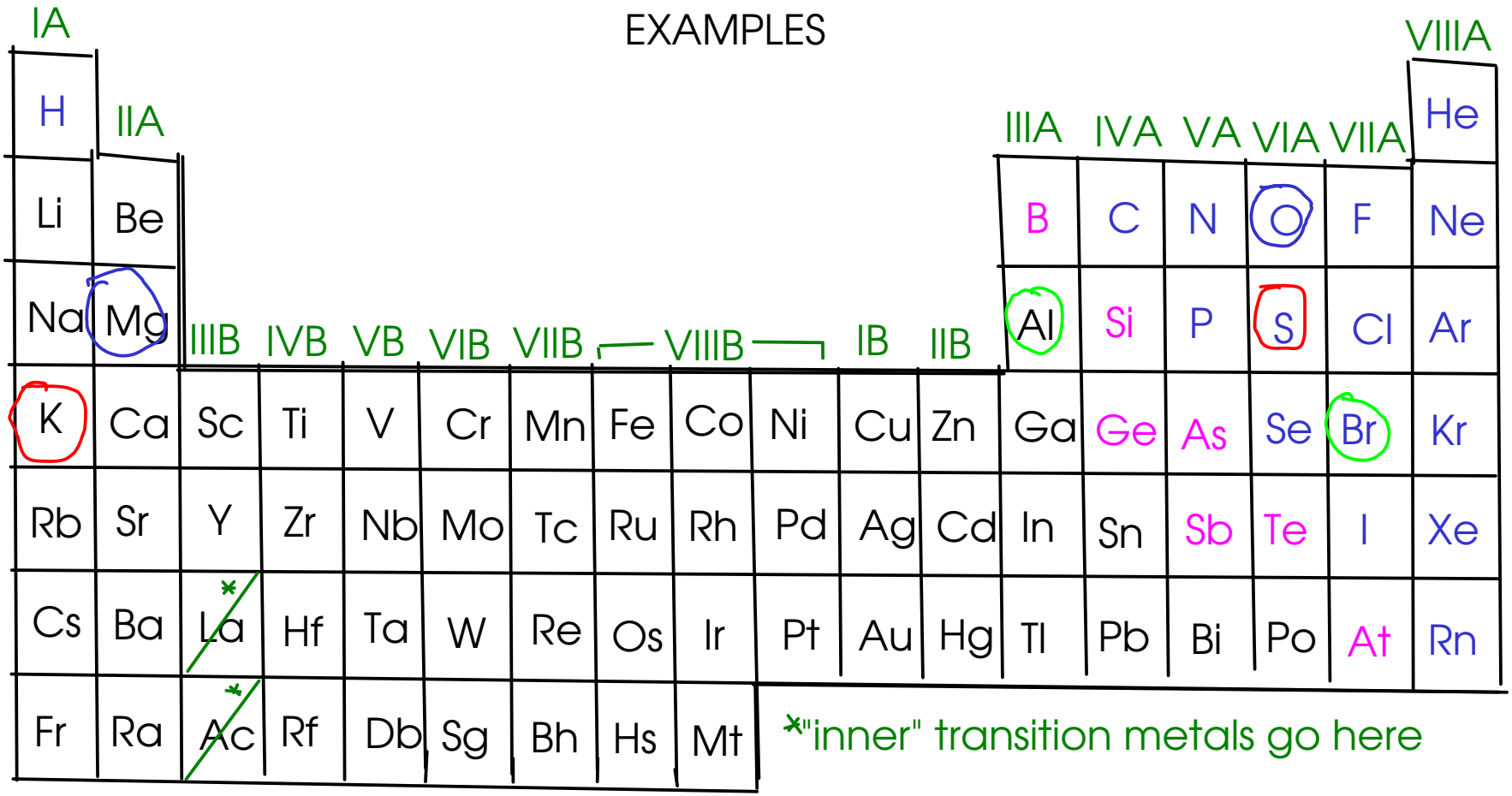
# EXAMPLES




Find the formulas of:

(1) an ionic compound containing Al and Br

(2) an ionic compound containing Mg and O

(3) an ionic compound containing S and K

$Al^{3+}$ $Br^{-}$

$Mg^{2+}$ $O^{2-}$

$S^{2-}$ $K^{+}$

Find the formula of:
* an ionic compound containing Al and Br

$Al^{3+}$ $Br^-$
$Br^-$
$Br^-$

$AlBr_3$

Find the formula of:
* an ionic compound containing Mg and O

$Mg^{2+}$ $O^{2-}$

$MgO$

Find the formula of:
* an ionic compound containing S and K

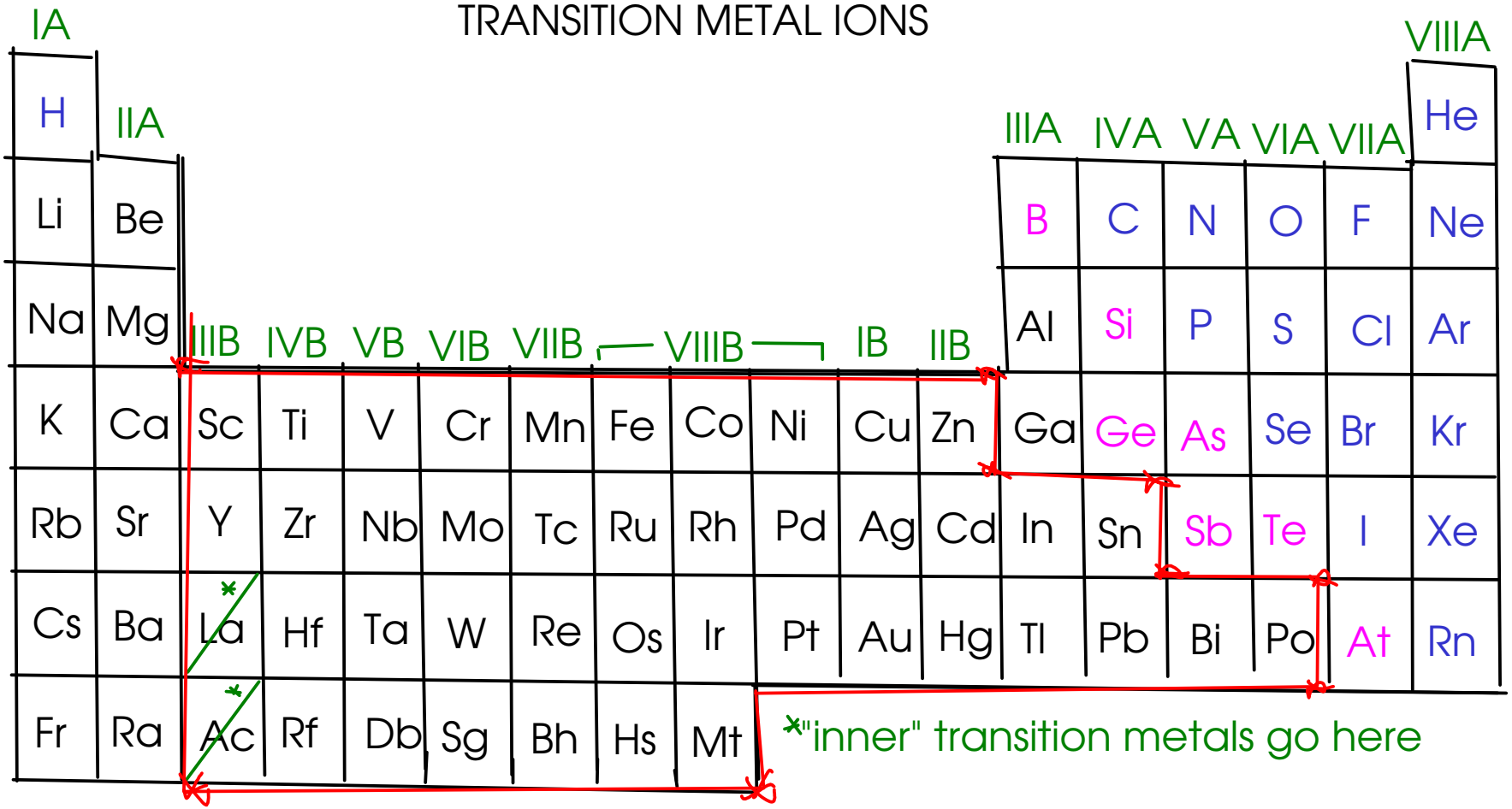
$S^{2-}$ $K^+$
$K^+$

$K_2S$

cation first!

~~$SK_2$~~

# TRANSITION METAL IONS




The transition metals always form CATIONS!

However, many transition metals are capable of forming SEVERAL DIFFERENT CATIONS!

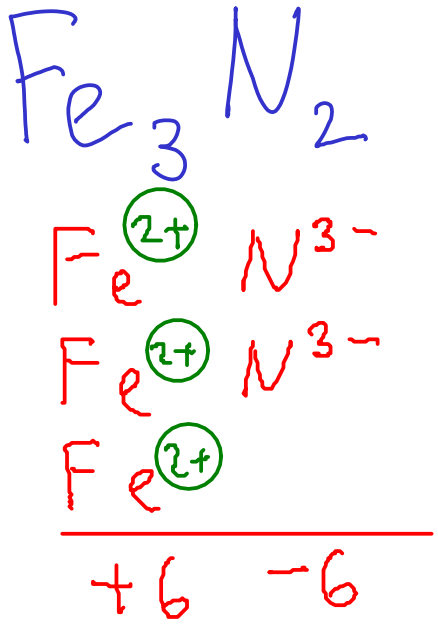
Example: Iron (Fe) forms two cations, depending on the situation: $Fe^{2+}$ or $Fe^{3+}$

# TRANSITION METAL CATIONS

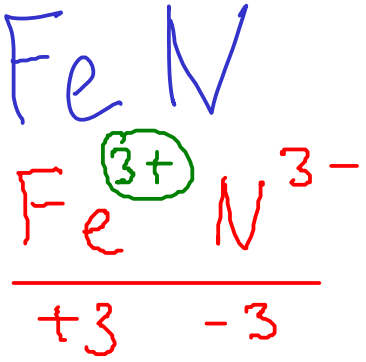
- So how do you know which cation you're dealing with? For now, you'll have to be told

- Either the chemical formula of an ionic compound or the name of an ionic compound can tell you what charge is on the transition metal cation.

Examples:




* We call this form of iron ion "iron(II)"!




* We call this form of iron ion "iron(III)"!

# POLYATOMIC IONS

- Some MOLECULES can gain or lose electrons to form CATIONS or ANIONS. These are called POLYATOMIC IONS

- Polyatomic ions form ionic compounds in the same way that single-element ions do.

Example: $CO_3^{2-}$ : CARBONATE ION

*Compare to $Al_2O_3$

$Al^{3+}$ $CO_3^{2-}$

$Al^{3+}$ $CO_3^{2-}$

$CO_3^{2-}$

$Al_2(CO_3)_3$

* Use parenthesis when an ionic compound's formula contains more than one of a polyatomic ion.

YOU MUST MEMORIZE THE NAMES AND FORMULAS OF THE MOST COMMON POLYATOMIC IONS. CHECK THE COURSE WEB SITE FOR A LIST!

# NAMES OF IONS

- To properly discuss ions and ionic compounds, we have to know how to name them!

CATIONS

3 kinds:

1. Main group cations (metals that take only one charge when forming ions)

- The element's name is the same as the ion's name!

$Mg^{2+}$: "magnesium ion"

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2. Transition metal cations (from metals that can form several cations)

- The CHARGE of the cation must be given. Use a ROMAN NUMERAL after the element name to indicate charge!

$Fe^{2+}$: "iron(II) ion"

$Cu^{+}$: "copper(I) ion"

$Fe^{3+}$: "Iron(III) ion"

---

3. Polyatomic cations

- Memorize list.

$NH_4^{+}$: "ammonium ion"

# ANIONS

2 kinds

1. Main-group nonmetals

- Use the STEM NAME of the element, then add "-ide" suffix

$N^{3-}$ : "nitride" ion  $P^{3-}$ : "phosphide ion"  $S^{2-}$: sulfide ion

$O^{2-}$ : "oxide ion"  $F^{-}$ : "fluoride ion"

---

2. Polyatomic ions

- Memorize list.(see web site)

$C_2H_3O_2^{-}$ : "acetate ion"  $SO_4^{2-}$: "sulfate ion"

$NO_3^{-}$ : "nitrate ion"  $SO_3^{2-}$ "sulfite ion"

$NO_2^{-}$ : "nitrite ion"

* Polyatomic ions ending in "-ate" and "-ite" suffixes always contain oxygen! "-ate" ions have more oxygen atoms than their "-ite" counterparts.

# NAMING IONIC COMPOUNDS

- The name of the compound is based on the name of the ions in the compound
- Cation first, anion second

Examples:

$Mg(OH)_2$

magnesium hydroxide

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$Na_2S$

sodium sulfide

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$BeBr_2$

beryllium bromide

---

$Fe_2O_3$

$Fe^{3+}$ $O^{2-}$
$Fe^{3+}$ $O^{2-}$
$O^{2-}$
+6 −6

iron(III) oxide

---

$CuO$

$Cu^{2+}$ $O^{2-}$
+2 −2

copper(II) oxide

---

$Cu_2O$

$Cu^{+}$ $O^{2-}$
$Cu^{+}$
+2 −2

copper(I) oxide

Remember to include the Roman numeral for CHARGE in the name of transition metal compounds!

Page 63 (9th edition): Chart of polyatomic ions

# NAMING IONIC COMPOUNDS

$(NH_4)_2S$

ammonium sulfide

$FeCO_3$ $Fe^{2+}$ $CO_3^{2-}$

−2

iron(II) carbonate

$TiS_2$ $Ti^{4+}$ $S^{2-}$ $S^{2-}$

+4 −4

titanium(IV) sulfide

$Ba_3(PO_4)_2$

barium phosphate

Spelling matters!

$Ba_3P_2$

barium phosphide

$Ca(NO_3)_2$

calcium nitrate

# DETERMINING THE FORMULA OF AN IONIC COMPOUND FROM THE NAME

- The name of an ionic compound is made of the names of the CATION and ANION in the compound.

- To get the FORMULA, you must figure out the SMALLEST RATIO of cation to anion that makes the charges balance out

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Examples:

iron(III) carbonate

$Fe^{3+}$ $CO_3^{2-}$
$Fe^{3+}$ $CO_3^{2-}$
$CO_3^{2-}$

$Fe_2(CO_3)_3$

potassium sulfide

$K^+$ $S^{2-}$
$K^+$

$K_2S$

calcium bromide

$Ca^{2+}$ $Br^-$
$Br^-$

$CaBr_2$

# DETERMINING IONIC FORMULAS

sodium sulfate

$Na^+$ $SO_4^{2-}$

$Na^+$

$Na_2SO_4$

strontium oxide

$Sr^{2+}$ $O^{2-}$

$SrO$

tin(II) phosphate

$Sn^{2+}$ $PO_4^{3-}$

$Sn^{2+}$ $PO_4^{3-}$

$Sn^{2+}$

$Sn_3(PO_4)_2$

chromium(III) nitrate

$Cr^{3+}$ $NO_3^-$

$NO_3^-$

$NO_3^-$

$Cr(NO_3)_3$

barium hydroxide

$Ba^{2+}$ $OH^-$

$OH^-$

$Ba(OH)_2$ ~~$BaOH_2$~~

titanium(IV) chloride

$Ti^{4+}$ $Cl^-$

$Cl^-$

$Cl^-$

$Cl^-$

$TiCl_4$

Don't forget the parenthesis when you have more than one hydroxide ion!

# HYDRATES

- many ionic compounds are formed by crystallizing the compound from water. Sometimes, this causes water molecules to become part of the crystal structure.

- This water is present in a definite ratio to the ions in the compound. Can be removed by heating, but will NOT evaporate if the compound is left standing.

ex: $CuSO_4 \cdot 5H_2O$

# water molecules per formula unit of compound

dot indicates that the water is weakly bound to the ionic compound

- many DESSICANTS are hydrates that have had their water molecules driven off. They will slowly reabsorb water from the air (and keep the environment in a dessicator at a low humidity)

- Hydrates are named using the name of the ionic compound, and a Greek prefix in front of the word "hydrate" to indicate how many water molecules are associated

$Cu^{2+}$ $SO_4^{2-}$

copper (II) sulfate pentahydrate

Why "copper(II)"?

# MOLECULAR COMPOUNDS

- There are several kinds of molecular compound. We will learn to name two simple but important classes

## 1 BINARY MOLECULAR COMPOUNDS

- molecular compounds containing only two elements

## 2 ACIDS

- molecular compounds that dissolve in water to release $H^+$ ions
- corrosive to metals (react with many to produce hydrogen gas)
- contact hazard: can cause chemical burns to eyes and skin
- sour taste
- turn litmus indicator RED
- two kinds of acids:

Usually from Group VIIA

### 1 BINARY ACIDS

- contain hydrogen and one other element

### 2 OXYACIDS

- contain hydrogen, OXYGEN, and another element

# BINARY MOLECULAR COMPOUNDS

- Named based on the elements they contain, plus prefixes to indicate the number of atoms of each element in each molecule

1. FIRST ELEMENT
   - Add a GREEK PREFIX to the name of the element.
   - Omit the "MONO-" (1) prefix if there is only one atom of the first element
2. SECOND ELEMENT
   - Add a GREEK PREFIX to the STEM NAME of the element
   - Add the suffix "-ide" (as if you were naming an anion)
   - DO NOT omit the "mono-" prefix if there is only one atom of the second element

MEMORIZE THE GREEK PREFIXES. SEE COURSE WEB SITE FOR A LIST!
THESE ARE THE SAME PREFIXES USED FOR THE HYDRATES!

# BINARY MOLECULAR COMPOUNDS

Examples:

$BF_3$ — boron trifluoride

$Cl_2O_7$ — dichlorine heptaoxide (OR dichlorine heptoxide)

$CO$ — carbon monoxide

$CO_2$ — carbon dioxide

*Note: metalloids like boron behave chemically like nonmetals do.

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carbon tetrachloride

$CCl_4$

dihydrogen monoxide

$H_2O$

dinitrogen tetrafluoride

$N_2F_4$

$MgCl_2$: magnesium CHLORIDE, not magnesium DICHLORIDE. Since this is an ionic compound, we must use the naming system for ionic compounds for this one!

We can tell this compound is ionic because it contains a metal joined to a nonmetal. (Metal/nonmetal compounds are usually ionic)

# ACIDS

## 1 BINARY ACIDS

- named after the element (other than hydrogen) they contain
- common binary acids include a Group VIIA element
- named: "Hydro-" + STEM NAME OF ELEMENT+ "-ic acid"

Four common binary acids

- HF : hydrofluoric acid * dissolves glass!
- HCl : hydrochloric acid *most common binary acid!
- HBr : hydrobromic acid
- HI : hydroiodic acid

# ACIDS

## 2 OXYACIDS

- Easy to think about as HYDROGEN IONS combined with POLYATOMIC IONS

- These acids are not true ionic compounds, but they interact with water to PRODUCE ions!

- named based on the polyatomic ion they contain, with an ending change:

1 - ions ending in -ATE form acids ending in -IC

2 - ions ending in -ITE form acids ending in -OUS

sulfATE

$H_2SO_4$

sulfuric acid

phosphATE

$H_3PO_4$

phosphoric acid

sulfITE

$H_2SO_3$

sulfurous acid

nitratP

$HNO_3$

nitric acid