

Chemistry: Writing and Naming Ionic Compounds

An ionic compound is composed of a positively charged ion (cation) bonded with a negatively charged ion (anion).

CATIONS are found in:

- Group 1 – all ions in this column are 1+ (usually written as just +)
- Group 2 – all ions in this column are 2+
- Group 3 – all ions in this column are 3+
- Group 4 – only Semimetal Ge (4+) and Metals Sn (2+/4+), and Pb (2+/4+)
- Group 5 – only Semimetal Sb (3+/5+) and Metal Bi (3+/5+)
- D-block - Transition Metals (often with variable oxidation states):

<u>Sc</u> 3+	<u>Ti</u> (2+) 3+ 4+	<u>V</u> (1+) 2+ 3+ 4+ 5+	<u>Cr</u> 2+ 3+ (4+) (5+) 6+	<u>Mn</u> 2+ (3+) 4+ (6+) 7+	<u>Fe</u> 2+ 3+ (4+) (6+)	<u>Co</u> 2+ 3+ (4+)	<u>Ni</u> 2+ (3+) (4+)	<u>Cu</u> 1+ 2+	<u>Zn</u> 2+
<u>Y</u> 3+	<u>Zr</u> 4+	<u>Nb</u> 3+ (4+) 5+	<u>Mo</u> (2+) 3+ 4+ 5+ 6+	<u>Tc</u> (2+) (3+) 4+ (5+) 6+ 7+	<u>Ru</u> 3+ 4+ 5+ 6+ 7+ 8+	<u>Rh</u> (1+) 3+ (4+) (6+)	<u>Pd</u> 2+ (3+) 4+	<u>Ag</u> 1+ (2+) (3+)	<u>Cd</u> 2+
<u>La</u> 3+	<u>Hf</u> 4+	<u>Ta</u> (3+) 4+ 5+	<u>W</u> 2+ 3+ 4+ 5+ 6+	<u>Re</u> 3+ 4+ 5+ 6+ 7+	<u>Os</u> 3+ 4+ (5+) 6+ 8+	<u>Ir</u> (1+) (2+) 3+ (4+) (6+)	<u>Pt</u> 2+ (3+) 4+	<u>Au</u> 1+ 3+	<u>Hg</u> 1+ 2+

- Nonmetallic Positive Polyatomic Ion:
 - NH_4^+ ammonium

The **ANION** is one of the following:

- Group 5 – only Nonmetals N and P and Semimetal As, which all are 3-
- Group 6 – Nonmetals O, S, and Se and Semimetals Te and Po, which are all 2-
- Group 7 - Halogens; all ions in this column are 1- (usually written as just -)
- Nonmetallic Negative Polyatomic Ion:

1-		2-		3-	
Ion	Name	Ion	Name	Ion	Name
$\text{C}_2\text{H}_3\text{O}_2^-$	acetate	CO_3^{2-}	carbonate	PO_3^{3-}	phosphite
HCO_3^-	bicarbonate	CrO_4^{2-}	chromate	PO_4^{3-}	phosphate
HSO_4^-	bisulfate	$\text{Cr}_2\text{O}_7^{2-}$	dichromate		
CrO_2^-	chromite	$\text{C}_2\text{O}_4^{2-}$	oxalate		
ClO_2^-	chlorite	O_2^{2-}	peroxide		
ClO_3^-	chlorate	SO_3^{2-}	sulfite		
CN^-	cyanide	SO_4^{2-}	sulfate		
OCN^-	cyanate	$\text{S}_2\text{O}_3^{2-}$	thiosulfate		
OH^-	hydroxide				
ClO^-	hypochlorite				
NO_2^-	nitrite				
NO_3^-	nitrate				
ClO_4^-	perchlorate				
MnO_4^-	permanganate				

(this is not a comprehensive list)

Steps for writing all Ionic Compounds:

- 1) Write the cation and its charge first (on the left).
- 2) Write the anion and its charge second (on the right).
- 3) Ignoring the +, drop the number of the charge of the cation down as a subscript on the second element/compound. Ignoring the -, drop the number of the charge of the anion down as a subscript on the first element/compound.

Exceptions:

- 3a. If the number is 1, there is no need to write it as a subscript.
- 3b. Consider the charges as ratios and simplify if possible.
- 3c. If a Polyatomic Ion is involved, parentheses are used to distinguish the compound from its new subscript.

Situation A: Group 1, 2, 3, 4, or 5 Cation with a Group 5, 6, or 7 Anion

Writing:

	Steps 1 & 2	Step 3
Typical	$Be^{2+} N^{3-}$	Be_3N_2
Exception 3a	$Li^{1+} O^{2-}$	Li_2O
Exception 3b	$Mg^{2+} S^{2-}$	MgS

Naming:

- 1) Write the cation name first
- 2) Write the anion name second, changing the suffix to *-ide*
 $Be_3N_2 \rightarrow$ *beryllium nitride*
 $Li_2O \rightarrow$ *lithium oxide*
 $MgS \rightarrow$ *magnesium sulfide*

Situation B: Metal w/ Variable Oxidation State with a Group 5, 6, or 7 Anion

Some of the Transition Metals, Semimetals, and Metals have various oxidation states (charges). (See the 4th, 5th, and 6th bullet points under "Cations" on Page 1.)

Writing:

	Steps 1 & 2	Step 3
Typical	$Zn^{2+} P^{3-}$	Zn_3P_2
Exception 3a	$Cu^{1+} Se^{2-}$	Cu_2Se
Exception 3b	$Cu^{2+} Se^{2-}$	$CuSe$

Naming:

- 1) Write the cation name first
 - a. If the Transition Metal, Semimetal, or Metal has various oxidation states, include the charge of it as Roman Numerals in parentheses after the name
- 2) Write the anion name second, changing the suffix to *-ide*
 $Zn_3P_2 \rightarrow$ *zinc (II) phosphide* or just *zinc phosphide*
 $Cu_2Se \rightarrow$ *copper (I) selenide*
 $CuSe \rightarrow$ *copper (II) selenide*

Situation C: Positive Polyatomic Ion with a Group 5, 6, or 7 Anion**Writing:**

	Steps 1 & 2	Step 3
Typical	NH_4^{1+} Cl^{1-}	NH_4Cl
Exception 3c	NH_4^{1+} S^{2-}	$(NH_4)_2S$

Naming:

- 1) Write the Positive Polyatomic Ion (cation) name first
- 2) Write the anion name second, changing the suffix to *-ide*
 $NH_4Cl \rightarrow$ ammonium chloride
 $(NH_4)_2S \rightarrow$ ammonium sulfide

Situation D: Group 1, 2, 3, 4, or 5 Cation with a Negative Polyatomic Ion**Writing:**

	Steps 1 & 2	Step 3
Exception 3a	K^{1+} $C_2H_3O_2^{1-}$	$KC_2H_3O_2$
Exception 3b	Ca^{2+} CO_3^{2-}	$CaCO_3$
Exception 3c	Ca^{2+} PO_4^{3-}	$Ca_3(PO_4)_2$

Naming:

- 1) Write the cation name first
- 2) Write the Negative Polyatomic Ion (anion) name second
 $KC_2H_3O_2 \rightarrow$ potassium acetate
 $CaCO_3 \rightarrow$ calcium carbonate
 $Ca_3(PO_4)_2 \rightarrow$ calcium phosphate

Situation E: Metal w/ Variable Oxidation State with Negative Polyatomic Ion

Some of the Transition Metals, Semimetals, and Metals have various oxidation states (charges). (See the 4th, 5th, and 6th bullet points under "Cations" on Page 1.)

Writing:

	Steps 1 & 2	Step 3
Exception 3a	Ag^{1+} ClO_2^{1-}	$AgClO_2$
Exception 3b	Mn^{2+} CrO_4^{2-}	$MnCrO_4$
Exception 3c	Mn^{3+} CrO_4^{2-}	$Mn_2(CrO_4)_3$

Naming:

- 1) Write the Transition Metal (cation) name first
 - a. If the Transition Metal has various oxidation states, include the charge of it as Roman Numerals in parentheses after the name
- 2) Write the Negative Polyatomic Ion (anion) name second
 $AgClO_2 \rightarrow$ silver chlorite
 $MnCrO_4 \rightarrow$ manganese (II) chromate
 $Mn_2(CrO_4)_3 \rightarrow$ manganese (III) chromate