

Naming Compounds Handout

IONIC COMPOUNDS versus MOLECULAR COMPOUNDS

- ionic compound:** consist of **cations** (positive ions) and **anions** (negative ions) held together by electrostatic attraction
- usually **metal + nonmetal(s)**
 - made of monatomic ions, polyatomic ions, and/or both
 - **monatomic ions:** consist of a single atom
 - **polyatomic ions:** consist of more than one atom

- molecular compound:** consist of **nonmetal atoms** bonded together by shared electrons (covalent bonding)
- **acid:** a molecular compound that releases hydrogen ions (H^+) when dissolved in water

NAMING MONATOMIC CATIONS:

Metal atoms lose valence electrons to form positively charged ions, called **cations**.

An ion formed from an individual atom is a **monatomic** (or monoatomic) **cation**.

- Groups IA to IIIA elements silver (Ag), zinc (Zn) and cadmium (Cd) form only one type of ion each:
 - Group IA elements form +1 ions: Li^+ , Na^+ , K^+ , Rb^+ , Cs^+
 - Group IIA elements form +2 ions: Be^{+2} , Mg^{+2} , Ca^{+2} , Sr^{+2} , Ba^{+2}
 - Group IIIA elements form +3 ions: Al^{+3}
 - silver ion = Ag^+ ; zinc ion = Zn^{+2} ; cadmium ion = Cd^{+2}

When a Group IA–IIIA element, silver, zinc, or cadmium forms an ion, it is named:

element name + ion

e.g. Na^+ = sodium ion

Sr^{+2} = strontium ion

Zn^{+2} = zinc ion

II. The **Stock system** is used to name transition metals and other metals that form more than one ion:

- iron (Fe) forms two ions: Fe^{+2} and Fe^{+3}
- lead (Pb) forms two ions: Pb^{+2} and Pb^{+4}

When a metal can form more than one ion, each ion is named:

element name (charge in Roman numerals) + ion

e.g. Fe^{+2} = iron (II) ion
 Fe^{+3} = iron (III) ion

Pb^{+2} = lead (II) ion
 Pb^{+4} = lead (IV) ion

Cu^{+} = copper (I) ion
 Cu^{+2} = copper (II) ion

Name each of the following monatomic cations:

Li^{+} = lithium ion

Cd^{+2} = cadmium ion

Ag^{+} = silver ion

Cu^{+2} = copper (II) ion

Al^{+3} = aluminum ion

Mg^{+2} = magnesium ion

Mn^{+2} = manganese (II) ion

Sn^{+4} = tin (IV) ion

H^{+} = hydrogen ion

Co^{+3} = cobalt (III) ion

Fe^{+3} = iron (III) ion

Na^{+} = sodium ion

K^{+} = potassium ion

Ti^{+4} = titanium (IV) ion

Ca^{+2} = calcium ion

Ni^{+2} = nickel (II) ion

NAMING MONATOMIC ANIONS:

Nonmetal atoms gain valence electrons to form **negatively charged ions** called **anions**.

When a nonmetal forms an ion, it is named:

element stem name + "ide" + ion

e.g. O = **oxygen** atom \Rightarrow O^{-2} = **oxide** ion
 N = **nitrogen** atom \Rightarrow N^{-3} = **nitride** ion

Name each of the following monatomic anions:

F^{-} = fluoride ion Cl^{-} = chloride ion
 Br^{-} = bromide ion S^{-2} = sulfide ion
 I^{-} = iodide ion P^{-3} = phosphide ion

NAMING POLYATOMIC IONS:

Ions made up of more than one atom are **polyatomic ions**:

- only one polyatomic cation: NH_4^{+} = **ammonium ion**
- many polyatomic anions: see table below

NH_4^{+} = ammonium ion

Polyatomic Ions

OH^{-} = hydroxide ion

NO_2^{-} = nitrite ion

$C_2H_3O_2^{-}$ = acetate ion

CN^{-} = cyanide ion

NO_3^{-} = nitrate ion

PO_4^{-3} = phosphate ion

CrO_4^{-2} = chromate ion

SO_4^{-2} = sulfate ion

MnO_4^{-} = permanganate ion

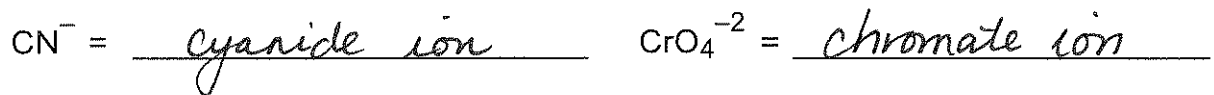
$Cr_2O_7^{-2}$ = dichromate ion

SO_3^{-2} = sulfite ion

CO_3^{-2} = carbonate ion

HCO_3^{-} = hydrogen carbonate ion or bicarbonate ion

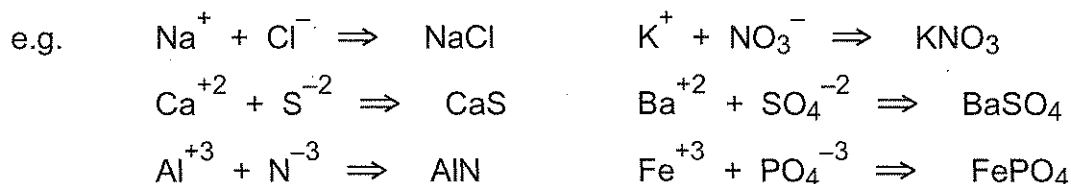
Name each of the following polyatomic ions:



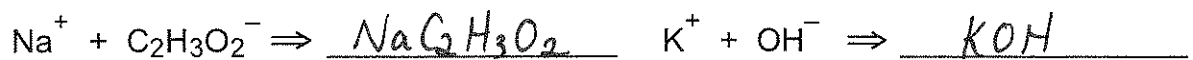
WRITING CHEMICAL FORMULAS GIVEN INDIVIDUAL IONS

Compounds must be neutral \Rightarrow total +ve charge = total -ve charge

1. If the two ions have exactly opposite charges (+1 and -1, +2 and -2, +3 and -3)
fi formula of the compound contains one of each ion



Combine each pair of ions to get the formula of the compound they form:

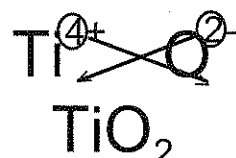
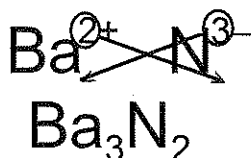
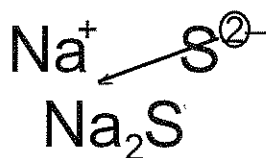


2a. If two monatomic ions have different charges

⇒ **use crossover rule to get formula of the compound**

- superscript for cation becomes subscript for anion
- superscript for anion becomes subscript for cation
- **simplify subscripts** to get lowest ratio of atoms

(Note: **Only the numbers cross down**, not the signs!)



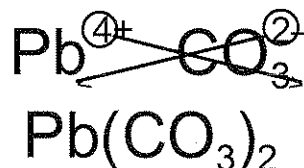
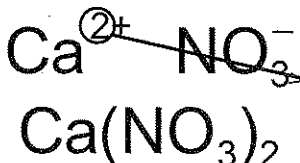
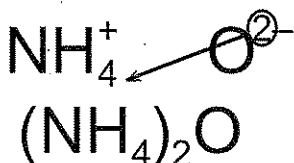
Ti₂O₄ is simplified!

b. If two ions have different charges and at least polyatomic ion is involved

⇒ **use crossover rule to get formula of the compound**

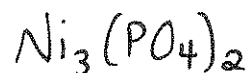
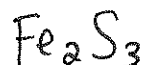
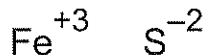
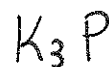
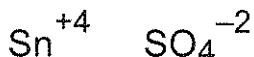
- if more than one of polyatomic ion in formula, use parentheses
- **simplify subscripts** to get lowest ratio of atoms

(Note: Again **only the numbers cross down**, not the signs!)



Pb₂(CO₃)₄ is simplified!

Combine each pair of ions to get the formula of the compound they form:



CHEMICAL FORMULAS AND NAMES FROM INDIVIDUAL IONS

Compounds are named from the individual ions they come from.

Name the cation and the anion, then remove "ion" from each name:

e.g. Na^+ = sodium ion

Cl^- = chloride ion \Rightarrow NaCl = sodium chloride

K^+ = potassium ion

CO_3^{-2} = carbonate ion \Rightarrow K_2CO_3 = potassium carbonate

Fe^{+3} = iron (III) ion

NO_3^- = nitrate ion \Rightarrow $\text{Fe}(\text{NO}_3)_3$ = iron (III) nitrate

Ag^+ = silver ion

S^{-2} = sulfide ion \Rightarrow Ag_2S = silver sulfide

Combine each pair of ions to get the chemical formula, then name the compound:

Individual ions

Compound Formula

Compound Name

Mg^{+2} F^-

MgF_2

magnesium fluoride

Ni^{+2} S^{-2}

NiS

nickel (II) sulfide

Ca^{+2} Br^-

CaBr_2

calcium bromide

Al^{+3} P^{-3}

AlP

aluminum phosphide

Co^{+2} NO_2^-

$\text{Co}(\text{NO}_2)_2$

cobalt (II) nitrite

K^+ CrO_4^{-2}

K_2CrO_4

potassium chromate

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

Fe_2O_3

iron (III) oxide

GIVEN THE CHEMICAL FORMULA, NAME THE COMPOUND

1. If the metal is in Groups IA–IIIA, silver, cadmium, or zinc, then just name the metal cation and the anion:

e.g. **NaCl** \Rightarrow Na = **sodium** and Cl = **chloride** \Rightarrow **sodium chloride**

BaI₂ \Rightarrow Ba = **barium** and I = **iodide** \Rightarrow **barium iodide**

Al(OH)₃ \Rightarrow Al = **aluminum** and OH = **hydroxide** \Rightarrow **aluminum hydroxide**

ZnSO₄ \Rightarrow Zn = **zinc** and SO₄ = **sulfate** \Rightarrow **zinc sulfate**

2. If the metal can form more than one ion,
 - a. Use reverse crossover to get the individual ions
 - Make the **subscript of cation** the **negative charge of anion**
 - Make the **subscript of anion** the **positive charge of cation**
 - b. Check to make sure the charges on the ions are correct
 - c. Name the cation and the anion, then remove “ion” from both

e.g. **NiBr₂** \Rightarrow **Ni⁺²** = **nickel (II) ion** **Br⁻** = **bromide ion**
Is bromide's charge really -1? YES!

then \Rightarrow **NiBr₂** = **nickel (II) bromide**

- d. If a polyatomic ion is involved, remember that more than one polyatomic is shown in parentheses—i.e. **DO NOT bring up the subscript of atoms in a polyatomic ion to be the charge of the metal!**

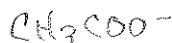
CuSO₄ \Rightarrow There is only ONE Cu and ONE SO₄, so get the charge for the Cu based on the SO₄. The formula is **SO₄⁻²**, and there is only ONE **SO₄⁻²**, so Cu's charge here must be **+2** for the compound to have an overall charge of zero.

\Rightarrow **Cu⁺²** = **copper (II) ion** **SO₄⁻²** = **sulfate ion**

then \Rightarrow **CuSO₄** = **copper (II) sulfate**

Give the name for each compound given its chemical formula:

Formula	Individual Ions	Name of Compound
MgCl ₂	Mg ⁺² Cl ⁻	magnesium chloride
LiOH	Li ⁺ OH ⁻	<i>lithium hydroxide</i>
ZnCO ₃	Zn ²⁺ CO ₃ ²⁻	<i>zinc carbonate</i>
K ₂ S	K ⁺ S ²⁻	<i>potassium sulfide</i>
FePO ₄	Fe ³⁺ PO ₄ ³⁻	<i>iron (III) phosphate</i>
SnO ₂	Sn ⁴⁺ O ²⁻	<i>tin (IV) oxide</i>
CuBr ₂	Cu ²⁺ Br ⁻	<i>copper (II) bromide</i>
Ag ₃ N	Ag ⁺ N ³⁻	<i>silver nitride</i>
Mn(CN) ₂	Mn ²⁺ CN ⁻	<i>manganese (II) cyanide</i>
AgC ₂ H ₃ O ₂	Ag ⁺ C ₂ H ₃ O ₂ ⁻	<i>silver acetate</i>



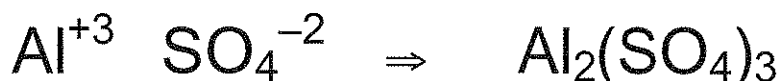
WRITING CHEMICAL FORMULAS GIVEN THE COMPOUND NAME

Get the individual ions from the name, then combine them using the crossover rule:

e.g. barium chloride \Rightarrow barium = Ba⁺² chloride = Cl⁻



aluminum sulfate \Rightarrow aluminum = Al⁺³ sulfate = SO₄⁻²



Give the name for each compound given its chemical formula:

Name of Compound	individual ions	Formula
lithium cyanide	$\text{Li}^+ \text{CN}^-$	LiCN
iron (III) sulfate	$\text{Fe}^{3+} \text{SO}_4^{2-}$	$\text{Fe}_2(\text{SO}_4)_3$
calcium iodide	$\text{Ca}^{2+} \text{I}^-$	CaI_2
tin (IV) dichromate	$\text{Sn}^{4+} \text{Cr}_2\text{O}_7^{2-}$	$\text{Sn}(\text{Cr}_2\text{O}_7)_2$
cadmium nitrite	$\text{Cd}^{2+} \text{NO}_2^-$	$\text{Cd}(\text{NO}_2)_2$
copper (II) acetate	$\text{Cu}^{2+} \text{CH}_3\text{O}_2^-$	$\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$
zinc carbonate	$\text{Zn}^{2+} \text{CO}_3^{2-}$	ZnCO_3
lead (II) phosphide	$\text{Pb}^{2+} \text{P}^{3-}$	Pb_3P_2
potassium sulfite	$\text{K}^+ \text{SO}_3^{2-}$	K_2SO_3
cobalt (II) nitride	$\text{Co}^{2+} \text{N}^{3-}$	Co_3N_2
nickel (II) permanganate	$\text{Ni}^{2+} \text{MnO}_4^-$	$\text{Ni}(\text{MnO}_4)_2$

NAMING MOLECULAR COMPOUNDS

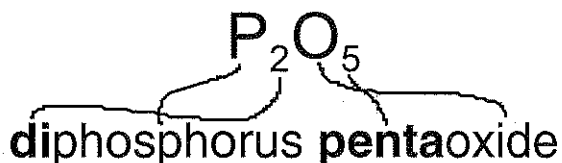
Indicate number of atoms of each element with **Greek prefix** before element name:

# of atoms	Greek Prefix	# of atoms	Greek Prefix
1	mono (usually omitted)	6	hexa
2	di	7	hepta
3	tri	8	octa
4	tetra	9	nona
5	penta	10	deca

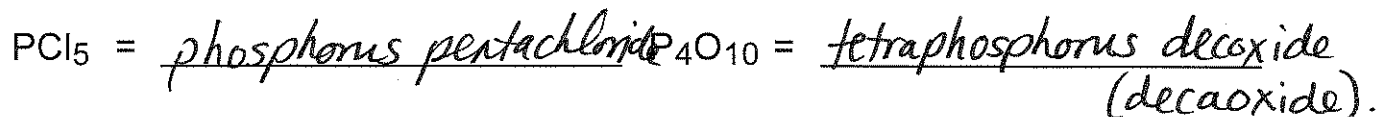
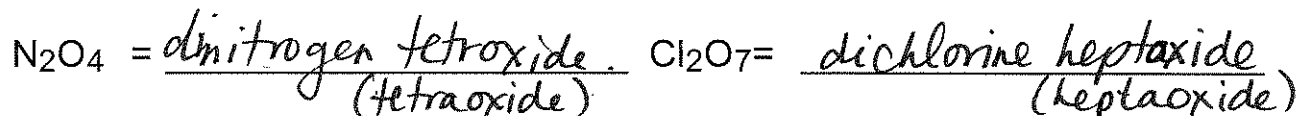
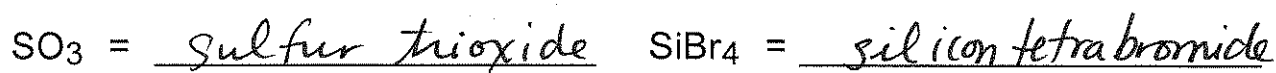
For the **first element**: Greek prefix + element name

For the **second element**: Greek prefix + element name stem + "-ide"

Note: **Mono** is generally omitted, except in common names like
CO = carbon monoxide



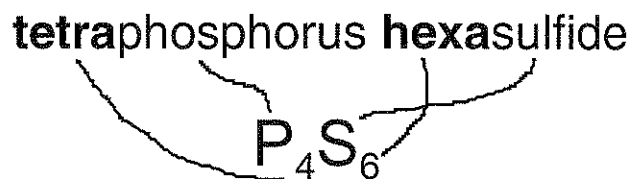
Name the following molecular compounds:



DETERMINING FORMULAS OF MOLECULAR COMPOUNDS

Use Greek prefix(es) to determine number of atoms of each element in formula.

Get **elements** and **number of atoms** of each from name:



Give the formulas for each of the following molecular compounds:

nitrogen trichloride

dibromine heptaoxide

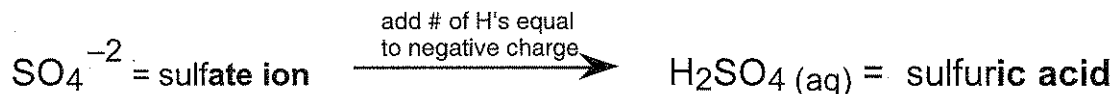
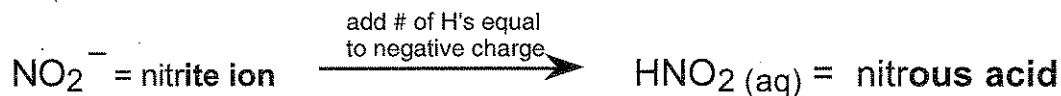
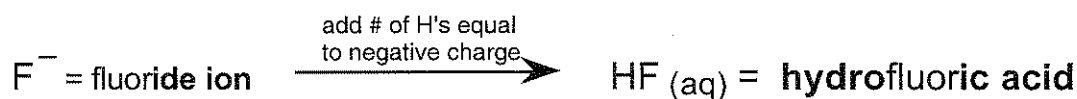
dinitrogen pentasulfide



DETERMINING FORMULAS AND NAMES OF ACIDS FROM IONS

Given an ion,

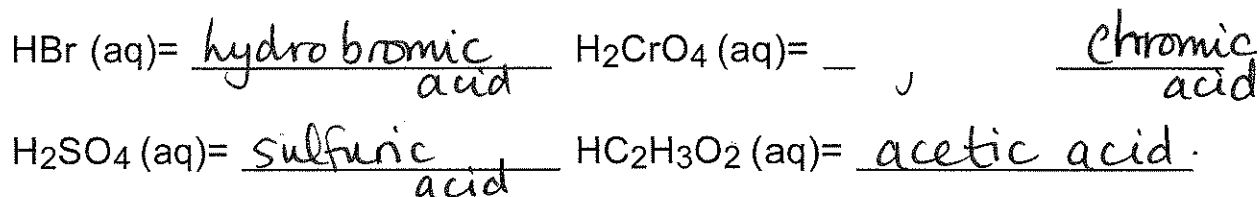
we can get formula of acid by: adding **H atoms** equal to negative charge on ion
we can name for acid: depending on suffix of ion name



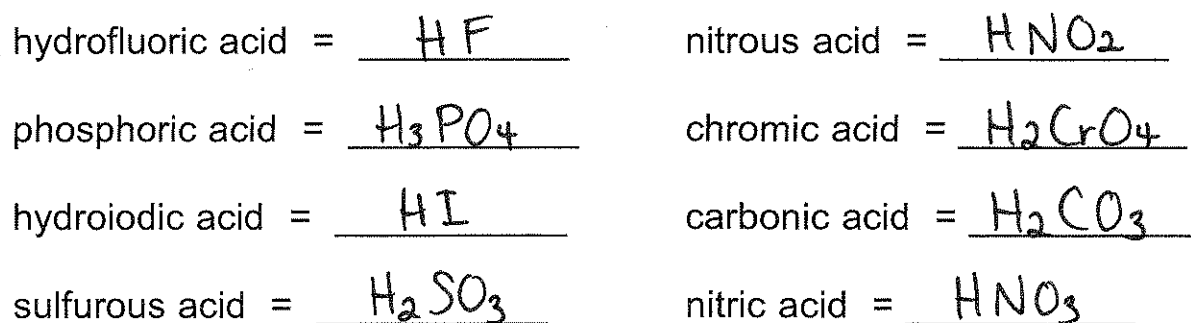
Name each of the following ions, and determine the formula and name of the corresponding acid that forms from the ion.

Name of Ion	Formula of Acid	Name of Acid
$\text{Cl}^- =$ <u>chloride ion</u>	\Rightarrow <u>HCl</u> (aq)	<u>hydrochloric acid</u>
$\text{CO}_3^{2-} =$ <u>carbonate ion</u>	\Rightarrow <u>H_2CO_3</u> (aq)	<u>carbonic acid</u>
$\text{SO}_3^{2-} =$ <u>sulfite ion</u>	\Rightarrow <u>H_2SO_3</u> (aq)	<u>sulfurous acid</u>
$\text{PO}_4^{3-} =$ <u>phosphate ion</u>	\Rightarrow <u>H_3PO_4</u> (aq)	<u>phosphoric acid</u>
$\text{NO}_3^- =$ <u>nitrate ion</u>	\Rightarrow <u>HNO_3</u> (aq)	<u>nitric acid</u>

Name each of the following acids:



Give the formula for each of the following acids: [Don't forget to indicate (aq)!]



PUTTING IT ALL TOGETHER:

Name each of the following compounds:

