

Activity 8: Chemical Names & Formulas

Nomenclature: A system of naming

IUPAC: Chemical organization that designates all rules for naming compounds.

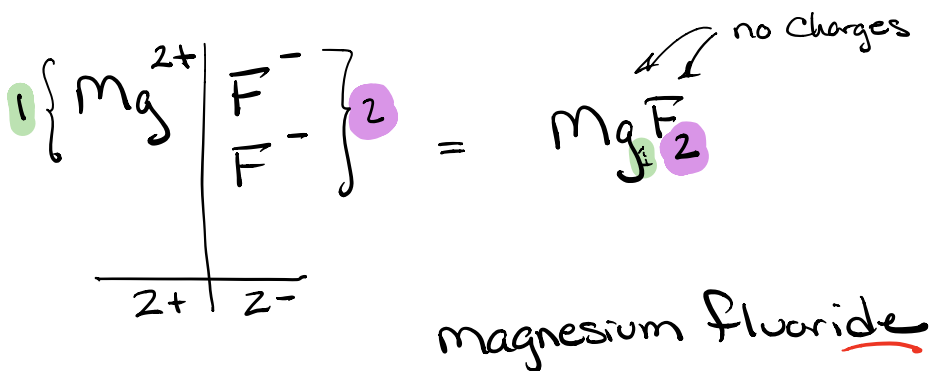
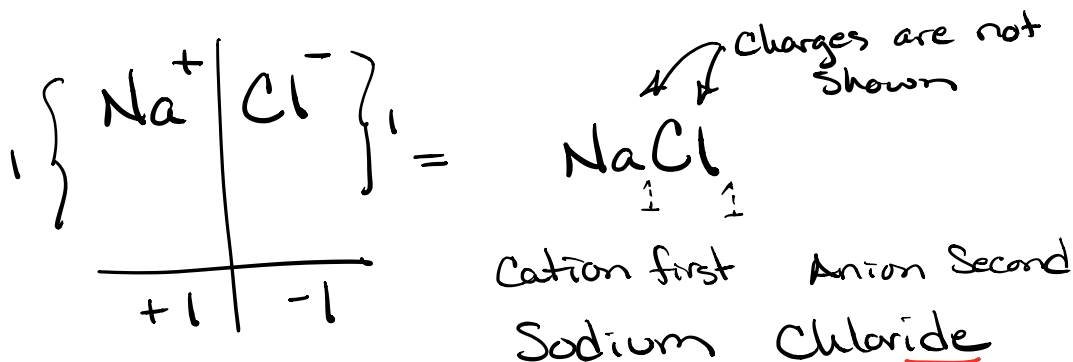
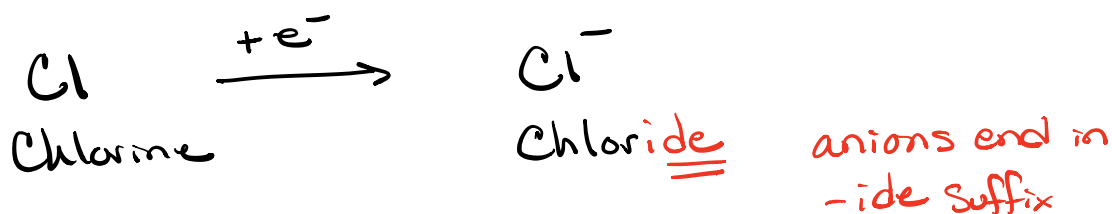
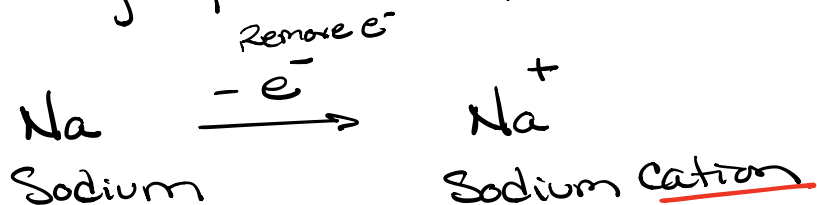
3 Types of Ionic nomenclature:

① - main group metals - nonmetals

② - Transition metals - nonmetals

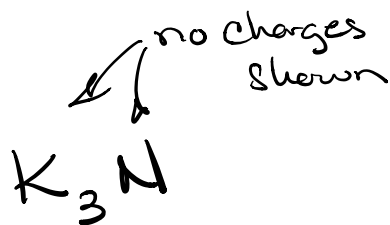
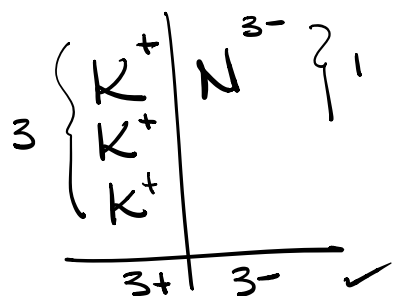
③ - Transition & main group - polyatomics

main group metals w/ non-metals



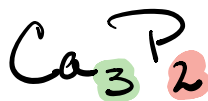
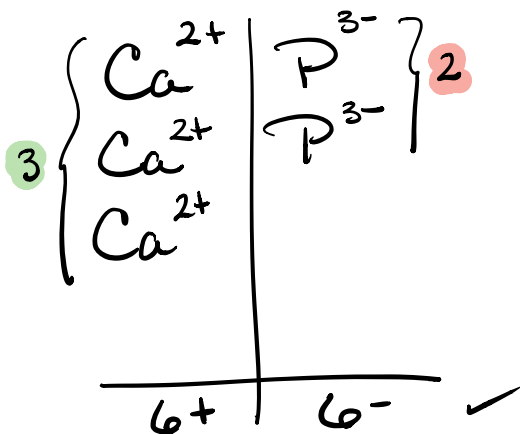
working Backwards

Potassium Nitride



Charges must be balanced

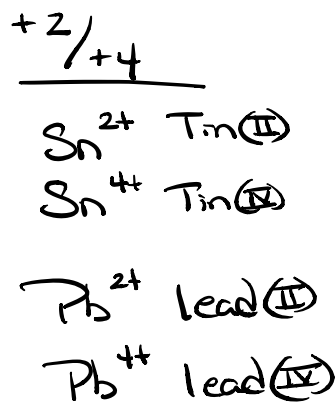
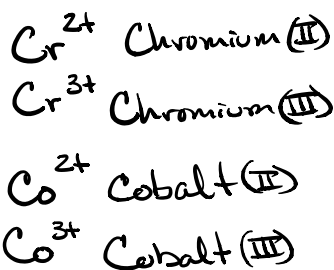
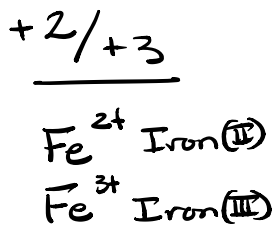
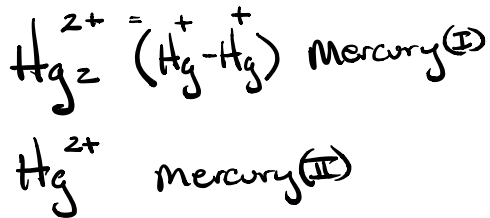
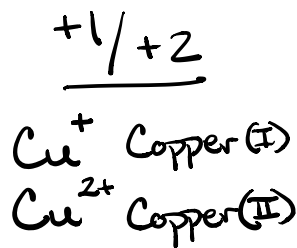
Calcium Phosphide



1A Type 2 - Transition metals w/ nonmetals 18 8A

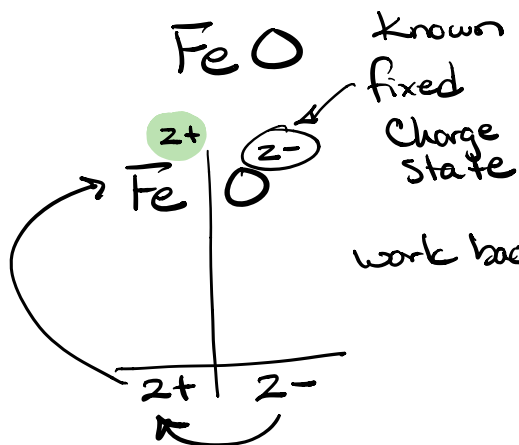
Have multiple charge states

1 H Hydrogen 1.008	2 He Helium 4.003											13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.30	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.84	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 97.91	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Cesium 132.9	56 Ba Barium 137.3	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222	
87 Fr Francium 223	88 Ra Radium 226	104 Rf Rutherfordium 261	105 Db Dubnium 262	106 Sg Seaborgium 263	107 Bh Bohrium 262	108 Hs Hassium 265	109 Mt Meitnerium 266	110 Ds Darmstadtium 269	111 Rg Roentgenium 272	112 Cn Copernicium 277	113 Nh Nihonium 289	114 Fl Flerovium 289	115 Mc Moscovium 289	116 Lv Livermorium 289	117 Ts Tennessine 289	118 Og Oganesson 289	
Lanthanides		57 La Lanthanum 138.9	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium 145	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.2	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0	
Actinides		89 Ac Actinium 227	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium 237	94 Pu Plutonium 244	95 Am Americium 243	96 Cm Curium 247	97 Bk Berkelium 247	98 Cf Californium 251	99 Es Einsteinium 252	100 Fm Fermium 257	101 Md Mendelevium 258	102 No Nobelium 259	103 Lr Lawrencium 262	

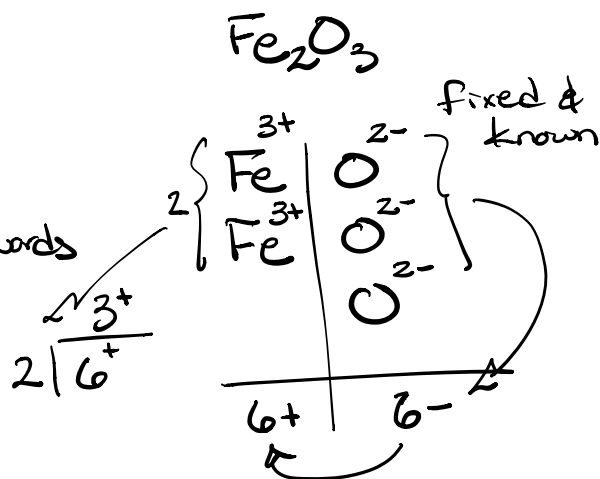


* Zn^{2+} Zinc ion Like main group
 Ag^+ Silver ion

Examples

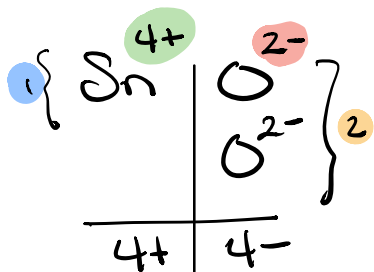


Iron(II) Oxide

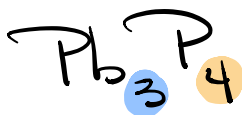
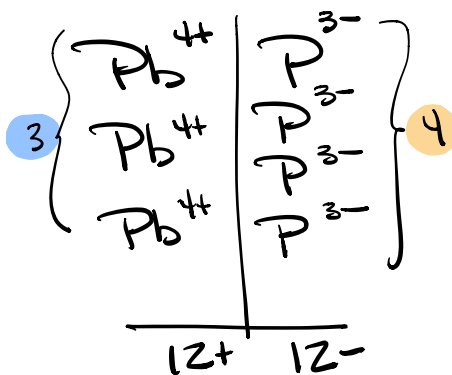


Iron(III) Oxide

Tin ^{IV} oxide



Lead ^{IV} Phosphide



Ag₂O

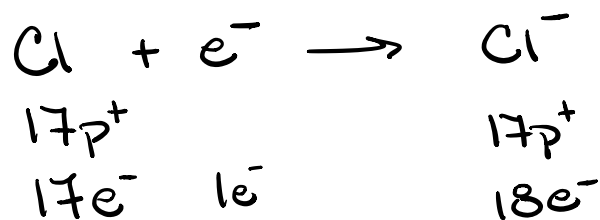
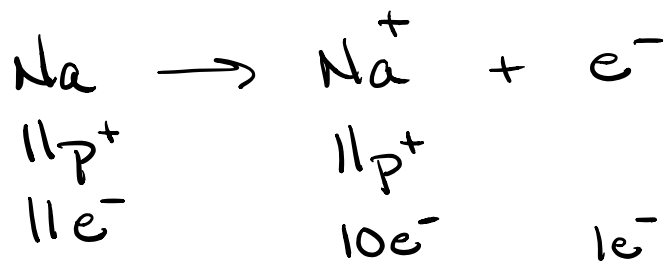


Silver Oxide

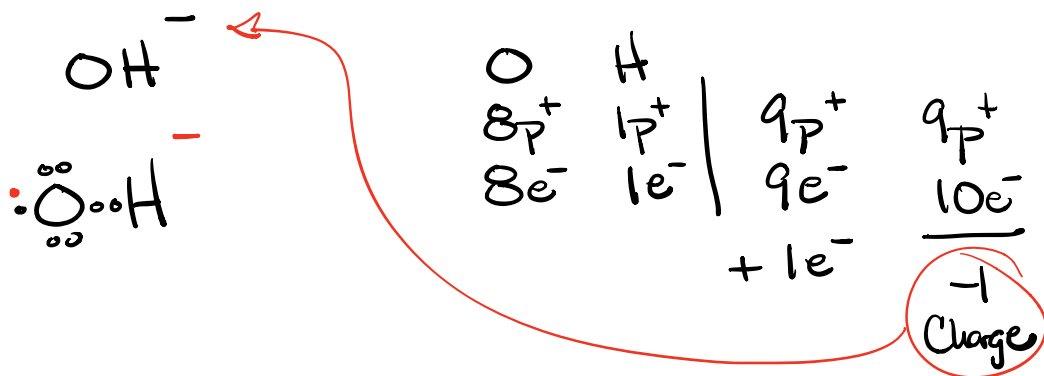
no Roman numeral needed

Polyatomic ions - many atom ion

Monatomic ion - Single atom ion w/
more or less e^- than
total protons



Polyatomic Ion



Nomenclature of polyatomic ions

Chlorine family

Cl Chlorine

Cl^- Chloride

ClO_4^- perchlorate per = more than
ate

ClO_3^- Chlorate ate = more oxygen

ClO_2^- Chlorite ite = less oxygen

ClO^- hypochlorite hypo = less than
ite

Bromine family

Br^- Bromide

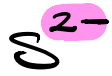
BrO_4^- perbromate

BrO_3^- Bromate

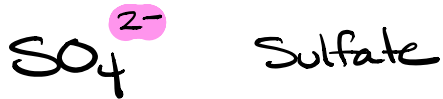
BrO_2^- Bromite

BrO^- hypobromite

Sulfur family



Root Sulf



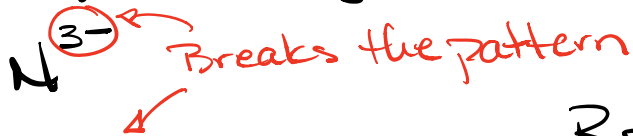
Phosphorus family



Root phosph



Nitrogen family

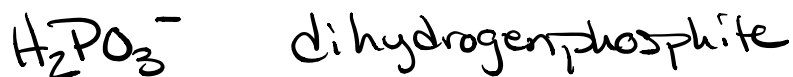
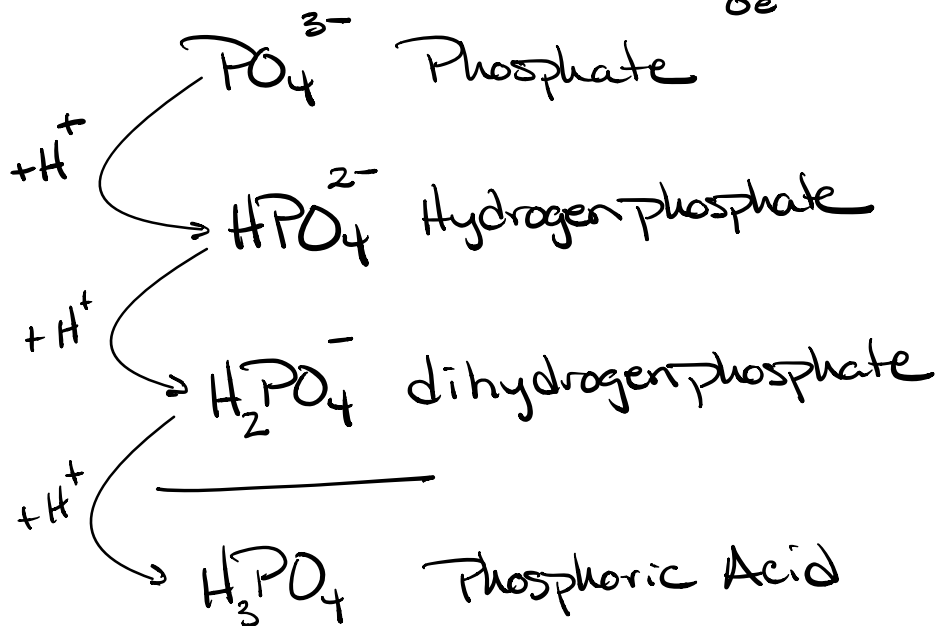


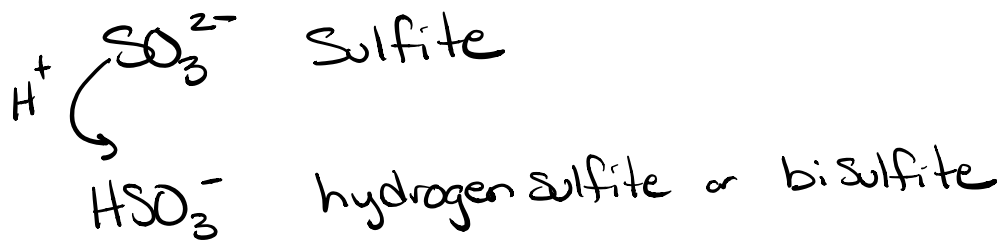
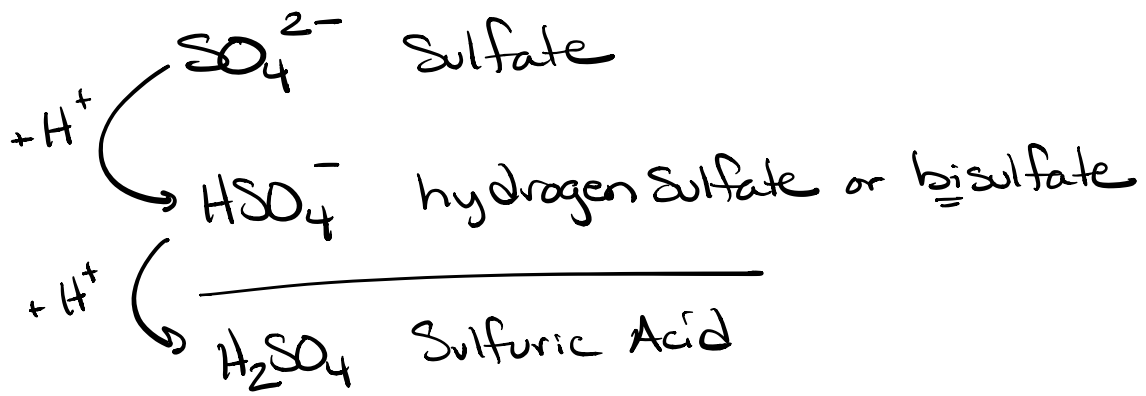
Root Nitr



Proton family →

H^+ Proton
 lp^+
 oe^-





Common Ions

Positive Ions (CATIONS)

+1 Charge

Ammonium (NH_4^+)*



Copper (I) or cuprous (Cu^+)*

Hydrogen (H^+) "proton"*

Hydronium (H_3O^+) "aqueous proton"*

Silver (Ag^+)*

+2 Charge

Cadmium (Cd^{2+})

Cobalt (II) or cobaltous (Co^{2+})

Copper (II) or cupric (Cu^{2+})*

Iron (II) or ferrous (Fe^{2+})*

Lead (II) or plumbous (Pb^{2+})*

Manganese (II) or manganous (Mn^{2+})*

Mercury (I) or mercurous (Hg_2^{2+})*

Mercury (II) or mercuric (Hg^{2+})*

Nickel (Ni^{2+})*

Tin (II) or stannous (Sn^{2+})*

Zinc (Zn^{2+})*

+3 Charge

Aluminum (Al^{3+})*

Chromium (III) or chromic (Cr^{3+})*

Iron (III) or ferric (Fe^{3+})*

+4 Charge

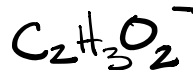
Lead (IV) or plumbic (Pb^{4+})*

Tin (IV) or stannic (Sn^{4+})*

Negative Ions (ANIONS)

-1 Charge

Acetate ($\text{C}_2\text{H}_3\text{O}_2^-$)*



Perchlorate (ClO_4^-)

Chlorate (ClO_3^-)

Chlorite (ClO_2^-)

Hypochlorite (ClO^-)*

Cyanide (CN^-)



Dihydrogen phosphate (H_2PO_4^-)*

Hydrogen carbonate or bicarbonate (HCO_3^-)*

Hydrogen sulfate or bisulfate (HSO_4^-)*

Hydrogen sulfite or bisulfite (HSO_3^-)*

Hydroxide (OH^-)*



Nitrate (NO_3^-)*

Nitrite (NO_2^-)*

Permanganate (MnO_4^-)*



Thiocyanate (SCN^-)

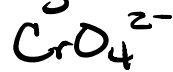


-2 Charge

Carbonate (CO_3^{2-})*



Chromate (CrO_4^{2-})*



Dichromate ($\text{Cr}_2\text{O}_7^{2-}$)*



Hydrogen phosphate (HPO_4^{2-})*

Oxalate ($\text{C}_2\text{O}_4^{2-}$)*



Sulfate (SO_4^{2-})*

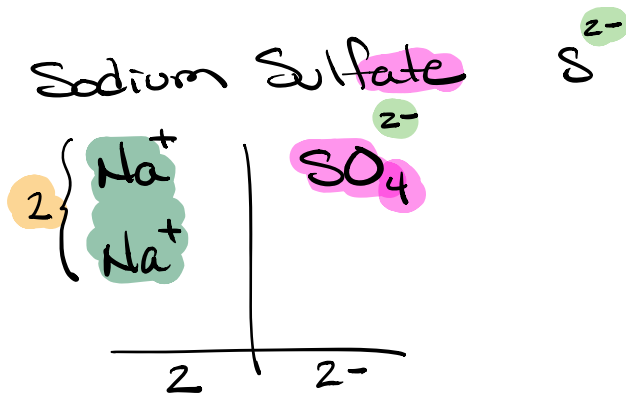
Sulfite (SO_3^{2-})*

Peroxide (O_2^{2-})*

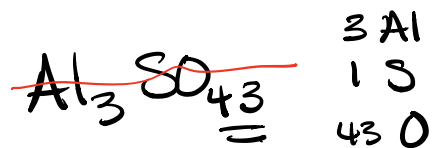
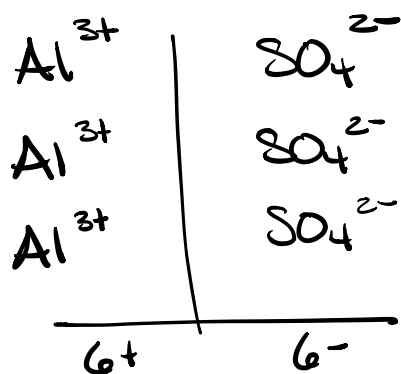
-3 Charge

Phosphate (PO_4^{3-})*

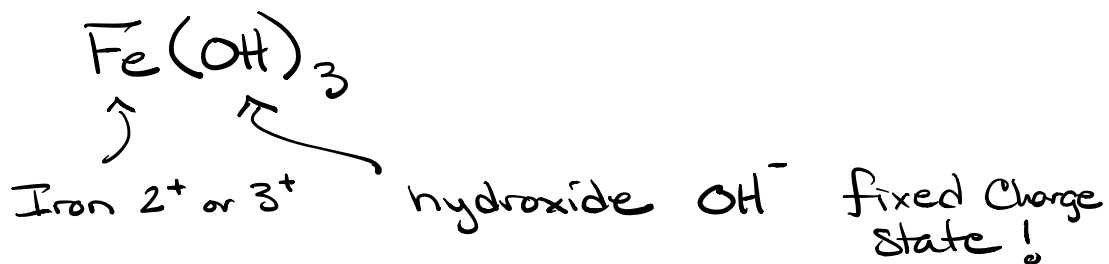
Polyatomic Ions in Ionic Compounds



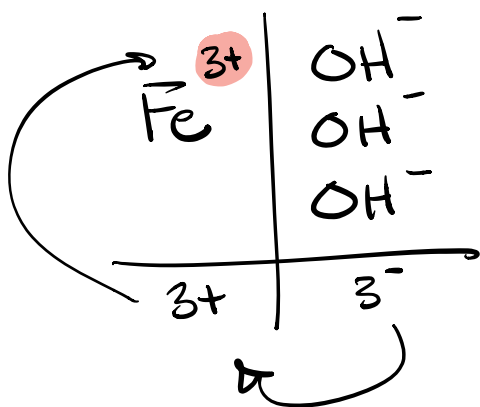
Aluminum Sulfate



⇒ When there is more than 1 polyatomic include it in parenthesis

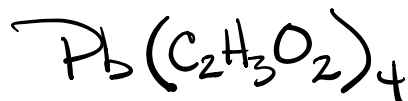
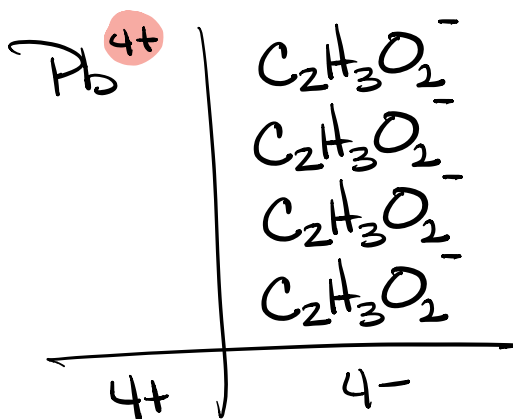


Anions always have fixed (known) Charge States



Iron (III) hydroxide

Lead (IV) acetate



Activity 8 – Chemical Names and Formulas¹

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 Na₁Cl₁.) 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 Na₂O. 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
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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 ₂ H ₃ O ₂ ⁻				
Hydroxide	OH ⁻				
Nitrate	NO ₃ ⁻				
Nitrite	NO ₂ ⁻				
Hydrogen carbonate (bicarbonate)	HCO ₃ ⁻	Carbonate	CO ₃ ²⁻		
Dihydrogen phosphate	H ₂ PO 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 (AgNO₃) 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			
FeCl ₃	×	×			
KI	×	×			
			CuSO ₄	MgSO ₄	FeCl ₃
NaOH	×	×	×	×	×
Na ₂ CO ₃	×	×	×	×	×
Na ₃ PO ₄	×	×	×	×	×

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**

Potassium iodide

Compound Name **Formula**

Sodium carbonate

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

$\text{AgNO}_3(\text{aq})$

Iron (III) chloride

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
$\text{AgNO}_3(\text{aq}) + \text{FeCl}_3(\text{aq})$	
$\text{AgNO}_3(\text{aq}) + \text{KI}(\text{aq})$	
$\text{AgNO}_3(\text{aq}) + \text{NaOH}(\text{aq})$	
$\text{AgNO}_3(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq})$	
$\text{AgNO}_3(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq})$	
$\text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{FeCl}_3(\text{aq})$	
$\text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{KI}(\text{aq})$	
$\text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{NaOH}(\text{aq})$	
$\text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq})$	
$\text{Pb}(\text{NO}_3)_2(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq})$	
$\text{CuSO}_4(\text{aq}) + \text{NaOH}(\text{aq})$	
$\text{CuSO}_4(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq})$	
$\text{CuSO}_4(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq})$	
$\text{MgSO}_4(\text{aq}) + \text{NaOH}(\text{aq})$	
$\text{MgSO}_4(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq})$	
$\text{MgSO}_4(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq})$	
$\text{FeCl}_3(\text{aq}) + \text{NaOH}(\text{aq})$	
$\text{FeCl}_3(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq})$	
$\text{FeCl}_3(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq})$	

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).
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).
3. Write a simple rule for naming ionic compounds (which element comes first, when/how do element names change).
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?
6. What does a numerical subscript following an element in a chemical formula mean?
7. When is it correct to use parentheses in chemical formulas?