

Welcome!

This is a chemistry lesson, covering *how to name ionic compounds containing transition metals*.

I will guide you step-by-step.

I will be asking you many questions along the way.

Each time I ask a question, **you should attempt to answer the question on your own** before you scroll down to view my answer.

This lesson builds on the material covered in the previous lessons:

[Naming Ionic Compounds](#)

[Writing Formulas for Ionic Compounds](#)

[Writing Formulas for Ionic Compounds with Transition Metals](#)

You should complete those lessons before attempting this lesson.

This lesson was written by Freelance-Teacher.

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I offer **tutoring** in chemistry, and a variety of other subjects.

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Let's review some ideas from the previous lesson on [Writing Formulas for Ionic Compounds with Transition Metals](#) that we will need to build on for this lesson.

1. List the elements whose cations can commonly take two different charges.

The following elements have cations which can commonly take two different charges:

chromium, Cr

cobalt, Co

copper, Cu

iron, Fe

lead, Pb

tin, Sn

You should have these six elements memorized.

These are the elements that can take two charges that we will focus on in this lesson.

It's possible that your professor may require you to be familiar with some additional elements that can take two charges that are not on this list.

**2. What are the transition metals whose cations commonly take only *one* charge?
List the specific charge that is possible for each of these elements.**

Here is a list of the transition metals that commonly take only one charge, together with the specific charge that is possible for each element.

In common practice,

silver ions always take the form of Ag^+ ,

cadmium ions always take the form of Cd^{2+} , and

zinc ions always take the form of Zn^{2+} .

You should have these three elements, and the charges they take, memorized.

**3. When is it necessary to include a roman numeral in the name of a cation?
When is a roman numeral not necessary?**

If an element's ion has *only one* common charge,
then the cation's name is: the element's name + "ion";
for example, "calcium ion" or "silver ion".

If an element can commonly have *more than one charge*,
you need to say which one, using Roman numerals in parentheses;
for example, "chromium(II) ion" vs. "chromium(III) ion".

In the previous lesson, [Writing Formulas for Ionic Compounds with Transition Metals](#), we learned how to solve problems involving transition metals, or lead, or tin, that take this form:
name → chemical formula

In this lesson, we will discuss how to solve problems involving transition metals, lead, or tin, that take this form:
chemical formula → name

If an ionic compound includes a cation which has *only one* common charge, then the compound's name does *not* need to include a roman numeral.

If an ionic compound includes a cation which commonly takes *more than one charge* then you *do* need to include a roman numeral in the name of the compound.

If an ionic compound includes a cation which commonly takes *more than one charge*, then you need to include a roman numeral in the name of the compound.

For example, the name “cobalt chloride” is *not* an adequate name, because cobalt cations can commonly take two different charges.

If you saw the name “cobalt chloride” in a lab report, you wouldn't be able to tell whether the compound involved a Co^{2+} cation or a Co^{3+} cation.

Instead, the compound should be named “cobalt(II) chloride” or “cobalt(III) chloride”, because those names would make clear what the charge on the cobalt cation is.

If an ionic compound includes a cation which has *only one* common charge, then the compound's name does not need to include a roman numeral.

For example, the name “calcium chloride” is acceptable, because calcium cations commonly take only one charge.

If you see the name “calcium chloride” in a lab report, you know that the compound involves a Ca^{2+} cation, because that's the only type of cation that calcium can form.

For another example, the name “silver oxide” is acceptable, because silver cations commonly take only one charge.

If you see the name “silver oxide” in a lab report, you know that the compound involves an Ag^+ cation, because you should have memorized that that's the only type of cation that silver can form.

4. Is “copper sulfide” an acceptable name for a compound?

Answer:

No, “copper sulfide” is not an acceptable name for a compound; the name for this compound needs to include a roman numeral, to indicate what the charge on the copper cations is.

Analysis:

The compound contains both a metal (copper) and a nonmetal (sulfur), so we’re dealing with an ionic compound.

We have memorized that copper cations can take *two different charges*.

Therefore, the name “copper sulfide” is not an adequate name for the compound.

If you read a lab report about “copper sulfide”, you wouldn’t be able to tell what the charge on the copper cations was.

The name for this compound needs to include a roman numeral, to indicate what the charge on the copper cations is.

5. Is “tin bromide” an acceptable name for a compound?

Answer:

No, “tin bromide” is not an acceptable name for a compound; the name for this compound needs to include a roman numeral, to indicate what the charge on the tin cations is.

Analysis:

The compound contains both a metal (tin) and a nonmetal (bromine), so we’re dealing with an ionic compound.

Tin is a main group element; however, we have memorized that tin cations can take *two different charges*.

Therefore, the name “tin bromide” is not an adequate name for the compound.

If you read a lab report about “tin bromide,” you wouldn’t be able to tell what the charge on the tin cations was.

The name for this compound needs to include a roman numeral, to indicate what the charge on the tin cations is.

6. Is sodium iodide an acceptable name for a compound?

Answer:

Yes, “sodium iodide” is an acceptable name for a compound;
a roman numeral is not needed for the name of this compound.

Analysis:

The compound contains both a metal (sodium) and a nonmetal (iodine), so we’re dealing with an ionic compound.

Sodium (Na) is an ordinary main group element, so sodium cations can commonly take *only one* charge.

Therefore, the name “sodium iodide” is an adequate name for the compound.

If you read a lab report about “sodium iodide,” you would know (from the position of sodium in the periodic table), that the charge on the sodium cations is +1.

So the name for this compound does not need to include a roman numeral.

7. Is cadmium nitride an acceptable name for a compound?

Answer:

Yes, “cadmium nitride” is an acceptable name for a compound;
a roman numeral is not needed for the name of this compound.

Analysis:

The compound contains both a metal (cadmium) and a nonmetal (nitride), so we’re dealing with an ionic compound.

Cadmium (Cd) is a transition element; however, we have memorized that cadmium cations can commonly take *only one* charge (+2).

Therefore, the name “cadmium nitride” is an adequate name for the compound.

If you read a lab report about “cadmium nitride,” you would know that the charge on the cadmium cations is +2, since you should have memorized that that’s the only charge commonly taken by cadmium ions.

So the name for this compound does not need to include a roman numeral.

Chromium, cobalt, copper, iron, lead, and tin form cations that can take two different charges.

And we know that different charges require different names; e.g., copper(I) for Cu^+ , and copper(II) for Cu^{2+} .

Therefore, in order to give the correct name for a compound involving chromium, cobalt, copper, iron, lead, or tin,
*we will first need to determine the **charge** on the cation.*

Otherwise, we won't know how to name the compound properly.

For example:

8. Write the name for the compound represented by the formula CrBr_3 .

Answer:

The name of CrBr_3 is *chromium(III) bromide*.

Analysis:

The first step is to identify whether CrBr_3 is an ionic compound or a covalent compound. CrBr_3 contains a metal (chromium) and a nonmetal (bromine), so CrBr_3 is an ionic compound.

We have memorized that chromium can form two different cations with two different charges.

Before we can name CrBr_3 ,
we need to figure out the charge on the chromium ion.

Ionic compounds have a net charge of zero.
(We can also see from the formula that CrBr_3 has a net charge of zero; otherwise, the net charge would be indicated in the formula.)

So our goal is to figure out what the charge on the chromium ion must be, in order for the net charge of the compound to be zero.

We will use the notation we introduced in previous lessons for keeping track of individual and group charges.

Write the formula for CrBr_3 .

For clarity, we will write the Cr with a ₁ subscript.

Our goal is to determine the charge on each individual chromium ion:

group charges		
	Cr_1	Br_3
individual charges	?	

From its position in the periodic table,

we know that the individual charge on each individual bromine is -1.

group charges		
	Cr_1	Br_3
individual charges	?	-1

Taken as a group, the group of three bromines have a charge of $3(-1) = -3$.

group charges		-3
	Cr_1	Br_3
individual charges	?	-1

We know that CrBr_3 has a net charge of zero.

In order for the net charge to be zero,

the “group” of one chromium must have a group charge of +3.

group charges	+3	-3
	Cr_1	Br_3
individual charges	?	-1

The formula contains only one chromium ion

so in order for the chromium “group” charge to be +3,

the individual charge on the chromium must also be +3.

group charges	+3	-3
	Cr_1	Br_3
individual charges	+3	-1

Our goal was to determine the individual charge on the chromium ion.

We have achieved that goal: the chromium has a +3 charge.

Therefore, the name of CrBr_3 is *chromium(III) bromide*.

If you said that the name of CrBr_3 is “chromium bromide”,
your answer is *incorrect*.

If a lab report said that an experiment involved “chromium bromide”,
the reader wouldn’t be able to tell whether the experiment involved Cr^{3+} or Cr^{2+} ;
so “chromium bromide” is *not* an adequate name for CrBr_3 .

Here are the rules we learned in [an earlier lesson](#) for naming ionic compounds,
modified to handle the case of cations that can take more than one charge.

In the name for the ionic compound,
the cation is named first, and
the anion is named second.

Rule for Naming a Monatomic Cation as part of an ionic compound:

The name of a monatomic cation is the *same* as the name of the element.

Exception: If the cation can take more than one charge, then the name of the cation is the same as the
name of the element, plus a roman numeral to indicate the cation’s charge.

Rule for Naming a Monatomic Anion as part of an ionic compound:

The name of a monatomic anion is *adapted* from the name of the element, but with the suffix -ide.

The subscripts in the formula for an ionic compound
are not referred to in the name of the compound.

(Later, we will see that this rule does *not* apply to covalent compounds.)

Notice that, for the ionic compound CrBr_3 ,
the name “chromium(III) bromide” follows each of the above rules:

The cation, chromium(III), is named first, and the anion, bromide, is named second.

The chromium cation can take more than one charge, so the name for the monatomic cation is the same
as the name of the element, plus a roman numeral to indicate the cation’s charge: chromium(III).

The name of the monatomic anion (bromide) is adapted from the name of the element, but with the
suffix -ide.

The subscripts $_1$ and $_3$ in the formula for the ionic compound are not referred to in the name of the
compound.

We will work through more examples on the next page.

9. What is the name of Cu_2O ?

Answer:

The name for Cu_2O is copper(I) oxide.

Analysis:

The first step is to identify whether Cu_2O is an ionic compound or a covalent compound. Cu_2O contains a metal (copper) and a nonmetal (oxygen), so Cu_2O is an ionic compound.

We have memorized that copper can form two different cations with two different charges.

Before we can name Cu_2O ,
we need to figure out the charge on the copper ion.

Ionic compounds have a net charge of zero.
So our goal is to figure out what the charge on the copper ion must be, in order for the net charge of the compound to be zero.

From its position in the periodic table,
we know that the individual charge on each oxide anion is -2.
Taken as a group, the “group” of one oxide has a charge of $1(-2) = -2$.

group charges		-2
	Cu_2	O_1
individual charges	?	-2

We know that Cu_2O has a net charge of zero.
In order for the net charge to be zero,
the group of two copper ions must have a group charge of +2.

group charges	+2	-2
	Cu_2	O_1
individual charges	?	-2

group charges	+2	-2
	Cu ₂	O ₁
individual charges	?	-2

Since there are two copper ions in the formula, the charge on each individual copper ion must be +1, because $2(+1) = +2$.

group charges	+2	-2
	Cu ₂	O ₁
individual charges	+1	-2

Our goal was to determine the individual charge on the copper ion. We have achieved that goal: the copper has a +1 charge.

Therefore, the name for Cu₂O is *copper(I) oxide*.

10. What is the name of Co_2S_3 ?

Answer:

The name for Co_2S_3 is cobalt(III) sulfide.

Analysis:

The first step is to identify whether Co_2S_3 is an ionic compound or a covalent compound. Co_2S_3 contains a metal (cobalt) and a nonmetal (sulfur), so Co_2S_3 is an ionic compound.

We have memorized that cobalt can form two different cations with two different charges.

Before we can name Co_2S_3 ,
we need to figure out the charge on the cobalt ion.

Ionic compounds have a net charge of zero.
So our goal is to figure out what the charge on the cobalt ion must be, in order for the net charge of the compound to be zero.

From its position in the periodic table,
we know that the individual charge on each sulfide anion is -2.
Since there are three sulfide ions in the formula,
the “group” of sulfide ions has a total charge of $3(-2) = -6$.

		-6
	Co_2	S_3
individual charges	?	-2

We know that Co_2S_3 has a net charge of zero.
In order for the net charge to be zero,
the group of two cobalt ions must have a total group charge of +6.

	+6	-6
	Co_2	S_3
individual charges	?	-2

Since there are two cobalt ions in the formula,
the charge on each individual cobalt ion must be +3,
because $2(+3) = +6$.

	+6	-6
	Co_2	S_3
individual charges	+3	-2

	+6	−6
	Co ₂	S ₃
individual charges	+3	−2

Our goal was to determine the individual charge on the cobalt ion.
We have achieved that goal: the cobalt has a +3 charge.

Therefore, the name for Co₂S₃ is *cobalt(III) sulfide*.

11. What is the name of PbS?

Answer:

The name for PbS is lead(II) sulfide.

Analysis:

The first step is to identify whether PbS is an ionic compound or a covalent compound.

PbS contains a metal (lead) and a nonmetal (sulfur), so PbS is an ionic compound.

Lead can form cations with *two different charges*.

So, before we can name PbS, we need to figure out the charge on the lead ion.

We know that the individual charge on each sulfide anion is -2.

So the “group” of one sulfide has a group charge of $1(-2) = -2$.

	Pb₁	S₁
individual charges	?	-2

We know that PbS has a net charge of zero.

In order for the net charge to be zero,

the “group” of one lead ion must have a group charge of “+2.”

Since there is only one lead ion in the formula,

the charge on each individual lead ion must also be +2.

	+2	-2
	Pb₁	S₁
individual charges	+2	-2

We have determined that each individual lead ion has a +2 charge.

Therefore, the name for PbS is *lead(II) sulfide*.

12. What is the name of Zn_3N_2 ?

Answer:

The name for Zn_3N_2 is *zinc nitride*. No roman numeral is necessary in the name.

Analysis:

The first step is to identify whether Zn_3N_2 is an ionic compound or a covalent compound.

Zn_3N_2 contains a metal (zinc) and a nonmetal (nitrogen), so Zn_3N_2 is an ionic compound.

Even though zinc (Zn) is a transition metal,

in the lesson on [Writing Formulas for Ionic Compounds with Transition Metals](#) we memorized that zinc ions can take only one charge (+2).

If an ion can take only one charge,

there is no need to indicate the charge with a roman numeral.

So the correct name for Zn_3N_2 is zinc nitride.

There is no need to include a roman numeral in the name of the compound,

because for a metal that can take only one charge,

there is no need to indicate the charge of the cation in the name.

As a result, for this problem,

there was no need to use our special notation for keeping track of individual and group charges.

If a lab report says that an experiment involves “zinc nitride”,

the reader will know that the experiment involves Zn^{2+} ,

because that is the only ion commonly formed by zinc.

(We are assuming a cultured reader, who is familiar with the Table of Special Charges.)

So “zinc nitride” is an adequate name for Zn_3N_2 .

The moral of this last problem is:

when writing the name for a formula involving zinc (Zn) or silver (Ag) or cadmium (Cd)

(elements whose ions commonly take only one charge)

there is no need to use our special notation for keeping track of individual and group charges;

and there is no need to use a roman numeral to indicate the charge of the cation in the name for the compound.

Let's review what we've discussed in this lesson.

13. List the elements whose cations can commonly take two different charges.

chromium, Cr
cobalt, Co
copper, Cu
iron, Fe
lead, Pb
tin, Sn

These are the elements that can take two charges that we have focused on in this lesson.

Your professor may require you to be familiar with some additional elements that can take two charges that are not on this list.

**14. What are the transition metals whose cations commonly take only one charge?
List the specific charge that is possible for each of these elements.**

Here is a list of the transition metals that commonly take only one charge,
together with the specific charge that is possible for each element.

In common practice,
silver ions always take the form of Ag^+ ,
cadmium ions always take the form of Cd^{2+} , and
zinc ions always take the form of Zn^{2+} .

**15. When is it necessary to include a roman numeral in the name of an ionic compound?
When is a roman numeral not necessary?**

If an ionic compound includes a cation which has *only one* common charge, then the compound's name does not need to include a roman numeral; for example, "calcium chloride" or "silver oxide".

If an ionic compound includes a cation which commonly takes *more than one charge*, you need to include a roman numeral in the name of the compound; for example, "chromium(II) chloride" or "chromium(III) chloride".

**16. True or false? Explain why it's true or false.
The correct name for FeS is iron sulfide.**

Answer: False.

You should have memorized that iron cations can take two different charges.

Therefore, the name "iron sulfide" is not adequate, because the reader can't tell from that name what the charge on the iron cation is.

From the formula FeS, we know that the iron must have a +2 charge to balance the -2 charge on the sulfur.

So the correct name for this compound is *iron(II) sulfide*.

You have reached the end of the lesson.

You're ready now to proceed to the next lesson:

[Ionic Compounds with Oxyanions: Names and Formulas](#)