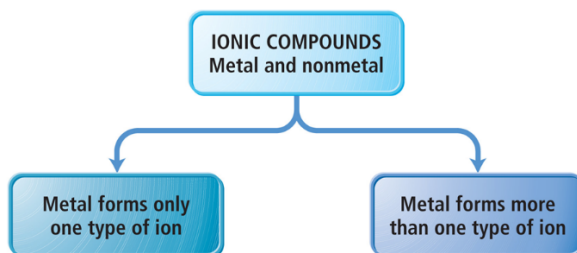


Module-12: Chemical Nomenclature



NAMING IONIC COMPOUNDS

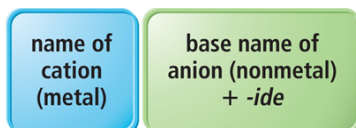
- The first step in naming ionic compounds is to recognize which are ionic compounds, remember that ionic compounds are formed between metal and non-metals. Exceptions are ammonium salts, which are ionic, but they do not contain a metal ion.
- Before naming, correctly identifying charge on the metal is essential in naming ionic compounds. The rules that we follow for nomenclature depends whether we are naming ionic compounds formed by metal ions that have fixed oxidation states (charges) or variable oxidation states.



- The main group metal ions display fixed oxidation states (except Sn & Pb), and the charges on the metal ions in the main group is equal to the group numbers.
- The transition metal ions display variable oxidation states and we cannot assign oxidation states based on the group numbers.

IA																	VIIIA
H ⁺																	
Li ⁺																	
Na ⁺	Mg ²⁺																
		IIIB	IVB	VB	VIB	VII B	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	
K ⁺	Ca ²⁺				Cr ²⁺	Mn ²⁺	Fe ²⁺	Co ²⁺	Ni ²⁺	Cu ⁺	Zn ²⁺			N ³⁻	O ²⁻	F ⁻	
					Cr ³⁺	Mn ³⁺	Fe ³⁺	Co ³⁺	Ni ³⁺	Cu ²⁺				P ³⁻	S ²⁻	Cl ⁻	
Rb ⁺	Sr ²⁺																
										Ag ⁺	Cd ²⁺		Sn ²⁺			I ⁻	
Cs ⁺	Ba ²⁺												Sn ⁴⁺				
											Hg ₂ ²⁺		Pb ²⁺				
											Hg ²⁺		Pb ⁴⁺				

- First, we will name the ionic compounds that are formed by the main group metal ions, more specifically binary inorganic compounds. These are compounds comprised of only two different elements.
- Binary ionic compounds formed by main group metallic elements are named by following this simple rule.



Example: 1

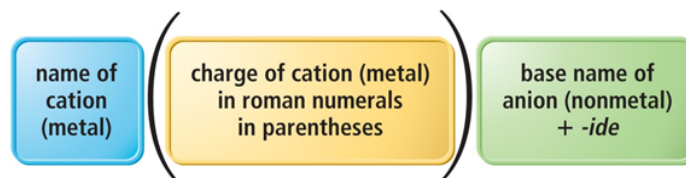
- | | |
|------------------------------------|---|
| ◆ NaCl – sodium chloride | ◆ K ₂ S – potassium sulfide |
| ◆ KCl – potassium chloride | ◆ CaCl ₂ – calcium chloride |
| ◆ Na ₂ O – sodium oxide | ◆ BeBr ₂ – beryllium bromide |
| ◆ CaO – calcium oxide | ◆ Al ₂ S ₃ – aluminum sulfide |

- As mentioned earlier, the anions, end with suffix, *ide*, the following table lists common anions with the appropriate names.

Some Common Anions

Nonmetal	Symbol for Ion	Base Name	Anion Name
Fluorine	F ⁻	fluor	Fluoride
Chlorine	Cl ⁻	chlor	Chloride
Bromine	Br ⁻	brom	Bromide
Iodine	I ⁻	iod	Iodide
Oxygen	O ²⁻	ox	Oxide
Sulfur	S ²⁻	sulf	Sulfide
Nitrogen	N ³⁻	nitr	Nitride
Phosphorus	P ³⁻	phosph	Phosphide

- Next, let us learn how to name ionic compounds that are formed by metal ions with variable oxidation states. The following rule is employed to name such ionic compounds.



Example: 2

- ◆ FeCl_2 – iron(II) chloride
- ◆ FeCl_3 – iron(III) chloride
- ◆ CuCl_2 – copper(II) chloride
- ◆ CrCl_3 – chromium(III) chloride
- ◆ AuCl_3 – gold(III) chloride
- ◆ Cu_2O – copper(I) oxide
- ◆ CuO – copper(II) oxide
- ◆ TiBr_4 – titanium(IV) bromide
- ◆ SnCl_2 – tin(II) chloride
- ◆ SnCl_4 – tin(IV) chloride

Metals Whose Charge Is Invariant from One Compound to Another

Metal	Ion	Name	Group Number
Li	Li^+	Lithium	1A
Na	Na^+	Sodium	1A
K	K^+	Potassium	1A
Rb	Rb^+	Rubidium	1A
Cs	Cs^+	Cesium	1A
Be	Be^{2+}	Beryllium	2A
Mg	Mg^{2+}	Magnesium	2A
Ca	Ca^{2+}	Calcium	2A
Sr	Sr^{2+}	Strontium	2A
Ba	Ba^{2+}	Barium	2A
Al	Al^{3+}	Aluminum	3A
Zn	Zn^{2+}	Zinc	*
Sc	Sc^{3+}	Scandium	*
Ag**	Ag^+	Silver	*

* The charge of these metals cannot be inferred from their group number.

** Silver does sometimes form compounds with other charges, but these are rare.

Some Metals That Form Cations with Different Charges

Metal	Ion	Name	Older Name*
Chromium	Cr^{2+}	Chromium(II)	Chromous
	Cr^{3+}	Chromium(III)	Chromic
Iron	Fe^{2+}	Iron(II)	Ferrous
	Fe^{3+}	Iron(III)	Ferric
Cobalt	Co^{2+}	Cobalt(II)	Cobaltous
	Co^{3+}	Cobalt(III)	Cobaltic
Copper	Cu^+	Copper(I)	Cuprous
	Cu^{2+}	Copper(II)	Cupric
Tin	Sn^{2+}	Tin(II)	Stannous
	Sn^{4+}	Tin(IV)	Stannic
Mercury	Hg_2^{2+}	Mercury(I)	Mercurous
	Hg^{2+}	Mercury(II)	Mercuric
Lead	Pb^{2+}	Lead(II)	Plumbous
	Pb^{4+}	Lead(IV)	Plumbic

*An older naming system substitutes the names found in this column for the name of the metal and its charge. Under this system, chromium(II) oxide is named chromous oxide. In this system, the suffix *-ous* indicates the ion with the lesser charge and *-ic* indicates the ion with the greater charge. We will *not* use the older system in this text.

- Polyatomic ions: There are ions which contain more than one atom, and in most cases more than one element, these are called polyatomic ions.

Some Common Polyatomic Ions

Name	Formula	Name	Formula
Acetate	$\text{C}_2\text{H}_3\text{O}_2^-$	Hypochlorite	ClO^-
Carbonate	CO_3^{2-}	Chlorite	ClO_2^-
Hydrogen carbonate (or bicarbonate)	HCO_3^-	Chlorate	ClO_3^-
Hydroxide	OH^-	Perchlorate	ClO_4^-
Nitrite	NO_2^-	Permanganate	MnO_4^-
Nitrate	NO_3^-	Sulfite	SO_3^{2-}
Chromate	CrO_4^{2-}	Hydrogen sulfite (or bisulfite)	HSO_3^-
Dichromate	$\text{Cr}_2\text{O}_7^{2-}$	Sulfate	SO_4^{2-}
Phosphate	PO_4^{3-}	Hydrogen sulfate (or bisulfate)	HSO_4^-
Hydrogen phosphate	HPO_4^{2-}	Cyanide	CN^-
Dihydrogen phosphate	H_2PO_4^-	Peroxide	O_2^{2-}
Ammonium	NH_4^+		

- Ionic compounds formed by polyatomic ions are named as usual like any ionic compounds, cation is named first and then the anion.

Example: 3

- | | |
|--|--|
| ◆ NaNO_2 – sodium nitrite | ◆ Na_2CO_3 – sodium carbonate |
| ◆ NaNO_3 – sodium nitrate | ◆ CaCO_3 – calcium carbonate |
| ◆ Na_2SO_4 – sodium sulfate | ◆ CuCO_3 – copper(II) carbonate |
| ◆ K_3PO_4 – potassium phosphate | ◆ FeSO_4 – iron(II) sulfate |
| ◆ $\text{Fe}(\text{NO}_3)_3$ – iron(III) nitrate | ◆ $\text{Fe}_2(\text{SO}_4)_3$ – iron(III) sulfate |
| ◆ NH_4Cl – ammonium chloride | ◆ $(\text{NH}_4)_2\text{SO}_4$ – ammonium sulfate |

NAMING MOLECULAR COMPOUNDS

- Unlike ionic compounds, it is not easy to predict the ratio in which the elements combine to form the molecular compounds. For example, nitrogen and oxygen combine in many different ways.



- The following method of nomenclature is followed while naming molecular compounds:



- The number of each type of atom in a binary molecule is specified with Greek prefixes.

Greek Prefixes

mono-	= 1 (often omitted)	hexa-	= 6
di-	= 2	hepta-	= 7
tri-	= 3	octa-	= 8
tetra-	= 4	nona-	= 9
penta-	= 5	deca-	= 10

Example: 4

<p>PF₅ = phosphorus pentafluoride</p> <p>N₂O = dinitrogen monoxide</p> <p>NI₃ = nitrogen triiodide</p> <p>N₂O₄ = dinitrogen tetraoxide</p> <p>CO = carbon monoxide</p>	<p>PCl₃ = phosphorus trichloride</p> <p>SO₂ = sulfur dioxide</p> <p>CCl₄ = carbon tetrachloride</p> <p>NO₂ = nitrogen dioxide</p> <p>CO₂ = carbon dioxide</p>
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NAMING COMPOUNDS THAT ARE HYDRATED

- Hydrates are ionic compounds containing a specific number of water molecules in each formula unit. The names of hydrates contain the name of the ionic compounds first followed by the part that indicates the number of water molecules.
- For example, the formula for Epsom salt is $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, the systematic name is magnesium sulfate heptahydrate.

Example: 5

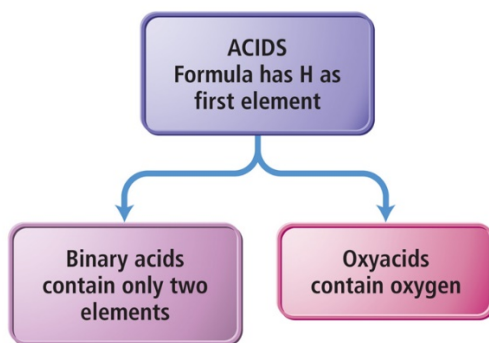
$\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$: calcium sulfate hemihydrate

$\text{BaCl}_2 \cdot 6 \text{H}_2\text{O}$: barium chloride hexahydrate

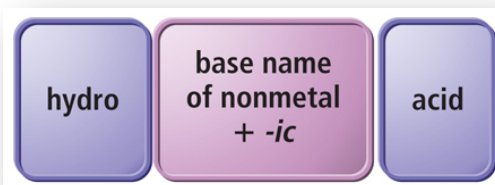
$\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$: copper(II) sulfate pentahydrate

NAMING ACIDS

- Acids are broadly divided into binary and oxyacids.



- Naming binary acids is simple; they are named as illustrated below



Example: 6

HCl – hydrochloric acid

HBr – hydrobromic acid

HF – hydrofluoric acid

HI – hydroiodic acid

- The oxyacids with corresponding anions ending with *ite* and *ate* are named as illustrated below.

**Example: 7**

Base ion	sulfite SO_3^{2-}	H_2SO_3 – sulfurous acid
Base ion	sulfate SO_4^{2-}	H_2SO_4 – sulfuric acid
Base ion	nitrite NO_2^-	HNO_2 – nitrous acid
Base ion	nitrate NO_3^-	HNO_3 – nitric acid

Practice Problems

1. Give the systematic names for the following ionic binary compounds.

- (a) Na_2S
- (b) K_2O
- (c) Al_2O_3
- (d) CaBr_2
- (e) BaS
- (f) FeS
- (g) Fe_2S_3
- (h) SnCl_2
- (i) SnCl_4
- (j) CuS
- (k) CuBr
- (l) CuCl_2

2. Write chemical formula for the binary ionic compounds.

- (a) lead(II) iodide
- (b) potassium bromide
- (c) nickel(II) oxide
- (d) calcium fluoride
- (e) manganese(IV) oxide
- (f) chromium(III) oxide

3. Give the systematic names for the following ionic compounds formed by polyatomic ions.

- (a) Na_2CrO_4
- (b) $\text{Cu}(\text{ClO}_4)_2$
- (c) $\text{Mn}_3(\text{PO}_4)_2$
- (d) Cs_2CO_3
- (e) $\text{Au}_2(\text{SO}_4)_3$
- (f) Ag_2CO_3
- (e) $\text{Sn}_3(\text{PO}_4)_4$

4. Write the chemical formula for the ionic compounds formed by polyatomic ions.

- (a) ammonium sulfate
- (b) iron(II) phosphate
- (c) chromium(II) sulfate
- (d) zinc(II) carbonate
- (e) sodium phosphate
- (f) calcium phosphate
- (g) sodium sulfite
- (h) sodium peroxide
- (i) nickel(II) nitrate
- (j) nickel(II) nitrite

5. Name the following molecular compounds.

- (a) PF_3
- (b) BCl_3
- (c) SiO_2
- (d) BrF_5
- (e) SO_2
- (f) SO_3
- (g) SF_6
- (h) XeF_4
- (i) N_2F_2

6. Write the molecular formula for the following compounds.

- (a) chlorine dioxide
- (b) nitrogen trichloride
- (c) disulfur dichloride
- (d) silicon tetrabromide

7. Name the following oxyacids



8. The formula of an oxyacid is H_2XO_4 , identify the element is X?

(A) C

(B) Se

(C) N

(D) B