How Do We Name and Write Formulas for Compounds?

Activity

- Names in Everyday life

The chemical name of an ionic compound communicates its composition

Binary ionic compound:

- Made up of ions of one metal element and ions of one non-metal element; joined by ionic bonds
- *Binary* in chemistry means “composed of two elements

Figure 2.36: Potassium iodide is a binary ionic compound that is added to table salt to prevent iodine deficiency. Seaweed contains compounds that include iodide ion. Iodine deficiency leads to swellings called goiters.

Names of Binary Ionic Compounds

- The name of a binary ionic compound comes from the name of its elements.

Example: potassium iodide

- Write down the elements inside the compound
- The first part names the positive ion, potassium (K^+)
  - In a binary ionic compound, the positive ion is always a metal and you do not change the name
- The second part names the negative ion, iodide (I^-)
  - In a binary ionic compound, the negative ion is always a non-metal
  - Replace the ending of the non metal and add the suffix *–ide*
  - The negative ion of iodine is iodide

Name the Following

- Ca_3N_2
  - calcium and nitrogen  calcium nitride
- NaCl
- K_2O
- Li_3N

Time out

- Naming binary ionic compounds worksheet

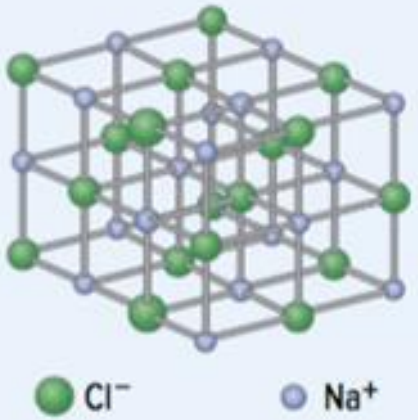
- What is the difference between the name of a non-metal element and the name of the negative ion it forms?

Activity

Activity

Ion Ratios

This diagram represents a crystal of sodium chloride. How does the structure of sodium chloride relate to its chemical formula? Follow these steps to find out:



1. Count the total number of ions of each element.
2. Compare the total number of positive ions with the total number of negative ions.
3. What is the ratio of positive ions to negative ions for each compound?
4. The chemical formula of sodium chloride is NaCl. The chemical formula of calcium chloride, another ionic compound, is $CaCl_2$. What ratio of ions would you expect to see in calcium chloride?

You can determine the formula of an ionic compound from its name.

Formulas for binary ionic compounds:

- Positive ion (metal) first, negative ion (non-metal) second
- Subscripts indicate the ratio of each type of ion in the compound (no subscript: assume the number is 1)
- Chemical formula represents the <u>smallest (lowest terms)</u> repeating part of the crystal lattice (*formula unit*)

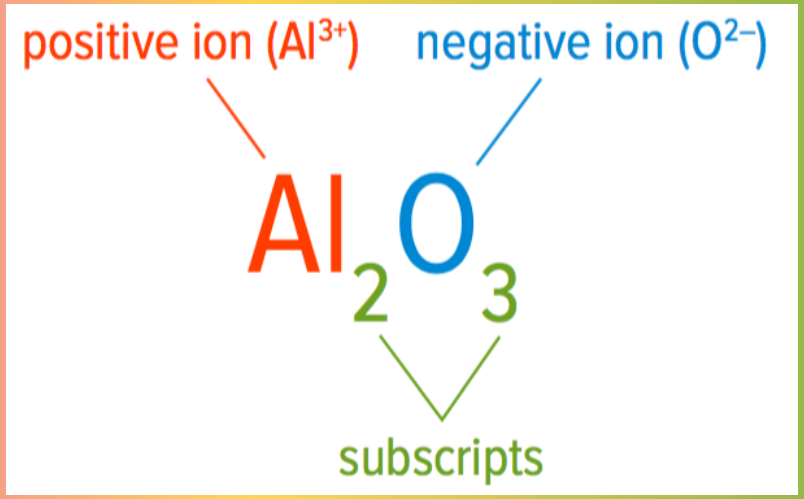


Figure 2.37: Formulas for ionic compounds are always written with the positive ion first and the negative ion second. In binary ionic compounds, the positive ion is a metal ion and the negative ion is a non-metal ion.

Examples of Chemical Formulas of Binary Ionic Compounds

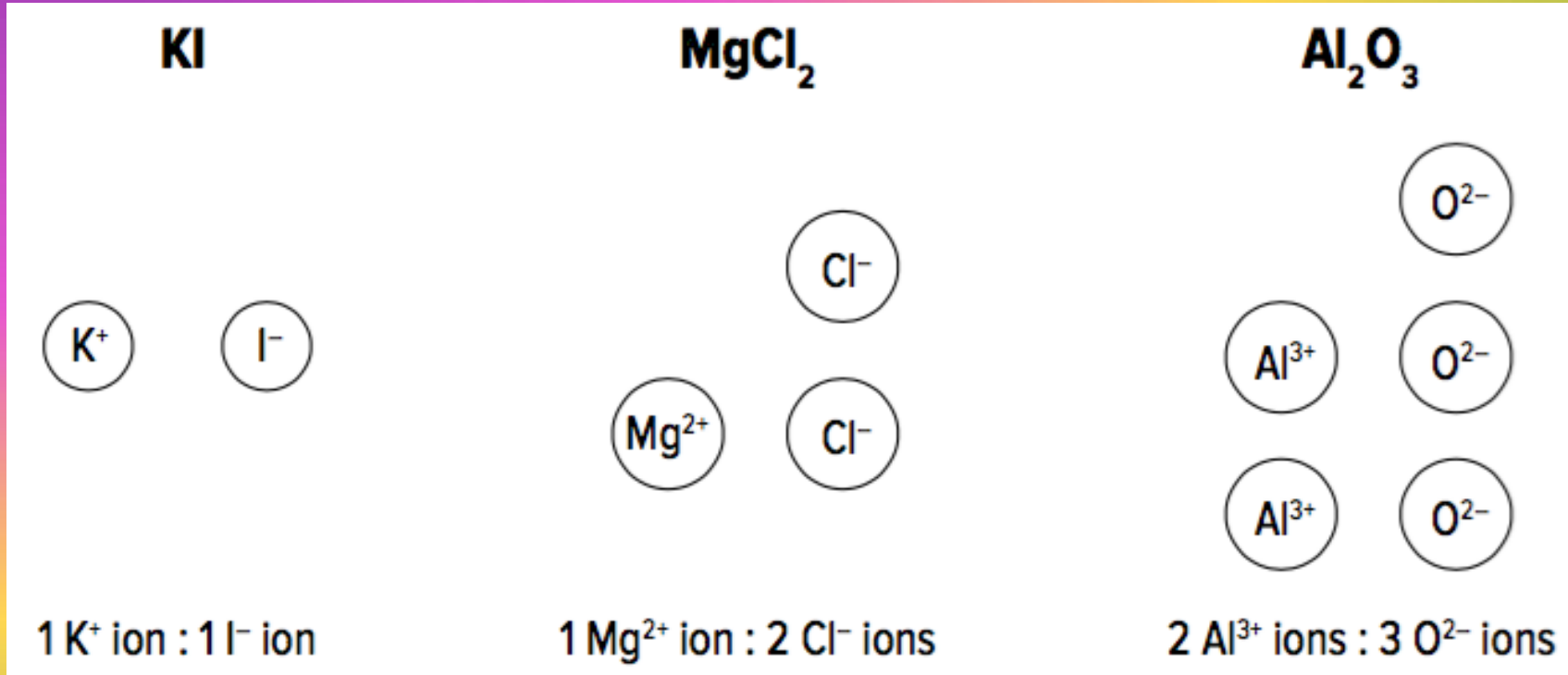


Figure 2.38: The subscripts in chemical formulas of ionic compounds tell you the ratio of the ions in the compound.

Writing Formulas of Ionic Compounds

Although an ionic compound is made up of ions, the compound's overall charge is 0 (it is electrically neutral)

- Positive charges on the metal ions must balance the negative charges on the non-metal ions
- Example: Aluminum oxide has two aluminum ions, Al^{3+}, and three oxide ions, O^{2-}. What is the total charge?

Charge from Al^{3+} ions	Charge from Cl^{-} ions
There are 2 aluminum ions in the formula, each with a charge of 3+. $2 \times (3+) = 6+$	There are 3 oxide ions in the formula, each with a charge of 2−. $3 \times (2-) = 6-$
Total charge: $(6+) + (6-) = 0$	

Writing Formulas

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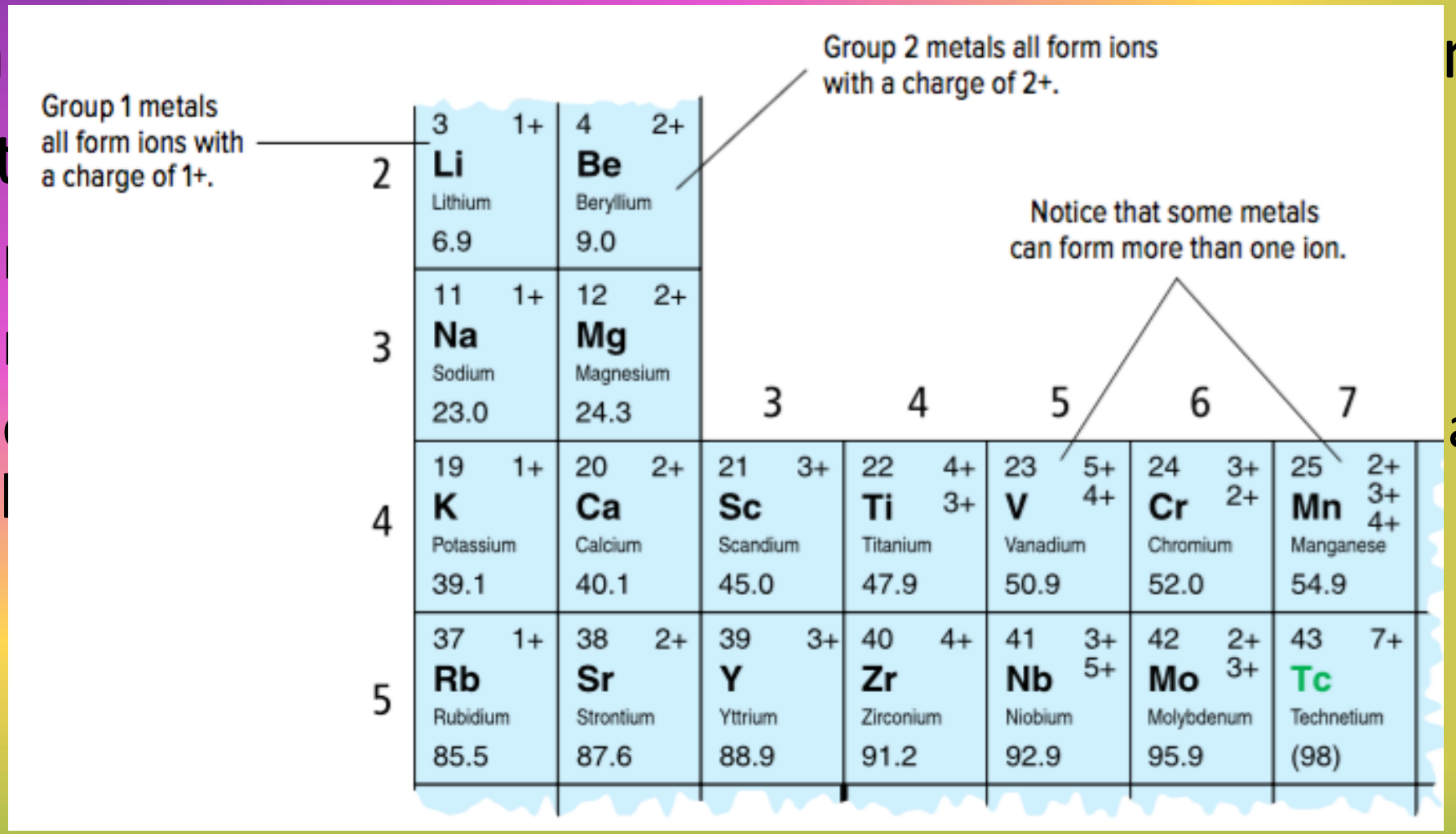
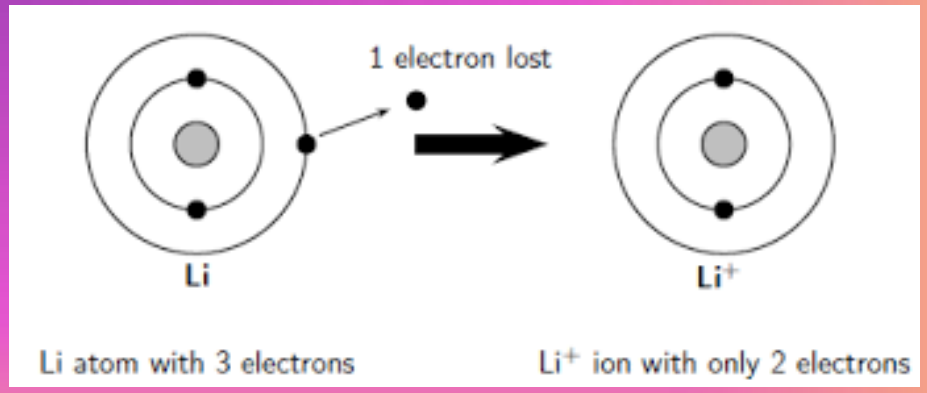
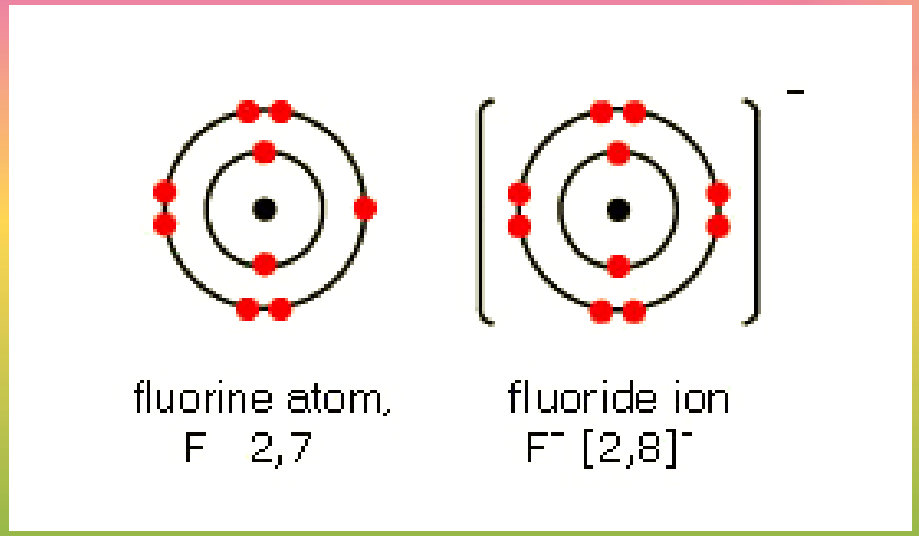


What is the ion charge related to?





Sample Problem: Writing the Formulas of Ionic Compounds (Step 1)

Problem:

What is the chemical formula for calcium chloride?

Step 1: Identify each ion and its charge

- Look at the periodic table to find the ion charge
- Calcium is a Group 2 metal, so its ion charge is 2+: **Ca^{2+}**
- Chlorine is a Group 17 metal, so its ion charge is 1-: **Cl^{-}**

Step 2: Determine the number of ions needed to balance positive charges with negative charges.

- A calcium ion (Ca^{2+}) has a charge of 2+
- A chloride ion (Cl^{-}) has a charge of 1-
- Therefore, two chloride ions are needed to balance the positive charge of one calcium ion

Charge from Ca^{2+}	Charge from Cl^{-}
A calcium ion has a charge of 2+. $1 \times (2+) = 2+$	A chloride ion has a charge of 1–. Therefore, two chloride ions are needed to balance the charge of one calcium ion. $2 \times (1-) = 2-$

Step 3: Use subscripts to write the formula (do not include a subscript if the subscript would be "1"). Remember to write the metal ion first.

- Recall: Two chloride ions are needed to balance the positive charge of one calcium ion
- Therefore, the formula for calcium chloride is

$$CaCl_2$$

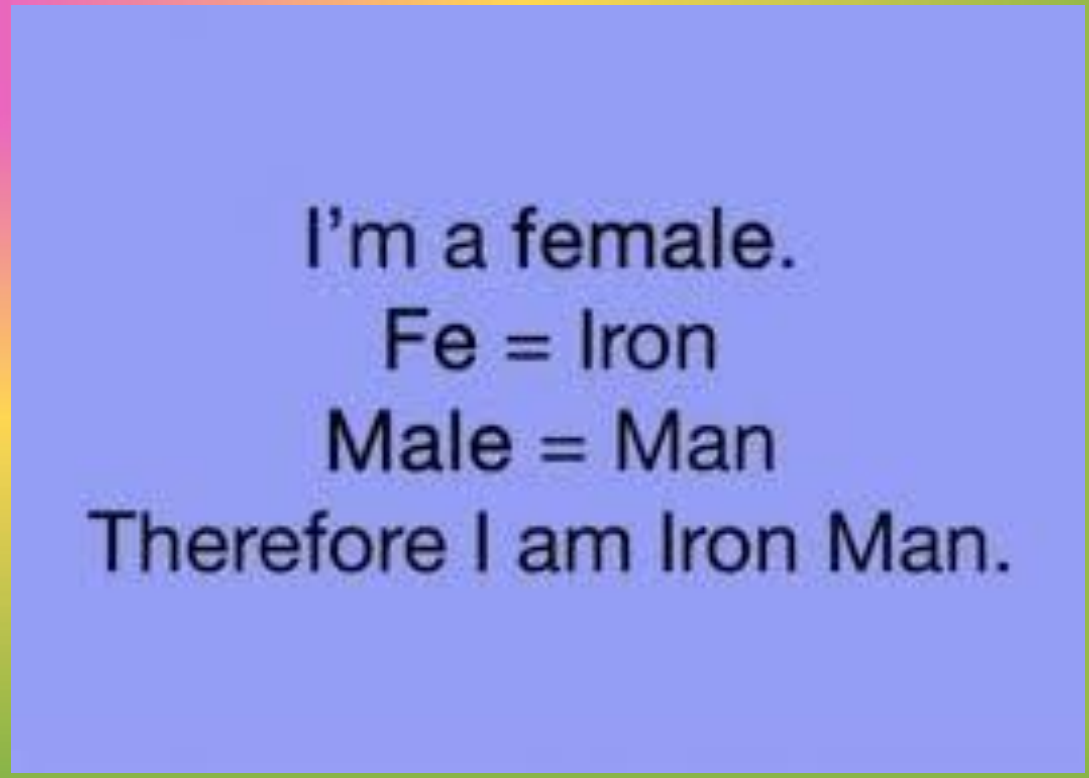
Discussion Questions

1. What is the formula for aluminum sulphide?

2. Even though ionic compounds are made up of charged particles, they are electrically neutral. Why is this?

Time out

- Pg 94-95 in workbook



Multivalent metals form more than one ion

Multivalent metal: a metal element that can form <u>two or more</u> types of ions with different charges

Example: Copper can form ions with a 1+ or 2+ charge

- A Roman numeral is written after the name of the metal to distinguish between the ions
- Cu^{+}: copper(I)
- Cu^{2+}: copper(II)

Figure 2.41: Although both of these compounds contain copper and oxygen, copper(II) oxide, CuO, is black and copper(I) oxide, Cu_2O, is red.

Writing Formulas for Ionic Compounds Containing Multivalent Metals

To write the chemical formula of a compound with a multivalent metal, follow the same process as for binary ionic compounds.

- Difference: You cannot tell the charge on the metal ion by looking at the periodic table, since there will be multiple charges listed
- Look at the Roman numeral in the name, which will tell you the charge
- Example: chromium(III) chloride tells you that the chromium ion is Cr^{3+}

Table 2.6 Roman Numerals

Metal Ion Charge	Roman Numeral
1+	I
2+	II
3+	III
4+	IV
5+	V
6+	VI
7+	VII

Sample Problem: Writing Formulas for Ionic Compounds Containing Multivalent Metals (Step 1)

Problem:

What is the chemical formula for chromium(III) chloride?

Step 1: Identify each ion and its charge.

- Look at the periodic table to find the ion charge
- Chromium is a multivalent metal (ion charge can be 3+ or 2+). Its ion charge is 3+ since its name contains the Roman numeral "III": **Cr^{3+}**
- Chlorine is a Group 17 metal, so its ion charge is 1-: **Cl^{-}**

Step 2: Determine the number of ions needed to balance positive charges with negative charges.

- A chromium ion (Cr^{3+}) has a charge of 3+
- A chloride ion (Cl^{-}) has a charge of 1-
- Therefore, three chloride ions are needed to balance the positive charge of one chromium ion

Step 3: Use subscripts to write the formula (do not include a subscript if the subscript would be "1").

Remember to write the metal ion first.

- Recall: Three chloride ions are needed to balance the positive charge of one chromium ion
- Therefore, the formula for chromium(III) chloride is **$CrCl_3$**.

Practice

- Workbook Pg 96 #2 only

Naming Compounds with Multivalent metals

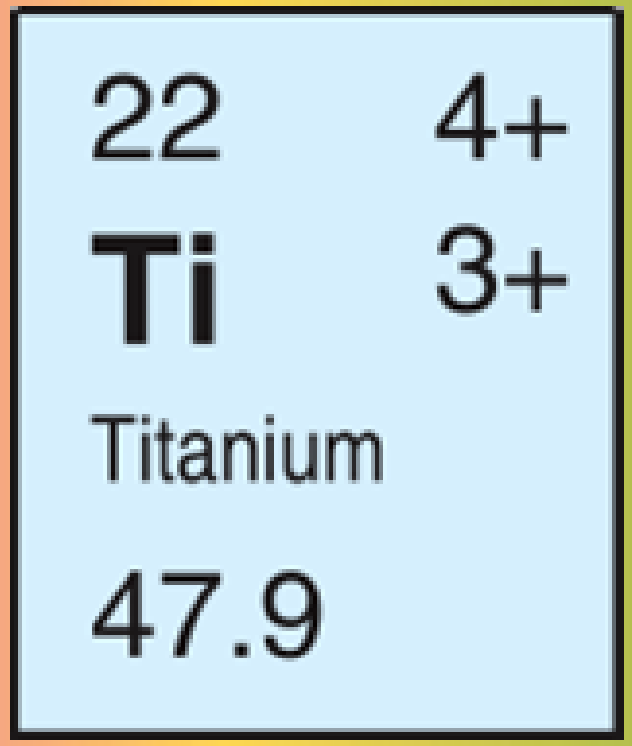
- The same naming rules apply as in other binary ionic compounds
  - In addition, in the name of the compound, Roman numerals are used following the positive ion to indicate which ion was used
- To determine which ion was used
  - Look at the negative ion, determine what charge is coming from that side
  - The negative ion is used because there is only one charge

- Ex: TiF_4

Titanium has multiple charges

Fluorine is -1, if there is 4

4 x -1 = -4



Therefore, in order for the overall charge of the compound to be 0, +4 must be coming from titanium. Since there is only one Titanium, we know the charge used was +4

Therefore the name is titanium (IV) fluoride

Naming an Ionic Compound with a Multivalent Metal (Step 1)

Problem:

What is the name of Fe_2O_3?

Step 1: Identify each ion and its charge

- Look at the periodic table to find the ion charge
- Iron is a multivalent metal (ion charge can be 2+ or 3+): **Fe^{2+}** or **Fe^{3+}**
- Oxygen's ion charge is 2-: **O^{2-}**

Step 2: Determine the ratio of ions in the compound.

- According to the formula, the compound has 2 iron (Fe) ions for every 3 oxide (O) ions

Step 3: The negative charges and the positive charges must be equal in magnitude for the compound to be electrically neutral. Which of the two possible iron ions achieves this balance?

- Recall:
  - Iron is a multivalent metal (ion charge can be 2+ or 3+): **Fe^{2+}** or **Fe^{3+}**
  - Oxygen's ion charge is 2-: **O^{2-}**
- Since there are 3 oxide ions, there is an overall negative charge of 6- [calculation: 3 x (2-) = 6-]
- Since there are 2 iron ions, they must each have a charge of 3+ to give an overall positive charge of 6+ [calculation: 2 x (3+) = 6+]
- Therefore the iron ion in this compound is **Fe^{3+}**

Step 4: Write the name of the compound using a Roman numeral to indicate the charge of the metal ion.

- Recall: The iron ion in this compound is **Fe^{3+}**
- Therefore, the name of Fe_2O_3 is iron(III) oxide

Discussion Questions

1. Explain why copper is able to form two different compounds with oxygen.

2. Why are Roman numerals included in the names of multivalent metal ions?

Time Out

- Complete # 1 and #3 on pg 96 in the workbook.

Polyatomic ions are made up of more than one atom

Polyatomic ion: an ion made up of two or more covalently bonded atoms

- Example: carbonate ion (CO_3^{2-})
  - 1 carbon atom
  - 2 oxygen atoms
- There are a limited number of polyatomic ions that regularly occur in compounds

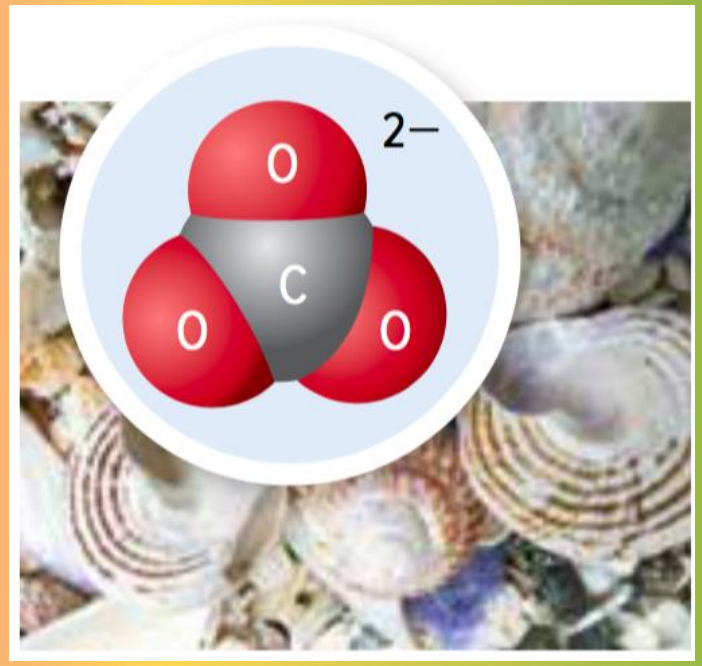


Figure 2.43: Shellfish use calcium carbonate to make their shells. The carbonate ion is shown here.

Common Polyatomic ions

Table 2.7 Names, formulas, and charges of some common polyatomic ions

1+ Charge	1– Charge	2– Charge	3– Charge
ammonium, NH_4^+	acetate, CH_3COO^- chlorate, ClO_3^- chlorite, ClO_2^- hydrogen carbonate, HCO_3^- hydroxide, OH^- nitrate, NO_3^- nitrite, NO_2^- permanganate, MnO_4^-	carbonate, CO_3^{2-} chromate, CrO_4^{2-} dichromate, $Cr_2O_7^{2-}$ peroxide, O_2^{2-} sulfate, SO_4^{2-} sulfite, SO_3^{2-}	phosphate, PO_4^{3-} phosphite, PO_3^{3-}

Naming ionic compounds containing Polyatomic ions

- Follows the same rules as binary ionic compounds
  - Exception: you NEVER change the name of the polyatomic
  - If the polyatomic is positive it will be written first and the non metal ion will change its suffix to “ide”
    - Example: NH_4Cl
      - ammonium chloride
  - If the polyatomic is negative the metal ion will not change its name, since you do not change the polyatomic it also does not change.
    - Example: $NaNO_3$
      - sodium nitrate

Writing Chemical Formulas of a Compound with a Polyatomic Ion (Step 1)

Problem:

What is the chemical formula for calcium nitrate?

Step 1: Identify each ion and its charge. Use Table 2.7 to find the formula of the polyatomic ion.

- Look at the periodic table to find the ion charge of calcium. Use Table 2.7 to find the formula and charge of nitrate.
- Calcium is a Group 2 metal, so its ion charge is 2+: **Ca^{2+}**
- Nitrate: **NO_3^-**

Step 2: Determine the number of ions needed to balance positive charges with negative charges.

- A calcium ion (Ca^{2+}) has a charge of 2+
- A nitrate ion (NO_3^-) has a charge of 1-
- Therefore, two nitrate ions are needed to balance the positive charge of one calcium ion

Charge from Ca^{2+}	Charge from NO_3^-
A calcium ion has a charge of 2+. $1 \times (2+) = 2+$	A nitrate ion has a charge of 1−. Therefore, 2 nitrate ions are needed to balance the charge of one calcium ion. $2 \times (1-) = 2-$

Step 3: Use subscripts to write the formula (do not include a subscript if the subscript would be "1").

If there is more than one polyatomic ion needed, use parentheses to enclose the polyatomic ion before adding the subscript.

- Recall: Two nitrate ions are needed to balance the positive charge of one calcium ion
- Therefore, the formula for calcium nitrate is **$Ca(NO_3)_2$**.

Discussion Questions

1. What is a polyatomic ion?

2. How are parentheses used in writing formulas containing polyatomic ions?

Time OUT

- Complete page 97 in workbook