcium and sulfur Formula _____ Name _____	8. potassium and oxygen Formula _____ Name _____	9. lithium and bromine Formula _____ Name _____

10. magnesium and bromine	11. calcium and oxygen	12. potassium and sulfur
Formula _____	Formula _____	Formula _____
Name _____	Name _____	Name _____

C. Give the formula for each of the following ionic compounds.

1. calcium nitride _____
2. aluminum phosphide _____
3. aluminum sulfide _____
4. sodium chloride _____
5. potassium oxide _____
6. calcium chloride _____
7. lithium fluoride _____
8. sodium bromide _____
9. potassium oxide _____
10. magnesium iodide _____

D. Name the following ionic compounds.

1. Na_2O _____
2. MgF_2 _____
3. MgS _____
4. K_3N _____
5. Ca_3P_2 _____
6. AlF_3 _____
7. LiCl _____
8. MgO _____
9. Al_2O_3 _____
10. KI _____

E. When is an ionic bond formed? _____

Which groups tend to form ionic bonds? _____

A. Transition Metals

Most of the transition metals form ions that have two or more positive ionic charges. We will illustrate variable valence with iron. Iron forms two ions, one (Fe^{2+}) with a 2+ charge, and another (Fe^{3+}) with a 3+ charge. To distinguish between the two ions, the element name is followed by a Roman numeral that gives the ionic charge of that particular ion. The Roman numeral is always included in the names of compound with variable positive ions. In an older naming system, the ending -ous indicates the lower valence; the ending -ic indicates the higher one.

Ions	Names	Formula of Compound	Name
Fe^{2+}	iron (II) ion or ferrous ion	$FeCl_2$	iron (II) chloride or ferrous chloride
Fe^{3+}	iron (III) ion or ferric ion	$FeCl_3$	iron (III) chloride or ferric chloride
Cu^{1+}	copper (I) ion or cuprous ion	CuCl	copper (I) chloride or cuprous chloride
Cu^{2+}	copper (II) ion or cupric ion	$CuCl_2$	copper (II) chloride or cupric chloride

other combinations you must know are Pb^{2+} and Pb^{4+}, Sn^{2+} and Sn^{4+}, Hg_2^{2+} and Hg^{2+}.

Among the transition metals, a few elements namely zinc, silver and cadmium form only a single type of ion; they have fixed ionic charges. Thus, they are not variable and do not use a Roman numeral in their names.

Zn^{2+}	zinc ion
Ag^{+}	silver ion
Cd^{2+}	cadmium ion

Complete the following chart.

Name	Positive Ion	Negative Ion	Formula
iron (II) chloride			
	Fe^{2+} or Fe^{3+}	Br^-	
			$CuCl_2$
cupric sulfide = Copper(II) Sulfide			
	Cu^{1+}	N^{3-}	
			Ag_2S
zinc oxide			
	Pb^{2+}	P^{3-}	
			PbO_2

PART 3 : Polyatomic ions

When an ionic compound consists of three or more kinds of atoms, there is a positive ion (usually a metal), and a group of nonmetals called a polyatomic ion. A polyatomic ion is a group of atoms (nonmetals) with an overall charge. That charge, which is usually negative, is the result of adding electrons (1, 2, or 3) to that group of atoms to complete octets. The most common polyatomic ions consist of the nonmetals C, N, S, P, Cl or Br combined with two to four oxygen atoms. Some examples are given below. The ions are named by replacing the ending of the nonmetal with -ate or -ite. The most common form of the ion takes the ate ending; the ite ending has one less oxygen. A complete list is found on your reference tables. Ammonium ion, NH^{4+}, is positive because its group of atoms lost one electron.

To write the correct formula of a compound with a polyatomic ion, determine the ions required to achieve charge balance just as we did earlier. When two or more polyatomic ions are needed, enclose the formula of the ion in parenthesis, and write the subscript outside. No change is made in the formula of the polyatomic ion itself: Consider the formula of the compound formed by Ca^{2+} and NO^{3-} ions.

Ions	Formula	Name
Ca^{2+} NO_3^- NO_3^-	$Ca(NO_3)_2$	Calcium nitrate

Determine the positive ions and negative polyatomic ions needed for charge balance. Write the formula using parentheses if necessary. Name the compounds listed using the correct names of the polyatomic ions.

Name	positive ion	negative ion	Formula
sodium ~~nitite~~ nitrite			
	Li^{1+}	CO_3^{2-}	
			K_2SO_4
calcium hydrogen carbonate			
	Al^{3+}	OH^{1-}	
			$Pb_3(PO_4)_2$
plumbic sulfate or Lead(IV) sulfate			
	Mg^{2+}	CH_3COO^{1-}	
			$Ca(ClO_2)_2$
ammonium sulfite			
	Cu^{2+}	ClO_3^{1-}	