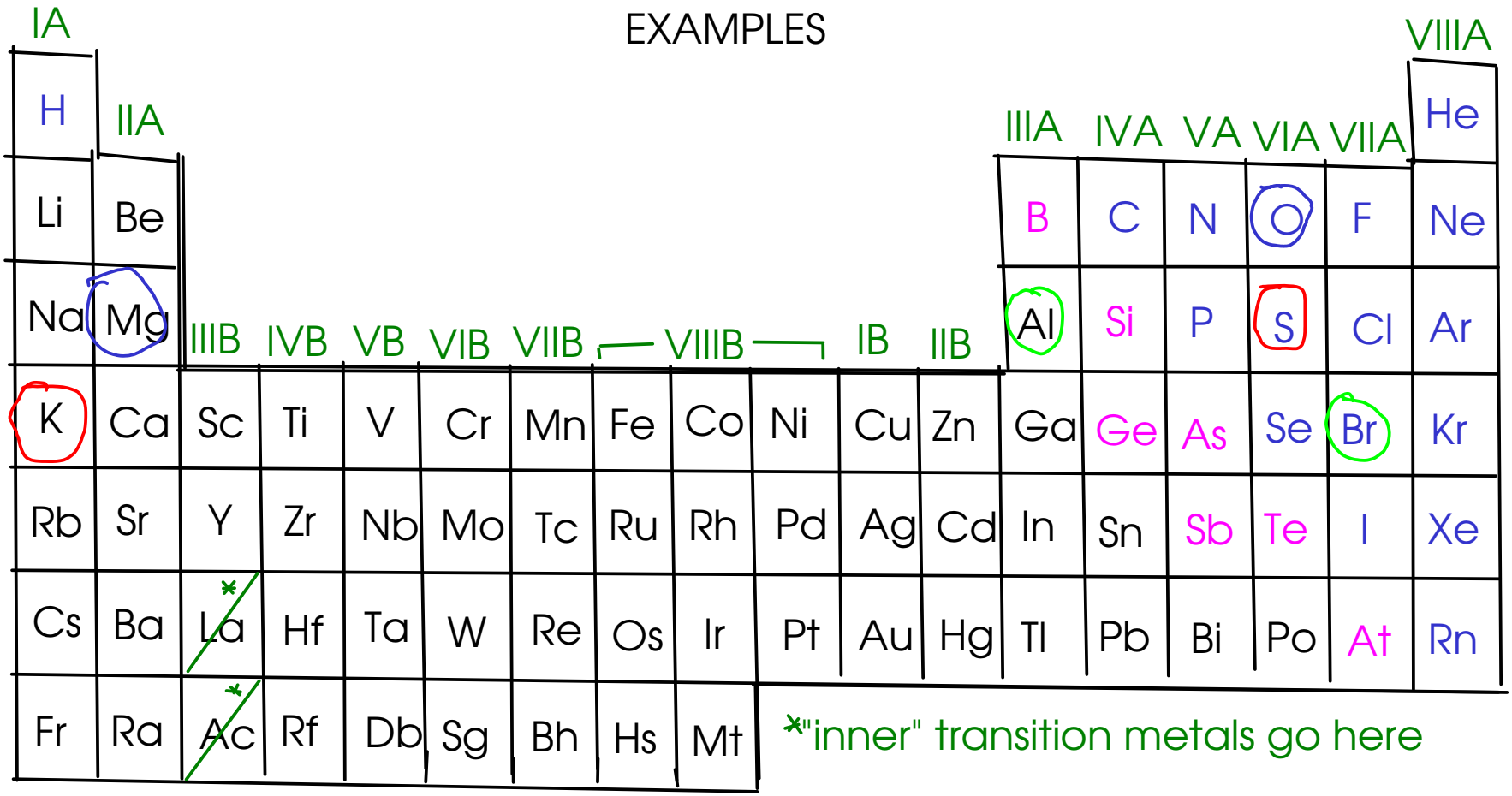
EXAMPLES



Find the formulas of:

(1) an ionic compound containing Al and Br

(2) an ionic compound containing Mg and O

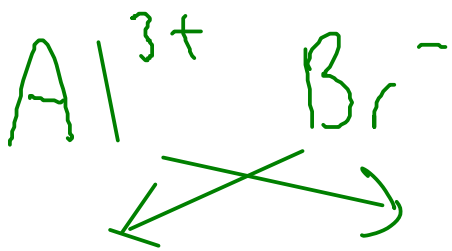
(3) an ionic compound containing S and K

Al^{3+} Br^{-}

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

S^{2-} K^{+}

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



$AlBr_3$

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

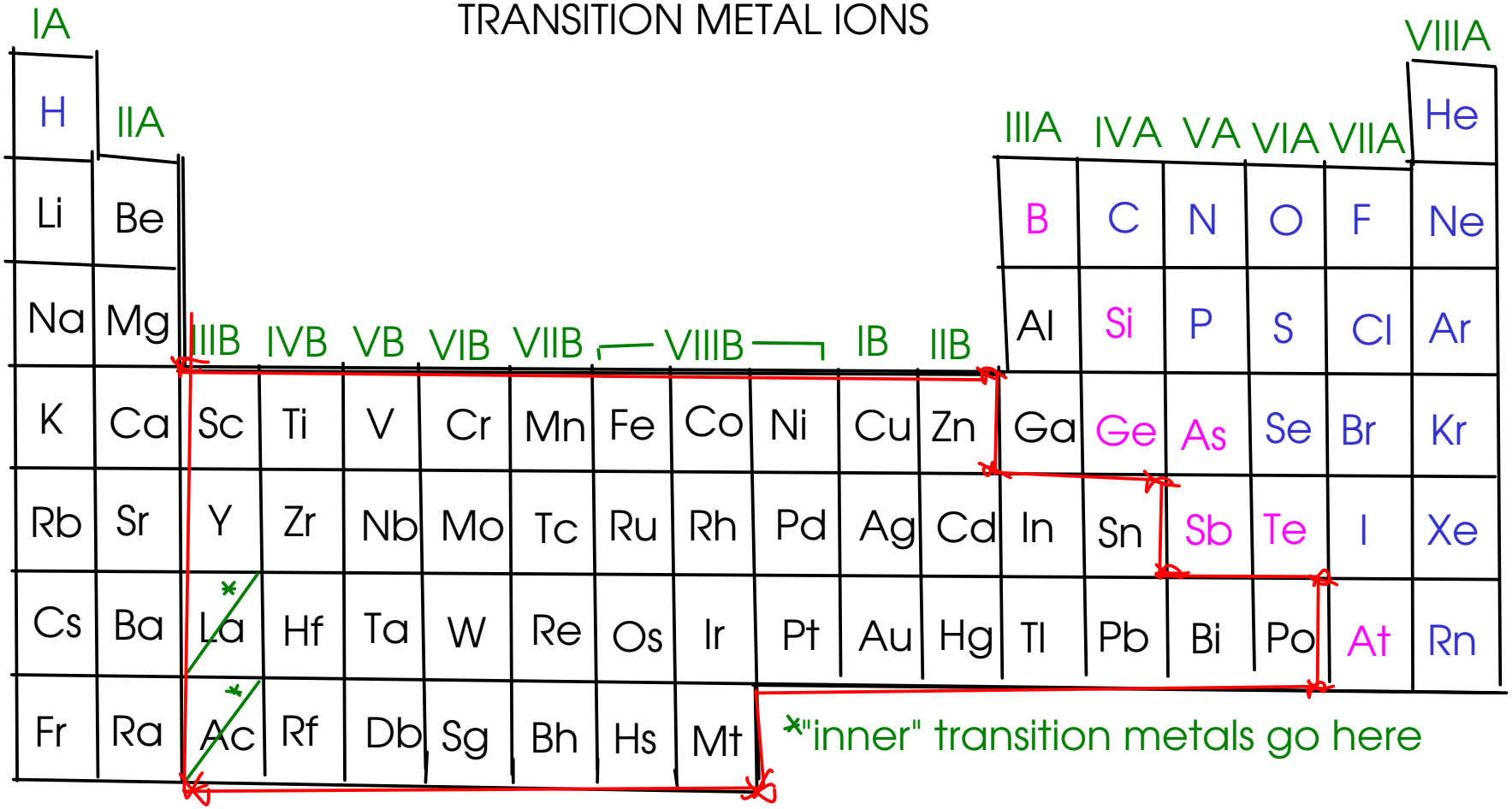
S^{2-} K^{+}

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

K_2S

Reminder: When pairing ions to make an ionic compound, alwaly put the cation (+) first in the formula you write! ---------->

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:

Fe_3N_2

Fe^{2+} N^{3-}

Fe^{2+} N^{3-}

Fe^{2+}

$+6$ -6

* The iron in this compound has a charge of +2. We call this kind of iron ion "iron(II) ion" ... pronounced "iron two ion". The compound is called "iron(II) nitride".

FeN

Fe^{3+} N^{3-}

$+3$ -3

* The iron in this compound has a charge of +3. We call this kind of iron ion "iron(III) ion" ... pronounced "iron three ion". The compound is called "iron(III) nitride".

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

From Al^{3+} O^{2-}

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.

See the web site or Openstax page 100 - table 2.5 for a list of common polyatomic ions!

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"

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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

Na_2S

sodium sulfide

$Ba_3(PO_4)_2$

barium phosphate

Fe_2O_3

$Fe^{3+}\ O^{2-}$

$Fe^{3+}\ O^{2-}$

+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 when you're writing transition metal compound names!

(See Openstax p 100 for a chart of polyatomic ions)

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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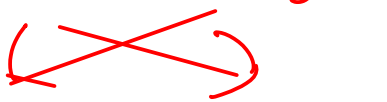
Examples:

iron(III) carbonate

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



$Fe_2(CO_3)_3$

potassium sulfide

K^+ S^{2-}

K^+

K_2S

calcium bromide

Ca^{2+} Br^-

Br^-

$CaBr_2$

DETERMINING IONIC FORMULAS

tin(II) phosphate

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

$Sn_3(PO_4)_2$

barium hydroxide

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

$Ba(OH)_2$

~~$BaOH_2$~~

chromium(III) nitrate

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

$Cr(NO_3)_3$

titanium(IV) chloride

Ti^{4+} Cl^-

$TiCl_4$

Reminder: When indicating more than one of a polyatomic ion, enclose the ion's formula in parenthesis before adding the new subscript. Be particularly careful with HYDROXIDE, CYANIDE, and HYPOCHLORITE ions!

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

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

BINARY MOLECULAR COMPOUNDS

Examples:

BF_3	Cl_2O_7	CO	CO_2
boron trifluoride	dichlorine heptaoxide	carbon monoxide	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

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

nitrate

HNO_3

nitric acid

OXYACID EXAMPLES

based on acetate

acetic acid

$H^+ \quad C_2H_3O_2^-$

$HC_2H_3O_2$

based on nitrite

nitrous acid

$H^+ \quad NO_2^-$

HNO_2

based on carbonate

carbonic acid

$H^+ \quad CO_3^{2-}$

H^+

H_2CO_3

The number of hydrogen atoms at the beginning of the formula equals the charge of the anion the acid is based on!