Elements and Compounds.

Goals

To practice naming and classifying elements and compounds

Background

Properties of Elements

Elements on the periodic table can be classified as metals, nonmetals or metalloids. The zigzag line on the table separates the metals from the nonmetals. The metals make up over 75% of known elements and are found on the lower left side of the table. **Metals** are shiny, good conductors of heat and electricity, and malleable (can be pounded into sheets). Nonmetals are found on the upper right corner of the periodic table. **Nonmetals** are dull, poor conductors of heat and electricity, and brittle. Metalloids, or semi-metals are located on the zigzag line of the periodic table. Aluminum touches the line, but is considered a metal. **Metalloids** have properties that are intermediate between metals and nonmetals. They tend to be shiny, brittle, and average conductors of heat and electricity.

1 **1A**	2 **2A**	3	4	5	6	7	8	9	10	11	12	13 **3A**	14 **4A**	15 **5A**	16 **6A**	17 **7A**	18 **8A**
Alkali Metals																	*Nobel Gases*
1 H **Hydrogen**	*Alkaline Earth Metals*															*Halogens*	2 He **Helium**
3 Li Lithium	4 Be Berylium				Metal		Mettalloid		**Nonmetal**			5 B Boron	6 C **Carbon**	7 N **Nitrogen**	8 O **Oxygen**	9 F **Fluorine**	10 Ne **Neon**
11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P **Phosphorus**	16 S **Sulfur**	17 Cl **Chlorine**	18 Ar **Argon**
19 K Potasium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se **Selenium**	35 Br **Bromine**	36 Kr **Krypton**
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I **Iodine**	54 Xe **Xenon**
55 Cs Cesium	56 Ba Barium	57-71 La-Lu	72 Hf Halfnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn **Radon**

Transition Metals

Elements can also be categorized by their group. The word periodic refers to the fact that properties of elements in the table repeat. Elements are arranged in columns, or groups, on the periodic table where all elements in the group have similar properties. For instance, all elements in group 8A, the **noble gasses**, are unreactive. Elements in group 1A, the **alkali metals**, are highly reactive and produce hydrogen when mixed with water. Other named groups include the **alkaline earth metals** (2A), the **halogens** (7A), and the **transition metals** (elements in the block between 2A and 3A).

Compounds

When two or more elements come together, a chemical compound is formed.

Naming Compounds

Many everyday compounds have common names. For example, water is the common name for H_2O, baking soda is the common name for $NaHCO_3$. However, there are too many compounds (80 million +) for memorizing common names to be practical so chemists have developed rules for naming. In this exercise you will practice rules for naming simple ionic and covalent compounds and learn to predict the ratios that chemicals combine in based on their ionic charge.

<u>Ionic Compounds with Metal Charges that Do Not Vary</u>

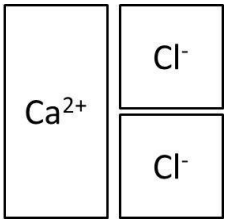
Simple ionic compounds are formed from metal and nonmetal ions. The metal is the cation, or positively charged ion and the nonmetal is the anion, or negatively charged ion. In the chemical formula, the cation is always written first and the anion is written second. Cations with charges that don't vary include Group 1A alkali metals, which always form 1+ cations and Group 2A alkaline earth metals which always form 2+ cations, and Group 3A metals, which always form 3+ ions.

1 1A	2 2A	3	4	5	6	7	8	9	10	11	12	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
H 1+ / 1-																	He
Li 1+	Be 2+				Fixed charges No Roman		Variable charges Roman		no ionic bonding or radioactive			B 3+	C	N 3-	O 2-	F 1-	Ne
Na 1+	Mg 2+											Al 3+	Si	P 3-	S 2-	Cl 1-	Ar
K 1+	Ca 2+	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn 2+	Ga 3+	Ge	As 3-	Se 2-	Br 1-	Kr
Rb 1+	Sr 2+	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag 1+	Cd 2+	In 3+	Sn	Sb 3-	Te 2-	I 1-	Xe
Cs 1+	Ba 2+	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl 3+	Pb	Bi	Po	At	Rn

To name this type of ionic compound, the cation gets written first using its full element name. The anion is written second using the stem of its element name and adding an "ide" ending. For instance, fluorine becomes fluoride and oxygen becomes oxide.

Examples: NaCl sodium chloride $MgBr_2$ magnesium bromide

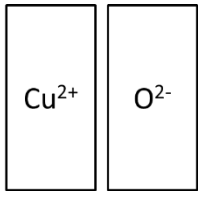
Ionic compounds are electronically neutral, meaning the charges on the anions and cations balance to zero. To determine a formula from a chemical name, you must first determine the charges on the ions in the compound and then figure out how many of each are needed to balance the charges. For instance calcium chloride is made of Ca^{2+} and Cl^- ions. For the charges to balance there needs to be two Cl^- ions, therefore the formula is $CaCl_2$.



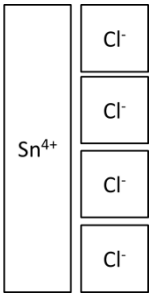
Ionic Compounds with Metal Charges that Vary

Some metals can form ions with different charges. For instance, iron in ionic compounds is found as both Fe^{2+} and Fe^{3+}. Metals with charges that vary include most transition metals (zinc, cadmium and silver are exceptions) plus tin and lead. Since more than one charge is possible, more than one chemical formula is possible. Iron can form two compounds with chlorine: Fe^{2+} forms $FeCl_2$, Fe^{3+} forms $FeCl_3$. These two different compounds have different physical and chemical properties. For example, $FeCl_2$ has a melting point of 306° C, while $FeCl_3$ melts at 677° C. Therefore, we cannot simply call both compounds "iron chloride."

When naming compounds with metal that have variable charge, a roman numeral in parentheses is written after the metal name and indicates the charge on the metal. For instance, Fe^{2+} is called iron (II) and Fe^{3+} is called iron (III). The anion is written as the "ide" form of the element.



When starting with the formula, the charge of the metal has to be deduced from the anion charge. The formula **CuO** indicates one atom of oxygen carrying a 2- charge. In order for the charges to sum to zero, the copper atom must have a 2+. Therefore the name is **copper (II) oxide**.



The formula **$SnCl_4$** has 4 chloride ions, each with a 1- charge, so the total negative charge is 4-. The charge on the tin must be 4+, so the compound is named **tin (IV) chloride**.

Ionic Compounds with Polyatomic Ions

Polyatomic ions are ions composed of two or more covalently bonded atoms that can be thought of as a single unit carrying a charge. Ionic compounds that have three or more elements are generally composed of a metal cation and polyatomic anion. Ammonium (NH_4^+) is the only common polyatomic cation. The names, formulas and charges of polyatomic ions must be memorized (see table of common polyatomic ions below). Ionic compounds with polyatomic

ions get named in the same way as Type I and II binary ionic compounds with the name of the polyatomic ion in the place of the anion name. If more than one polyatomic ion is needed to balance the charges, the whole ion gets put in parentheses.

Examples: Li_2CO_3 lithium carbonate $Pb(NO_3)_2$ lead (II) nitrate
NH_4Cl ammonium chloride

carbonate	CO_3^{2-}	nitrate	NO_3^-	hypochlorite	ClO^{1-}
hydrogen carbonate	HCO_3^{1-}	nitrite	NO_2^-	chlorite	ClO_2^{1-}
hydroxide	OH^{1-}	sulfate	SO_4^{2-}	chlorate	ClO_3^{1-}
cyanide	CN^{1-}	sulfite	SO_3^{2-}	perchlorate	ClO_4^{1-}
ammonium	NH_4^+			phosphate	PO_4^{3-}

Covalent (Molecular) Compounds

Covalent compounds are made of two or more nonmetals, as opposed to a metal and a nonmetal. The system for naming covalent compounds is different from the one for ionic compounds and it is important to keep the two systems separate.

To name a covalent compound, the first element is written as its element name, the second element is written as its "ide" form, and both elements get a prefix that indicates the number of each element in a compound. If the prefix of the first element is mono, the prefix is dropped.

Examples: P_2S_5 diphosphorus pentasulfide
N_2O dinitrogen monoxide
NO_2 nitrogen dioxide

Prefixes			
1	mono-	6	hexa-
2	di-	7	hepta
3	tri-	8	octa-
4	tetra-	9	nona-
5	penta-	10	deca-

Materials: element vials samples of Cu, Zn, C, Si conductivity probe

Procedure

A. Properties of Elements

1. Observe the properties of various element samples in the labeled bottles. Completely fill out the element properties table in the data sheet. If an element does not belong to a named group, write the group number (ex 4A) in the last column.

2. Touch the two wire ends of the conductivity probe to the four elements in the conductivity table. If the LED lights, the circuit was completed meaning that the element conducts electricity.

B. Naming Compounds

3. Ionic Naming: Find the bag of ions in the lab corresponding to that number. Layout the minimum number of each ion such that the charges (height) match. Write the correct formula based on that ratio of ions and write the systematic name. Return ions to the bag. Covalent naming - fill in the table

Name_____

Team Name _____

CHM101 Lab – Elements and Compounds – Grading Rubric

To participate in this lab you must have splash-proof goggles, proper shoes and attire.

Criteria	Points possible	Points earned
Followed procedure correctly without depending too much on instructor or lab partner. Safety and proper waste disposal procedures observed. Work space and glassware was cleaned up	3	
Part A (elements)	6	
Part A (conductivity)	2	
Part B (Ionic)	6	
Part B (Covalent)	3	
Total	20	

Subject to additional penalties at the discretion of the instructor.

A. Properties of Elements

	Look up on the periodic table:				Observe in samples:	
Element	Symbol	Atomic Number	Metal, nonmetal or metalloid?	Group Name (or number if none)	Color	Shiny or Dull?
Aluminum				13/3A		
Bismuth						
Carbon						
Copper				transition metal		
Helium						
Iodine						
Magnesium						
Mercury						
Nickel						
Oxygen						
Silicon						
Sulfur						
Tin						
Zinc						

Element	Metal, nonmetal or metalloid?	Predict if it will conduct based on periodic trends (Y/N)	Experimental results (did it conduct in your experiment? Y/N)
Silicon			
Copper			
Sulfur			
Zinc			

B. Complete the following table for ionic compounds

	Formula	**cation**	**anion**	**Name**
	Al_2O_3	Al^{3+}	O^{2-}	aluminum oxide example
	$Cu(NO_3)_2$	Cu^{2+}	NO_3^{1-}	copper (II) nitrate example
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.	K_3P			
10.				magnesium nitrate
11.	$FeSO_4$			
12.				gold (I) selenide

Complete the following table of covalent compounds

Formula	**Name**
NO_2	nitrogen dioxide example
SO_2	
	diphosphorus pentoxide
CBr_4	
	oxygen difluoride
N_2O	
N_2Cl_4	