

## NOMENCLATURE

### I. Binary Molecular (covalent) Compounds (2 non-metals)

- Decide the first element in the name (it will also be the first in the formula)
- The first element's name remains unchanged.
- The second element's name gets an -ide ending.
- Both elements get a prefix to denote the number of atoms of that element in the compound

EXCEPT mono is not used in front of the first element.

- When the prefix ends in "a" or "o" and the element name begins with "a" or "o" the final vowel of the prefix is dropped to make pronunciation easier.
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Number of Atoms	Prefix
1	mono
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

#### Examples:

Write the name of the following compounds: a) CO b) Cl<sub>2</sub>O<sub>7</sub> c) ICl<sub>3</sub>

Write formulas for the following compounds: a) dichlorine heptoxide b) sulfur hexafluoride

### II. Ionic compounds

#### Oxidation Numbers

- Represent how many electrons an atom has lost (positive oxidation number) or gained (negative oxidation number) when it is chemically combined with another element.

#### Rules for oxidation numbers:

- Group IA metals = +1 (always)
- Group IIA metals = +2 (always)

- Group VIA nonmetals = -2 in binary ionic compounds
- Group VA nonmetals = -3 in binary ionic compounds
- F = -1 (always)
- Cl, Br, I = -1 (except when attached to a more electronegative element: O or F)
- O = -2 (almost always)
- Al = +3, Zn = +2, Cd = +2, Ag = +1
- H = +1 except when attached to a metal then H = -1.

For ions the sum of the oxidation numbers = the charge on the ion. For neutral molecules the sum of all the oxidation numbers = 0. For elements the oxidation number = 0.

### Examples:

Predict the oxidation number for each atom in the following compounds: a)  $K_2Cr_2O_7$  b)  $PO_4^{3-}$  c)  $FeH_2$

### Naming Binary Ionic Compounds (salts) – metal and a non-metal.

- The cation (+) comes first, followed by the anion (-)

#### A. Metal ions with fixed charges (oxidation numbers)

- See oxidation number rules for the metals with fixed charges.
- The first element's name remains unchanged
- The second element's name gets an -ide ending.

#### Examples:

Name: a)  $MgS$  b)  $CaCl_2$

Give the formulas for: a) aluminum oxide b) lithium oxide c) calcium nitride

#### B. Metal ions with variable charges (oxidation numbers)

- Are followed by a Roman numeral to denote their charge (new/Stock naming system).
- Older naming system is derived from the Latin element name with an -ous or -ic ending.

+1 (-ous)	+2(-ic)	+2 (-ous)	+3(-ic)	+2 (-ous)	+4 (-ic)
$Cu^+$ copper (I)	(cuprous)	$Co^{2+}$ cobalt (II)	(cobaltous)	$Pb^{2+}$ lead (II)	(plumbous)
$Cu^{2+}$ copper (II)	(cupric)	$Co^{3+}$ cobalt (III)	(cobaltic)	$Pb^{4+}$ lead (IV)	(plumbic)
$Hg_2^{2+}$ mercury (I)	(mercurous)	$Fe^{2+}$ iron (II)	(ferrous)	$Sn^{2+}$ tin (II)	(stannous)
$Hg^{2+}$ mercury (II)	(mercuric)	$Fe^{3+}$ iron (III)	(ferric)	$Sn^{4+}$ tin (IV)	(stannic)

- The first element has the name as shown above.
- The second element gets an -ide ending.

### Examples:

Name the following: a) CuO b) NaBr c) AlN d) PbI<sub>4</sub> e) Fe<sub>2</sub>O<sub>3</sub> f) Hg<sub>2</sub>Cl<sub>2</sub>

Give formulas for the following: a) manganese (IV) oxide b) gold (I) sulfide c) plumbous oxide

### C. Polyatomic ions

- Charged groups of bonded atoms.
- Do not change their name

#### Common polyatomic ions:

NH<sub>4</sub><sup>+</sup> ammonium                      MnO<sub>4</sub><sup>-</sup>                      permanganate

OH<sup>-</sup> hydroxide                      C<sub>2</sub>H<sub>3</sub>O<sub>2</sub><sup>-</sup>                      acetate

H<sup>-</sup> hydride                      C<sub>2</sub>O<sub>4</sub><sup>2-</sup>                      oxalate

CN<sup>-</sup> cyanide                      CrO<sub>4</sub><sup>2-</sup>                      chromate

SCN<sup>-</sup> thiocyanate                      Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>                      dichromate

#### Oxyanions ending in ----ate:

- Polyatomic ions containing oxygen and a non-metal

IIIA	IVA	VA	VIA	VIIA
BO <sub>3</sub> <sup>3-</sup>	CO <sub>3</sub> <sup>2-</sup>	NO <sub>3</sub> <sup>-</sup>	---	---
borate	carbonate	nitrate		
	SiO <sub>3</sub> <sup>2-</sup>	PO <sub>4</sub> <sup>3-</sup>	SO <sub>4</sub> <sup>2-</sup>	ClO <sub>3</sub> <sup>-</sup>
	silicate	phosphate	sulfate	chlorate
		AsO <sub>4</sub> <sup>3-</sup>	SeO <sub>4</sub> <sup>2-</sup>	BrO <sub>3</sub> <sup>-</sup>
		arsenate	selenate	bromate
			TeO <sub>4</sub> <sup>2-</sup>	IO <sub>3</sub> <sup>-</sup>
			tellurate	iodate

### Other oxyanions:

- Memorize the –ate oxyanions then change the name according to the number of oxygens.
- The charge on the oxyanion does not change when the number of oxygens is changed.

### Prefixes and suffixes for oxyanions

2 oxygens less than -- ate ion	1 oxygen less than -- ate ion	--ate ion	1 oxygen more than
hypo-----ite	-----ite	-----ate	--ate ion per-----ate
$\text{ClO}^-$	$\text{ClO}_2^-$	$\text{ClO}_3^-$	$\text{ClO}_4^-$
hypochlorite ion	chlorite ion	chlorate ion	perchlorate ion

- Note: only Cl, Br, and I commonly have all of the oxyanions. B and C only commonly have the —ate ion, the rest of the elements above have the –ate and –ite forms.

### Examples of oxyanions:

Name the following: a)  $\text{PO}_3^{3-}$  b)  $\text{NO}_2^-$  c)  $\text{TeO}_2^{2-}$  d)  $\text{IO}_4^-$

Give the formulas for the following: a) bromite ion b) sulfite ion c) silicite ion d) arsenite ion

### Acid anions:

- All negative ions with a –2 or –3 charge can form acid anions by adding one or more hydrogens
- Addition of one hydrogen to the anion decreases the charge by one and is named by writing *hydrogen* in front of the anion name.
- Addition of two hydrogens decreases the charge by two and is named by writing *dihydrogen* in front of the anion name

**Example:**  $\text{HPO}_4^{2-}$  is the hydrogen phosphate ion,  $\text{H}_2\text{PO}_4^-$  is the dihydrogen phosphate ion

- Compounds containing acid anions are called *acid salts*

### Examples of ionic compounds containing polyatomic ions:

Write the formulas for the following: a) calcium hypochlorite b) chromium (III) sulfate

c) copper (II) periodate d) sodium sulfite e) barium arsenite f) ammonium chlorite

Give the names for the following: a)  $\text{Mg}(\text{ClO}_4)_2$  b)  $\text{KHCO}_3$  c)  $\text{FePO}_4$  d)  $\text{Mg}(\text{H}_2\text{PO}_4)_2$  e)  $\text{Ag}_2\text{C}_2\text{O}_4$  f)  $\text{Pb}_3(\text{PO}_3)_4$

### Hydrates:

- An ionic compound containing a fixed number of water molecules
- Name the ionic compound followed by ---hydrate
- Use a prefix to denote the number of water molecules.

### Example:

Name the following: a)  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$  b)  $\text{LiClO}_4 \cdot 3\text{H}_2\text{O}$  c)  $\text{MgCO}_3 \cdot 5\text{H}_2\text{O}$

## III. Acids and Bases

### Arrhenius Definition:

- An acid is a molecular compound that ionizes in water to form a solution containing  $\text{H}^+$  ions and anions.
- A base ionizes in water to give a solution containing  $\text{OH}^-$  ions and cations.

### Binary Acids:

- When in their natural (gaseous) state, they are named as binary covalent compounds without the prefixes.
- When in an aqueous solution, they behave differently and are named hydro-----ic acid.

### Example:

Name the following: a)  $\text{HF}_{(g)}$  and  $\text{HF}_{(aq)}$  b)  $\text{H}_2\text{S}_{(g)}$  and  $\text{H}_2\text{S}_{(aq)}$  c)  $\text{HCl}_{(g)}$  and  $\text{HCl}_{(aq)}$

### Oxyacids (acids derived from oxyanions):

- ---ate ions become ---ic acids
- the formula for the acid has as many hydrogens as charges on the oxyanion.

**Example:**  $\text{SO}_4^{2-}$  is the sulfate oxyanion. Its oxyacid is  $\text{H}_2\text{SO}_4$  and is named sulfuric acid.

Note the root name for sulfur derived oxyacids is *sulfur* instead of *sulf*

### Prefixes and suffixes for oxyacids:

2 oxygens less than --- ic acid hypo---ous acid	1 oxygen less than --- ic acid ---ous acid	---ic acid ---ic acid	1 oxygen more than -- -ic acid per---ic acid
$\text{HClO}$ hypochlorous acid	$\text{HClO}_2$ chlorous acid	$\text{HClO}_3$ chloric acid	$\text{HClO}_4$ perchloric acid

**Example:**

Name the following: a)  $\text{H}_3\text{PO}_3$  b)  $\text{HNO}_2$  c)  $\text{H}_2\text{TeO}_2$  d)  $\text{HIO}_4$

Give formulas for the following: a) bromous acid b) sulfurous acid c) hypoiodous acid

**Other acids:**

$\text{HCN}$  hydrocyanic acid       $\text{HC}_2\text{H}_3\text{O}_2$  acetic acid       $\text{H}_2\text{C}_2\text{O}_4$  oxalic acid

**Bases:**

- Ionic bases are named as for ionic compounds – most are formed from group IA and IIA cations. Many are hydroxides.
- Most bases are molecular. Many of them are ammonia and its compounds.

Ammonia :  $\text{NH}_{3(g)}$       Ammonia in solution:  $\text{NH}_{3(aq)}$  or  $\text{NH}_4\text{OH}$ : ammonium hydroxide