Activity 8 – Chemical Names and Formulas[1]

Goals

- Write chemical names and formulas of common chemical compounds.
- Describe the colors and textures of common ionic compounds.
- Synthesize chemical compounds and write their names and formulas.

Pre-Lab Lecture Questions. *Answer these questions on a separate sheet using complete sentences.*

1. What is an ion? What is an ionic compound? How can we recognize ionic compounds? What is a salt?
2. Compare cations, anions and polyatomic ions. What do they all have in common? How are they different?
3. How can the periodic table help to remember the charges on the simple ions of the representative (main group) elements?
4. What is the chemical name of baking soda? Is there more than one name that can be used?
5. Why do some cation names include Roman numerals in parentheses?
6. Why do some chemical formulas include parentheses and others do not?
7. What is the precipitate formed when iron (III) chloride reacts with silver nitrate?

Concepts to Review

Names of Elements
Periodic Table
Atomic Structure
Transition Elements, Representative Elements

Introduction

Chemistry is the central science, a study of all that has mass and volume. An effort of this magnitude requires a clear language that communicates in a broad but consistent way. At first appearance, chemistry may appear difficult because there are common words that take on new meaning. For example, "salt" is a term widely used to describe table salt (also known as sodium chloride). In chemistry, a **salt** is simply **any compound composed of ions other than hydrogen ion, oxide ion, or hydroxide ion**. Sodium chloride is an example of a salt, as is potassium chloride, calcium carbonate and stannous fluoride. In chemistry, there is an effort to move away from using common names to identify the majority of compounds because this would require memorization of every single name. Considering the vast number of ionic compounds (over a million), a systematic method of nomenclature has been developed to designate these.

As a student of chemistry you will learn how to translate a chemical formula into the systematic name and vice versa. The observations and experiments in today's lab only involve compounds containing charged species—cations, anions and polyatomic ions. The various combinations of oppositely charged ions are called **ionic compounds.** Their chemical formulas represent the proportion of positive ion to negative ion that results in electrical neutrality, i.e., no net charge. The correct chemical formula for sodium chloride is NaCl. The 1:1 ratio of sodium to chloride ions tells us that sodium ions and chloride ions must have the same charge magnitude. (Note that when there is only one of an ion per formula, we do not use the number one as subscript to indicate this; i.e., we don't write Na_1Cl_1.) After looking at the table on the following page, we see that sodium is a cation with a 1+ charge and chloride is an anion with a 1- charge. Knowing both the magnitude and the sign of the charge is necessary for writing the correct formulas and the correct chemical names. Sodium oxide has a formula of Na_2O. Without looking at the table of ions, what must the charge of oxide be? If you recognized that there are two sodium 1+ ions for each oxide ion and deduced that oxide must have a 2- charge you are well on your way to describing ionic compounds!

It is common to see **precipitates** in the chemical reactions of ionic compounds in solution, i.e. insoluble solids coming out of solution. *A general rule is that precipitates usually do not contain sodium, potassium, acetate, nitrate or sulfate ions.*

Table 1. A Collection of Common Ions.

Name	Formula	Name	Formula	Name	Formula

[1] Adapted from: Waterman, E. L. *Chemistry: Small-Scale Chemistry Laboratory Manual;* Addison-Wesley/Prentice-Hall, Inc.: Upper Saddle River, New Jersey, 2002; pp 51-58.

Sodium	Na^+	Magnesium	Mg^{2+}		
Potassium	K^+	Calcium	Ca^{2+}		
Copper (I)	Cu^+	Copper (II)	Cu^{2+}		
Silver	Ag^+	Iron (II)	Fe^{2+}	Iron (III)	Fe^{3+}
Ammonium	NH_4^+	Lead (II)	Pb^{2+}	Lead (IV)	Pb^{4+}
		Tin (II)	Sn^{2+}	Tin (IV)	Sn^{4+}

Fluoride	F^-	Oxide	O^{2-}	Nitride	N^{3-}
Chloride	Cl^-	Sulfide	S^{2-}		
Bromide	Br^-	Sulfate	SO_4^{2-}		
Iodide	I^-				
Acetate	$C_2H_3O_2^-$				
Hydroxide	OH^-				
Nitrate	NO_3^-				
Nitrite	NO_2^-				
Hydrogen carbonate (**bicarbonate**)	HCO_3^-	Carbonate	CO_3^{2-}		
Dihydrogen phosphate	$H_2PO_4^-$	Hydrogen phosphate	HPO_4^{2-}	Phosphate	PO_4^{3-}

Safety

Wear safety glasses at all times!
Act in accordance with the laboratory safety rules of Cabrillo College.
Avoid contact with all chemical reagents and dispose of reactions using appropriate waste containers.

Contact with silver nitrate ($AgNO_3$) will stain the skin.

Materials

Reagent Central chemicals include a variety of pure ionic compounds and aqueous solutions of ionic compounds as identified on your experimental pages.

Equipment: Empty pipet for stirring Lab top reaction surface

Experimental Procedure

A. Compound Observations

1. View the samples of solid compounds available at Reagent Central. Write a description of the color and any other adjectives that might distinguish one compound from another. If the formula is given on the data sheet, provide the correct name. If the name is given, write the correct formula. Record observations and answers in your laboratory notebook and/or the data page provided.

B. Precipitation Reactions

1. Insert your experimental page inside of your reaction surface.
2. Place one drop of each solution in the indicated spaces below, taking care not to contaminate the microburets. Stir by blowing air from a dry pipet. Record any observable changes, describing what happened when the two solutions were mixed.

3. Any precipitates represent new compounds formed from swapping ion partners. Write the correct formulas for the two possible products. The precipitate will be the product that doesn't contain sodium, potassium, or nitrate ions. Write the name and formula of the precipitate on your worksheet.

Reaction Template: Insert this page into the labtop. Mix one drop of each solution, using a long stem pipet to blow air past the droplet to complete the mixing.

	$AgNO_3$	$Pb(NO_3)_2$	$CuSO_4$	$MgSO_4$	$FeCl_3$
$FeCl_3$	AgNO3 + FeCl3	X			
KI	X	X			
NaOH	X	X	X	X	X
Na_2CO_3	X	X	X	X	X
Na_3PO_4	X	X	X	X	X

$AgNO_3 + FeCl_3 \longrightarrow$ products

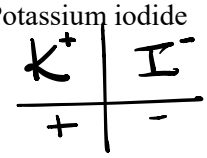
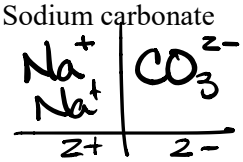
Activity 8 - Chemical Names and Formulas Worksheet

Name_____

Section_____ **Date**_____

Exercise A. Compound Names and Formulas

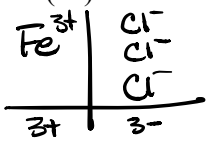
1. Provide the missing formula or name (translate the words to a chemical formula, or vice versa). **Remember to "criss-cross the charges,"** to ensure the correct subscripts on each ion in the formula.

Compound Name	**Formula**	**Compound Name**	**Formula**
Potassium iodide 	KI	Sodium carbonate 	Na_2CO_3
Sodium chloride		Lead (II) nitrate	
Magnesium sulfate		Sodium acetate	
Copper (II) sulfate		Ammonium chloride	
$NaHCO_3$		$CaCl_2$	
$AgNO_3$		$FeCl_3$	
KF		NaH_2PO_4	

Exercise B. More practice with ionic compounds' names and formulas.

1. Write the chemical formula for each of the compounds below:

Solution	**Formula**
Silver nitrate	$AgNO_3(aq)$
Iron (III) chloride	$FeCl_3(aq)$
Sodium hydroxide	
Sodium carbonate	
Sodium phosphate	
Lead (II) nitrate	
Copper (II) sulfate	
Magnesium sulfate	
Potassium Iodide	



2. " Mix and match," or "swap" the ions in the compounds below, to predict the two resulting products.

Reaction	Complete the reaction: write the 2 resulting products
(1) $AgNO_3(aq) + FeCl_3(aq)$	$AgCl_{(s)} + Fe(NO_3)_{(aq)}$
$AgNO_3(aq) + KI(aq)$	
$AgNO_3(aq) + NaOH(aq)$	
$AgNO_3(aq) + Na_2CO_3(aq)$	
$AgNO_3(aq) + Na_3PO_4(aq)$	
$Pb(NO_3)_2(aq) + FeCl_3(aq)$	
$Pb(NO_3)_2(aq) + KI(aq)$	
$Pb(NO_3)_2(aq) + NaOH(aq)$	
$Pb(NO_3)_2(aq) + Na_2CO_3(aq)$	
$Pb(NO_3)_2(aq) + Na_3PO_4(aq)$	
$CuSO_4(aq) + NaOH(aq)$	
$CuSO_4(aq) + Na_2CO_3(aq)$	
* $CuSO_4(aq) + Na_3PO_4(aq)$	$Cu_3(PO_4)_{2(s)} + Na_2SO_{4(aq)}$
$MgSO_4(aq) + NaOH(aq)$	
$MgSO_4(aq) + Na_2CO_3(aq)$	
$MgSO_4(aq) + Na_3PO_4(aq)$	
$FeCl_3(aq) + NaOH(aq)$	
$FeCl_3(aq) + Na_2CO_3(aq)$	
$FeCl_3(aq) + Na_3PO_4(aq)$	

Questions and Problems

1. Write the formulas (including charges) and names of all the **cations** represented in this experiment (you may need to refer to page 2 of this lab to see the charges on some of the polyatomic ions).

Fe^{3+} , Na^{+}
Iron(III) , Sodium , . . .

2. Write the formulas (including charges) and names of all the **anions** represented in this experiment (you may need to refer to page 2 of this lab to see the charges on some of the polyatomic ions).

CO_3^{2-} Cl^{-}
Carbonate , Chloride , . . .

3. Write a simple rule for naming ionic compounds (which element comes first, when/how do element names change).

-ide

4. Write a simple rule for writing chemical formulas of ionic compounds (order of elements, meaning of subscripts).

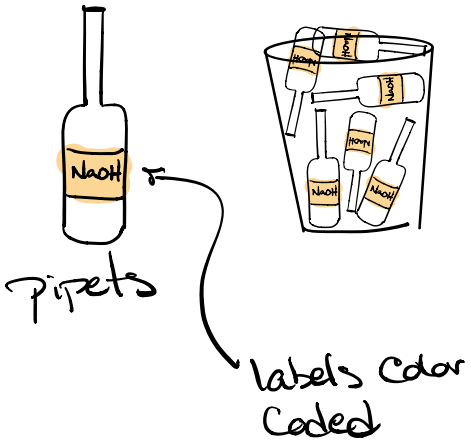
5. When are Roman numerals used in naming compounds? ex. Iron (III)

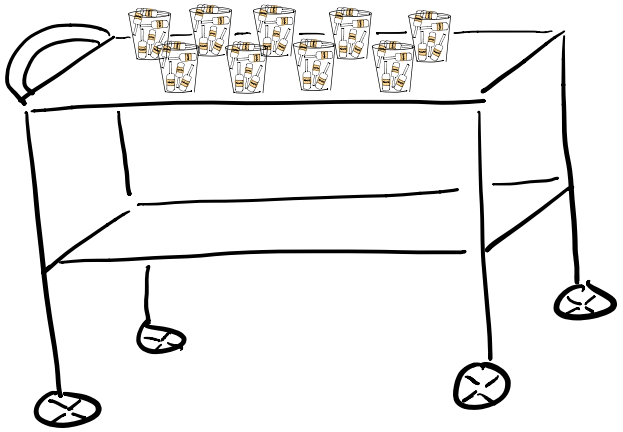
6. What does a numerical subscript following an element in a chemical formula mean? Na_2SO_4 $Cu_3(PO_4)_2$

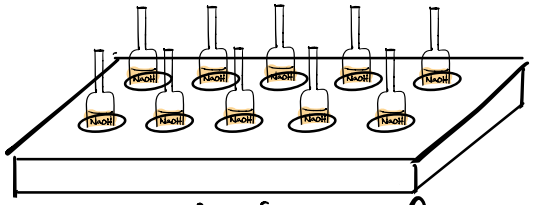
7. When is it correct to use parentheses in chemical <u>formulas</u>? $Cu_3(PO_4)_2$

Small Scale Chemistry

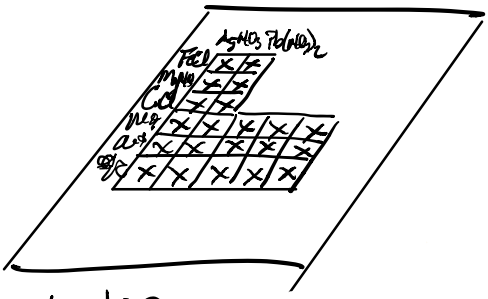
Done using droppers of Chemicals on open surface. The surface is plastic & the chemicals bead up on the surface. Clean up is with microtowels & water.





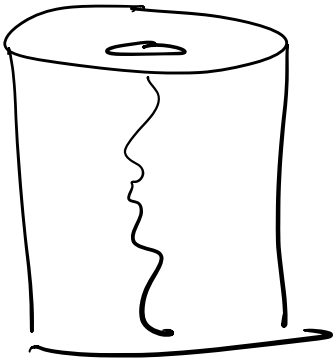


Collect Chemicals into tray to take back to desk

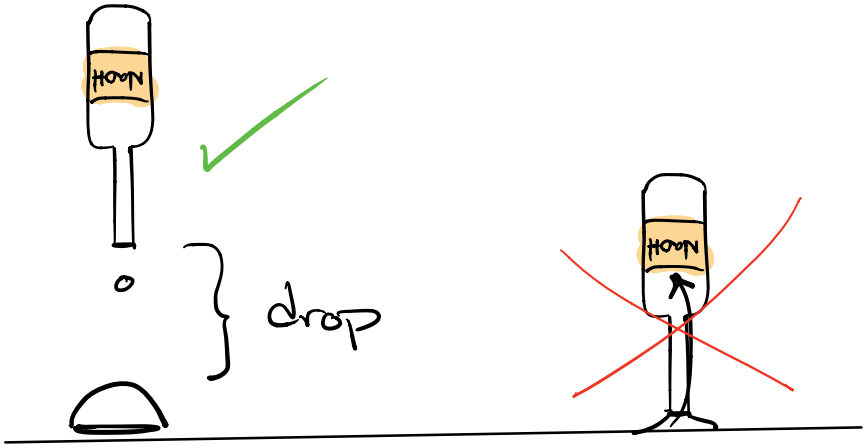


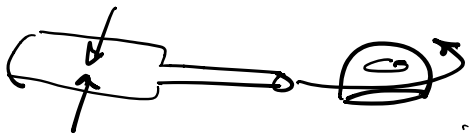
plastic Reaction Suface

LabTop



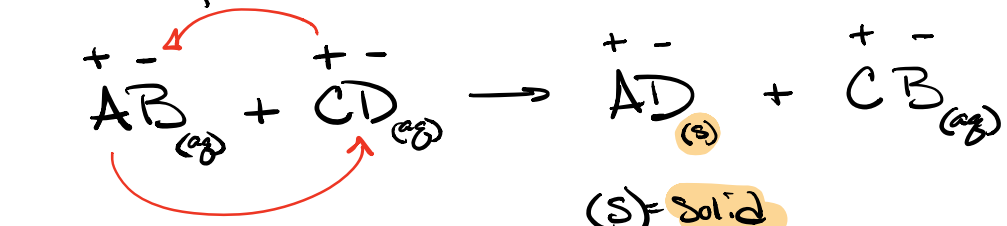
Micro Towels





Mix with
a stream of air

Double Displacement Reactions
(Replacement)
or Precipitation Reactions



(aq) = aqueous

(s) = solid precipitate

To precipitate means to come out of solution

Example

$AgNO_{3(aq)} + FeCl_{3(aq)} \rightarrow Fe(NO_3)_3 + AgCl$

Silver Nitrate → Iron(III) Chloride

Iron(III) Nitrate + Silver Chloride

Ag^+	NO_3^-
+	−

Fe^{3+}	Cl^-
	Cl^-
	Cl^-
3+	3−

Fe^{3+}	NO_3^-
	NO_3^-
	NO_3^-
3+	3−

Ag^+	Cl^-
+	−

Balanced the products for charge

$AgNO_{3(aq)} + FeCl_{3(aq)} \rightarrow AgCl_{(s)} + Fe(NO_3)_{3(aq)}$

Reactants → products

NO_3^- & Na^+ never precipitate

1. Name the reactants
2. Swap names for products
3. Write ions from names & balance formulas for charge
4. Look at products → anything with Na^+ or NO_3^- will be aq. the other will be the solid

How do we describe the reactants & products?

Solutions - have both a color & a clarity.

Color - Colorless, white, blue, yellow. (water)

Clarity - Opaque (light does not pass)

Clear (light transmits)

← Clear & Colorless

← Clear & blue

Solids have color, clarity, & adjective that describes how solid it is.

① milky
Cloudy
free flowing
Sticky
gel like
granular
sand like

② color & ③ clarity

Reactants - aqueous Solutions

$AgNO_3$ - Clear & Colorless

$Pb(NO_3)_2$ - Clear & Colorless

$FeCl_3$ - Clear & Slightly yellow

KI - Clear & Colorless

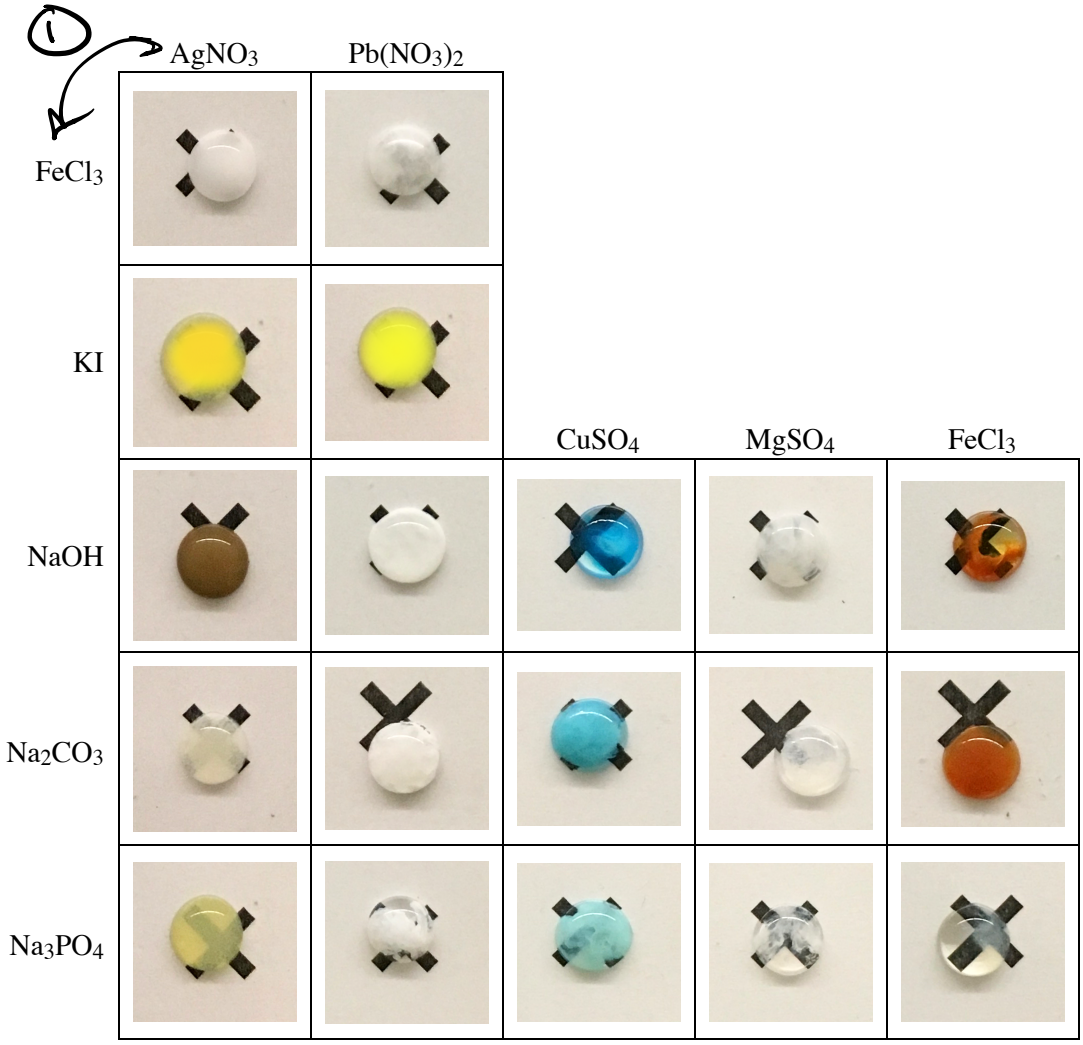
$NaOH$ - Clear & Colorless

Na_2CO_3 - Clear & Colorless

Na_3PO_4 - Clear & Colorless

$CuSO_4$ - Clear & Blue

$MgSO_4$ - Clear & Colorless


1
AgNO3
Pb(NO3)2
FeCl3
KI
CuSO4
MgSO4
FeCl3
NaOH
Na2CO3
Na3PO4

① $AgNO_{3(aq)} + FeCl_{3(aq)} \rightarrow AgCl_{(s)} + Fe(NO_3)_{3(aq)}$

Silver Nitrate — Iron(III) Chloride — Silver Chloride — Iron(III) Nitrate

Ag^+	Cl^-
+	−

Fe^{3+}	NO_3^- NO_3^- NO_3^-
3+	3−

$CuSO_{4(aq)} + Na_3PO_4 \rightarrow Cu_3(PO_4)_{2(s)} + Na_2SO_{4(aq)}$

Copper(II) Sulfate — Sodium Phosphate — Copper(II) Phosphate — Sodium Sulfate

Cu^{2+} Cu^{2+} Cu^{2+}	PO_4^{3-} PO_4^{3-}
6+	6−

Na^+ Na^+	SO_4^{2-}
2+	2−