

TABLE 3.8 Rules for Writing Formulas of Binary Ionic Compounds

Rules for Names	Examples	
	magnesium phosphide	aluminum bromide
1. Identify each ion and its charge.	magnesium: Mg^{+2} phosphide: P^{-3}	aluminum: Al^{+3} bromide: Br^{-1}
2. Determine the total charges needed to balance positive with negative.	Mg^{+2} : $+2 +2 +2 = +6$ P^{-3} : $-3 -3 = -6$	Al^{+3} : $= +3$ Br^{-1} : $-1 -1 -1 = -3$
3. Note the ratio of positive ions to negative ions.	3 Mg^{+2} ions for every 2 P^{-3} ions	1 Al^{+3} ion for every 3 Br^{-1} ions
4. Use subscripts to write the formula. Omit "1" where only one ion is needed.	Mg_3P_2	$AlBr_3$

Study Prep

1. Write the formulas of the ionic compounds containing the following ions:

a) Na^{+1} with F^{-1}

b) Mg^{+2} with Br^{-1}

c) Cs^{+1} with S^{-2}

d) Ba^{+2} with O^{-2}

e) Ca^{+2} with P^{-3}

~~SKIP~~

2. Write the formulas of the following binary ionic compounds:

a) potassium chloride _____

b) strontium nitride _____

c) silver sulphide _____

d) zinc selenide _____

e) beryllium sulphide _____

f) rubidium oxide _____

g) lithium nitride _____

h) radium iodide _____

i) aluminum phosphide _____

j) magnesium sulphide _____

k) lithium fluoride _____

l) beryllium iodide _____

m) magnesium oxide _____

n) radium nitride _____

o) potassium sulphide _____

3. Write the names of the following binary ionic compounds:

- a) CsI _____
- b) Ba₃N₂ _____
- c) CdCl₂ _____
- d) AlF₃ _____
- e) Li₂O _____
- f) K₂O _____
- g) Na₂O _____
- h) CaI₂ _____
- i) Sr₃P₂ _____
- j) CaO _____
- k) Cd₃N₂ _____
- l) RaBr₂ _____
- m) RbF _____
- n) AlCl₃ _____
- o) NaBr _____

Metals with More Than One Combining Capacity

An element that can form more than one stable ion is called a **multivalent** element. Most metals in the middle of the periodic table are multivalent. Their combining capacities are listed in the periodic table, with the most common one listed first. For example, iron can have either a +2 or a +3 ion, but the +3 ion is the most common. The symbols and names of the iron ions are:

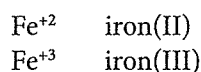


TABLE 3.9
Roman Numerals

Number	Roman Numeral
1	I
2	II
3	III
4	IV
5	V
6	VI
7	VII
8	VIII

Notice that the Roman numeral in the ion's name corresponds to the charge on the ion. A list of Roman numerals is given in Table 3.9.

Table 3.10 gives some examples of the names of binary ionic compounds containing a multivalent metal ion.

TABLE 3.10 Compounds with Multivalent Ions

Name	Formula
iron(III) iodide	FeI ₃
iron(II) iodide	FeI ₂
manganese(IV) sulphide	MnS ₂
copper(I) nitride	Cu ₃ N

Table 3.11 shows examples of how the compound's name is used to write the formula.

Study Prep

1. Write the names and formulas of the ionic compounds containing the following ions:

a) Cu^{+1} with S^{-2} _____

b) Cu^{+2} with S^{-2} _____

c) Cr^{+2} with F^{-1} _____

d) Cr^{+3} with F^{-1} _____

e) Fe^{+2} with N^{-3} _____

f) iron(III) ion with bromide ion _____

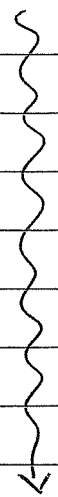
g) lead(IV) ion with iodide ion _____

h) lead(II) ion with iodide ion _____

i) cobalt(III) ion with phosphide ion _____

j) platinum(IV) ion with selenide ion _____

SKIP



2. Write the name of each ionic compound below. Remember to use a Roman numeral as part of the metal ion's name.

a) FeCl_2 _____

b) FeCl_3 _____

c) Cu_2O _____

d) CuO _____

e) PbS _____

f) PbS_2 _____

g) MnBr_2 _____

h) MnBr_3 _____

i) Ti_3N_4 _____

j) TiP _____

k) SnF_2 _____

l) TiS_2 _____

m) Co_3N_2 _____

n) PtI_2 _____

o) Cu_3P _____

Continued

3. Write the formulas of the following ionic compounds:

- a) iron(II) iodide _____
- b) chromium(III) chloride _____
- c) copper(II) bromide _____
- d) mercury(II) oxide _____
- e) tin(IV) nitride _____
- f) tin(II) nitride _____
- g) titanium(III) phosphide _____
- h) gold(III) sulphide _____
- i) manganese(IV) iodide _____
- j) mercury(II) selenide _____
- k) gold(I) iodide _____
- l) titanium(IV) nitride _____
- m) manganese(IV) oxide _____
- n) cobalt(II) chloride _____
- o) chromium(III) bromide _____

Polyatomic Ions

Some ions are made up of several atoms joined together by sharing electrons, just like a molecule. The difference is that this combination of atoms has an electric charge. It can have either a positive or a negative charge. A **polyatomic ion** is a group of atoms that are covalently bonded and have an overall electric charge ("poly" means *many*).

In the compound NaOH, for example, the sodium has a charge of +1. The oxygen and hydrogen together form the polyatomic ion hydroxide (OH^{-1}), which has a charge of -1. Another example of a polyatomic ion is the phosphate ion (PO_4^{-3}). It is made up of one phosphorus atom and four oxygen atoms joined together. They behave like a single unit with a charge of -3.

Table 3.13 gives some examples of common polyatomic ions. Page 1 of the *Data Booklet* lists the names and formulas of these and other common ions.

There are a few points worth noting about the ions in Table 3.13:

- There are many more negative ions than positive ions.
- The most common positive polyatomic ion is ammonium (NH_4^{+1}). Ammonium phosphate is the most common fertilizer ingredient in the world.

Study Prep

1. Write the name of each compound below:

- a) Li_2CO_3 _____
- b) $\text{Mg}(\text{HCO}_3)_2$ _____
- c) Na_2SO_4 _____
- d) K_2SO_3 _____
- e) $\text{Ba}(\text{OH})_2$ _____
- f) $\text{Al}(\text{CN})_3$ _____
- g) $(\text{NH}_4)_3\text{PO}_4$ _____
- h) $\text{Fe}(\text{NO}_3)_2$ _____
- i) $\text{Mg}(\text{OH})_2$ _____
- j) Cu_3PO_4 _____
- k) Ag_2CrO_4 _____
- l) $\text{Rb}_2\text{Cr}_2\text{O}_7$ _____
- m) NH_4F _____
- n) $\text{Co}(\text{HSO}_3)_2$ _____

2. Write the formula for each compound below:

- a) sodium carbonate _____
- b) strontium chlorate _____
- c) cesium cyanide _____
- d) barium hydrogen carbonate _____
- e) zinc hydrogen sulphate _____
- f) strontium phosphate _____
- g) calcium hydroxide _____
- h) ammonium sulphide _____
- i) ammonium sulphate _____
- j) ammonium sulphite _____
- k) copper(II) nitrate _____
- l) chromium(III) hydrogen sulphide _____
- m) potassium dichromate _____
- n) sodium oxalate _____
- o) manganese(II) thiocyanate _____
- p) magnesium sulphite _____
- q) lead(II) perchlorate _____
- r) tin(IV) phosphate _____
- s) aluminum hydroxide _____
- t) beryllium carbonate _____

Table 3.18 gives some examples of how names of molecular compounds can be written from their formulas.

TABLE 3.18 Hints for Writing Names of Molecular Compounds

Formula	Name	Hints for Writing Names
CS_2	carbon disulphide	Do not use a prefix when there is only one atom of the first element.
O_2F_2	dioxygen difluoride	Do not reduce the name to "oxygen fluoride."
CCl_4	carbon tetrachloride	Do not use a prefix when there is only one atom of the first element.
P_4O_{10}	tetraphosphorus decaoxide	Use rules 1 to 3.

Study Prep

1. Write the names of the following compounds:

- a) CO_2 _____
- b) N_2O _____
- c) PCl_3 _____
- d) PBr_5 _____
- e) SO_2 _____
- f) N_2O_4 _____
- g) P_4S_{10} _____
- h) S_2F_{10} _____
- i) NI_3 _____
- j) NO _____

2. Write the formulas of the following compounds:

- a) nitrogen tribromide _____
- b) sulphur hexafluoride _____
- c) dinitrogen tetrasulphide _____
- d) oxygen difluoride _____
- e) carbon tetraiodide _____
- f) sulphur trioxide _____
- g) phosphorus pentachloride _____
- h) diiodine hexachloride _____
- i) dichlorine monoxide _____
- j) xenon hexafluoride _____

ANSWERS

TABLE 3.8 Rules for Writing Formulas of Binary Ionic Compounds

Key

Rules for Names	Examples	
	magnesium phosphide	aluminum bromide
1. Identify each ion and its charge.	magnesium: Mg^{+2} phosphide: P^{-3}	aluminum: Al^{+3} bromide: Br^{-1}
2. Determine the total charges needed to balance positive with negative.	Mg^{+2} : $+2 +2 +2 = +6$ P^{-3} : $-3 -3 = -6$	Al^{+3} : $= +3$ Br^{-1} : $-1 -1 -1 = -3$
3. Note the ratio of positive ions to negative ions.	3 Mg^{+2} ions for every 2 P^{-3} ions	1 Al^{+3} ion for every 3 Br^{-1} ions
4. Use subscripts to write the formula. Omit "1" where only one ion is needed.	Mg_3P_2	$AlBr_3$

Study Prep

1. Write the formulas of the ionic compounds containing the following ions:

- a) Na^{+1} with F^{-1} NaF
- b) Mg^{+2} with Br^{-1} $MgBr_2$
- c) Cs^{+1} with S^{-2} Cs_2S
- d) Ba^{+2} with O^{-2} BaO
- e) Ca^{+2} with P^{-3} Ca_3P_2

2. Write the formulas of the following binary ionic compounds:

- a) potassium chloride KCl
- b) strontium nitride Sr_3N_2
- c) silver sulphide Ag_2S
- d) zinc selenide $ZnSe$
- e) beryllium sulphide BeS
- f) rubidium oxide Rb_2O
- g) lithium nitride Li_3N
- h) radium iodide RaI_2
- i) aluminum phosphide AlP
- j) magnesium sulphide MgS
- k) lithium fluoride LiF
- l) beryllium iodide BeI_2
- m) magnesium oxide MgO
- n) radium nitride Ra_3N_2
- o) potassium sulphide K_2S

3. Write the names of the following binary ionic compounds:

- a) CsI CESIUM IODIDE
- b) Ba₃N₂ BARIUM NITRIDE
- c) CdCl₂ CADMIUM CHLORIDE
- d) AlF₃ ALUMINUM FLUORIDE
- e) Li₂O LITHIUM OXIDE
- f) K₂O POTASSIUM OXIDE
- g) Na₂O SODIUM OXIDE
- h) CaI₂ CALCIUM IODIDE
- i) Sr₃P₂ STRONTIUM PHOSPHIDE
- j) CaO CALCIUM OXIDE
- k) Cd₃N₂ CADMIUM NITRIDE
- l) RaBr₂ RADIUM BROMIDE
- m) RbF RUBIDIUM FLUORIDE
- n) AlCl₃ ALUMINUM CHLORIDE
- o) NaBr SODIUM BROMIDE

Metals with More Than One Combining Capacity

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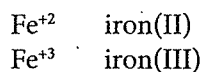


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manganese(IV) sulphide	MnS ₂
copper(I) nitride	Cu ₃ N

Table 3.11 shows examples of how the compound's name is used to write the formula.

ANSWERS

Study Prep

1. Write the names and formulas of the ionic compounds containing the following ions:

a) Cu^{+1} with S^{-2}

b) Cu^{+2} with S^{-2}

c) Cr^{+2} with F^{-1}

d) Cr^{+3} with F^{-1}

e) Fe^{+2} with N^{-3}

f) iron(III) ion with bromide ion

g) lead(IV) ion with iodide ion

h) lead(II) ion with iodide ion

i) cobalt(III) ion with phosphide ion

j) platinum(IV) ion with selenide ion

2. Write the name of each ionic compound below. Remember to use a Roman numeral as part of the metal ion's name.

a) FeCl_2 IRON (II) CHLORIDE

b) FeCl_3 IRON (III) CHLORIDE

c) Cu_2O COPPER (I) OXIDE

d) CuO COPPER (II) OXIDE

e) PbS LEAD (II) SULFIDE

f) PbS_2 LEAD (IV) SULFIDE

g) MnBr_2 MANGANESE (II) BROMIDE

h) MnBr_3 MANGANESE (III) BROMIDE

i) Ti_3N_4 TITANIUM (IV) NITRIDE

j) TiP TITANIUM (III) PHOSPHIDE

k) SnF_2 TIN (II) FLUORIDE

l) TiS_2 TITANIUM (IV) SULFIDE

m) Co_3N_2 COBALT (II) NITRIDE

n) PtI_2 PLATINUM (II) IODIDE

o) Cu_3P COPPER (I) PHOSPHIDE

Continued

3. Write the formulas of the following ionic compounds:

- a) iron(II) iodide FeI_2
b) chromium(III) chloride CrCl_3
c) copper(II) bromide CuBr_2
d) mercury(II) oxide HgO
e) tin(IV) nitride Sn_3N_4
f) tin(II) nitride Sn_3N_2
g) titanium(III) phosphide TiP
h) gold(III) sulphide Au_2S_3
i) manganese(IV) iodide MnI_4
j) mercury(II) selenide HgSe
k) gold(I) iodide AuI
l) titanium(IV) nitride Ti_3N_4
m) manganese(IV) oxide MnO_2
n) cobalt(II) chloride CoCl_2
o) chromium(III) bromide CrBr_3

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ANSWERS

Key

Study Prep

1. Write the name of each compound below:

- a) Li_2CO_3 LITHIUM CARBONATE
 b) $\text{Mg}(\text{HCO}_3)_2$ MAGNESIUM BICARBONATE
 c) Na_2SO_4 SODIUM SULFATE
 d) K_2SO_3 POTASSIUM SULFITE
 e) $\text{Ba}(\text{OH})_2$ BARIUM HYDROXIDE
 f) $\text{Al}(\text{CN})_3$ ALUMINIUM CYANIDE
 g) $(\text{NH}_4)_3\text{PO}_4$ AMMONIUM PHOSPHATE
 h) $\text{Fe}(\text{NO}_3)_2$ IRON (II) NITRATE
 i) $\text{Mg}(\text{OH})_2$ MAGNESIUM HYDROXIDE
 j) Cu_3PO_4 COPPER (I) PHOSPHATE
 k) Ag_2CrO_4 SILVER CHROMATE
 l) $\text{Rb}_2\text{Cr}_2\text{O}_7$ RUBIDIUM DICHROMATE
 m) NH_4F AMMONIUM FLUORIDE
 n) $\text{Co}(\text{HSO}_3)_2$ COBALT (I) BISULFITE

2. Write the formula for each compound below:

- a) sodium carbonate Na_2CO_3
 b) strontium chlorate $\text{Sr}(\text{ClO}_3)_2$
 c) cesium cyanide — OMIT —
 d) barium hydrogen carbonate $\text{Ba}(\text{HCO}_3)_2$
 e) zinc hydrogen sulphate $\text{Zn}(\text{HSO}_4)_2$
 f) strontium phosphate $\text{Sr}_3(\text{PO}_4)_2$
 g) calcium hydroxide $\text{Ca}(\text{OH})_2$
 h) ammonium sulphide $(\text{NH}_4)_2\text{S}$
 i) ammonium sulphate $(\text{NH}_4)_2\text{SO}_4$
 j) ammonium sulphite $(\text{NH}_4)_2\text{SO}_3$
 k) copper(II) nitrate $\text{Cu}(\text{NO}_3)_2$
 l) chromium(III) hydrogen sulphide $\text{Cr}(\text{HS})_3$
 m) potassium dichromate $\text{K}_2\text{Cr}_2\text{O}_7$
 n) sodium oxalate $\text{Na}_2\text{C}_2\text{O}_4$
 o) manganese(II) thiocyanate — OMIT —
 p) magnesium sulphite MgSO_3
 q) lead(II) perchlorate $\text{Pb}(\text{ClO}_4)_2$
 r) tin(IV) phosphate $\text{Sn}_3(\text{PO}_4)_4$
 s) aluminum hydroxide $\text{Al}(\text{OH})_3$
 t) beryllium carbonate BeCO_3

Table 3.18 gives some examples of how names of molecular compounds can be written from their formulas.

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CCl_4	carbon tetrachloride	Do not use a prefix when there is only one atom of the first element.
P_4O_{10}	tetraphosphorus decaoxide	Use rules 1 to 3.

Study Prep

1. Write the names of the following compounds:

- CO_2 CARBON DIOXIDE
- N_2O DINITROGEN MONOXIDE
- PCl_3 PHOSPHOROUS TRICHLORIDE
- PBr_5 PHOSPHOROUS PENTA BROMIDE
- SO_2 SULFUR DIOXIDE
- N_2O_4 DINITROGEN TETROXIDE
- P_4S_{10} TETRA PHOSPHORUS DECA SULFIDE
- S_2F_{10} DISULFUR DECA FLUORIDE
- NI_3 NITROGEN TRI IODIDE
- NO NITROGEN MONOXIDE

2. Write the formulas of the following compounds:

- nitrogen tribromide NBr_3
- sulphur hexafluoride SF_6
- dinitrogen tetrasulphide N_2S_4
- oxygen difluoride OF_2
- carbon tetraiodide CI_4
- sulphur trioxide SO_3
- phosphorus pentachloride PCl_5
- diiodine hexachloride I_2Cl_6
- dichlorine monoxide Cl_2O
- xenon hexafluoride XeF_6