Chapter 9
“Chemical Names and Formulas”

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Section 9.1
Naming Ions

● OBJECTIVES:
  - Identify the charges on monatomic ions by using the periodic table, and name the ions.

Section 9.1
Naming Ions

● OBJECTIVES:
  - Identify the two common endings for the names of most polyatomic ions.

Atoms and ions

● Atoms are electrically neutral.
  - Because there is the same number of protons and electrons.

● Ions are atoms, or groups of atoms, with a charge (positive or negative)
  - They have different numbers of protons and electrons.

● Only electrons can move, and ions are made by gaining or losing electrons.

An Anion is...

● A negative ion.
● Has gained electrons.
● Nonmetals can gain electrons.
● Charge is written as a superscript on the right.

- F\(^{\text{-}}\) has gained one electron (ide is new ending = fluoride)
- O\(^{2-}\) gained two electrons (oxide)
A Cation is...

- A positive ion.
- Formed by losing electrons.
- More protons than electrons.
- Metals can lose electrons
  - $K^{+}$: Has lost one electron (no name change for positive ions)
  - $Ca^{2+}$: Has lost two electrons

Predicting Ionic Charges

**Group 1A:** Lose 1 electron to form $1^+$ ions
- $H^{+}$, $Li^{+}$, $Na^{+}$, $K^{+}$, $Rb^{+}$

**Group 2A:** Loses 2 electrons to form $2^+$ ions
- $Be^{2+}$, $Mg^{2+}$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$

**Group 3A:** Loses 3 electrons to form $3^+$ ions
- $B^{3+}$, $Al^{3+}$, $Ga^{3+}$

**Group 4A:** Lose 4 electrons or gain 4 electrons?
- $N^{3-}$: Nitride
- $P^{3-}$: Phosphide
- $As^{3-}$: Arsenide

**Group 5A:** Gains 3 electrons to form $3^-$ ions
- $N^{3-}$: Nitride
- $P^{3-}$: Phosphide
- $As^{3-}$: Arsenide
Predicting Ionic Charges

- **Group 6A**: Gains 2 electrons to form 2- ions
- **Group 7A**: Gains 1 electron to form 1- ions

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**Naming cations**

- **Two methods** can clarify when more than one charge is possible:
  1. **Stock system** – uses roman numerals in parenthesis to indicate the numerical value
  2. **Classical method** – uses root word with suffixes (-ous, -ic)
    - Does not give true value

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**Group B elements**: Many transition elements have more than one possible oxidation state. Note the use of Roman numerals to show charges. Iron (II) = Fe²⁺, Iron (III) = Fe³⁺
Predicting Ionic Charges

Some of the post-transition elements also have more than one possible oxidation state.
- Tin (II) = Sn^{2+}
- Tin (IV) = Sn^{4+}
- Lead (II) = Pb^{2+}
- Lead (IV) = Pb^{4+}

Group B elements: Some transition elements have only one possible oxidation state, such as these that are always:
- Silver = Ag^{1+}
- Zinc = Zn^{2+}
- Cadmium = Cd^{2+}

Exceptions:
- Some of the transition metals have only one ionic charge:
  - Do not use roman numerals for these:
  - Silver is always 1+ (Ag^{+})
  - Cadmium and Zinc are always 2+ (Cd^{2+} and Zn^{2+})

Practice by naming these:
- Na^{+}
- Ca^{2+}
- Al^{3+}
- Fe^{2+}
- Fe^{3+}
- Pb^{2+}
- Li^{+}

Write Formulas for these:
- Potassium ion
- Magnesium ion
- Copper (II) ion
- Chromium (VI) ion
- Barium ion
- Mercury (II) ion

Naming Anions
- Anions are always the same charge
- Change the monatomic element ending to – ide
- F^{-} a Fluorine atom becomes a Fluoride ion.
Practice by naming these:

- Cl⁻
- N³⁻
- Br⁻
- O²⁻
- Ga³⁺

Write symbols for these:

- Sulfide ion
- Iodide ion
- Phosphide ion
- Strontium ion

Polyatomic ions are...

- Groups of atoms that stay together and have an overall charge, and one name.
- Usually end in -ate or -ite

- Acetate: \( \text{C}_2\text{H}_3\text{O}_2^- \)
- Nitrate: \( \text{NO}_3^- \)
- Nitrite: \( \text{NO}_2^- \)
- Permanganate: \( \text{MnO}_4^- \)
- Hydroxide: \( \text{OH}^- \) and Cyanide: \( \text{CN}^- \)

Note Table 9.3 on page 257

- Sulfate: \( \text{SO}_4^{2-} \)
- Sulfite: \( \text{SO}_3^{2-} \)
- Carbonate: \( \text{CO}_3^{3-} \)
- Chromate: \( \text{CrO}_4^{2-} \)
- Dichromate: \( \text{Cr}_2\text{O}_7^{2-} \)
- Phosphate: \( \text{PO}_4^{3-} \)
- Phosphite: \( \text{PO}_3^{3-} \)
- Ammonium: \( \text{NH}_4^+ \)

Polyatomic ions (react as a single unit) begin with H. When combining hydrogen with polyatomic ions:

- \( \text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{HCO}_3^- \)
- Hydrogen + carbonate \( \rightarrow \) hydrogen carbonate ion

Section 9.2 Naming and Writing Formulas for Ionic Compounds

- **OBJECTIVES:**
  - Apply the rules for naming and writing formulas for binary ionic compounds.

Section 9.2 Naming and Writing Formulas for Ionic Compounds

- **OBJECTIVES:**
  - Apply the rules for naming and writing formulas for compounds with polyatomic ions.
Writing Ionic Compound Formulas

Example: Barium nitrate
1. Write the formulas for the cation and anion, including **CHARGES**!
2. Check to see if charges are balanced.
3. Balance charges, if necessary, using subscripts. Use parentheses if you need more than one of a **polymatonic ion**. Use the **criss-cross** method to balance subscripts.

\[
\text{Ba}^2+ (\text{NO}_3^-)_2 \quad \text{Now balanced: } \text{Ba(NO}_3\text{)}_2 \\
\text{Not balanced!}
\]

Example: Ammonium sulfate
1. Write the formulas for the cation and anion, including **CHARGES**!
2. Check to see if charges are balanced.
3. Balance charges, if necessary, using subscripts. Use parentheses if you need more than one of a **polymatonic ion**. Use the **criss-cross** method to balance the subscripts.

\[
(\text{NH}_4)^+ \text{SO}_4^2- \quad \text{Now balanced: } (\text{NH}_4\text{)}\text{SO}_4 \\
\text{Not balanced!}
\]

Writing Ionic Compound Formulas

Example: Iron (III) chloride
1. Write the formulas for the cation and anion, including **CHARGES**!
2. Check to see if charges are balanced.
3. Balance charges, if necessary, using subscripts. Use parentheses if you need more than one of a **polymatonic ion**. Use the **criss-cross** method to balance the subscripts.

\[
\text{Fe}^{3+} \text{Cl}_3 \quad \text{Now balanced: } \text{FeCl}_3 \\
\text{Not balanced!}
\]

Example: Aluminum sulfide
1. Write the formulas for the cation and anion, including **CHARGES**!
2. Check to see if charges are balanced.
3. Balance charges, if necessary, using subscripts. Use parentheses if you need more than one of a **polymatonic ion**. Use the **criss-cross** method to balance the subscripts.

\[
\text{Al}^{3+} \text{S}_3 \quad \text{Now balanced: } \text{Al}_2\text{S}_3 \\
\text{Not balanced!}
\]

Writing Ionic Compound Formulas

Example: Magnesium carbonate
1. Write the formulas for the cation and anion, including **CHARGES**!
2. Check to see if charges are balanced.

\[
\text{Mg}^{2+} \text{CO}_3^2- \quad \text{They are balanced!} \\
\text{MgCO}_3
\]

Example: Zinc hydroxide
1. Write the formulas for the cation and anion, including **CHARGES**!
2. Check to see if charges are balanced.
3. Balance charges, if necessary, using subscripts. Use parentheses if you need more than one of a **polymatonic ion**. Use the **criss-cross** method to balance the subscripts.

\[
\text{Zn}^{2+} (\text{OH})_2 \quad \text{Now balanced: } \text{Zn(OH)}_2 \\
\text{Not balanced!}
\]
Writing Ionic Compound Formulas

Example: Aluminum phosphate
1. Write the formulas for the cation and anion, including CHARGES!
2. Check to see if charges are balanced.

\[ \text{Al}^{3+} \text{PO}_4^{3-} \]

They ARE balanced! = AlPO_4

Naming Ionic Compounds

- 1. Name the cation first, then anion
- 2. Monatomic cation = name of the element
  
  \[ \text{Ca}^{2+} = \text{calcium ion} \]
- 3. Monatomic anion = root + -ide
  
  \[ \text{Cl}^- = \text{chloride} \]
  
  \[ \text{CaCl}_2 = \text{calcium chloride} \]

Naming Ionic Compounds (Metals with multiple oxidation states)

- Some metals can form more than one charge (usually the transition metals)
- Use a Roman numeral in their name:
  
  \[ \text{PbCl}_2^- \text{ use the anion to find the charge on the cation (chloride is always 1-)} \]

  \[ \text{Pb}^{2+} \text{ is the lead (II) cation} \]
  
  \[ \text{PbCl}_2 = \text{lead (II) chloride} \]

Things to look for

- If cations have ( ), the number in parenthesis is their charge.
- If anions end in -ide they are probably off the periodic table (Monoatomic)
- If anion ends in -ate or -ite, then it is polyatomic

Section 9.3 Naming and Writing Formulas for Molecular Compounds

- OBJECTIVES:
  - Interpret the prefixes in the names of molecular compounds in terms of their chemical formulas.

Section 9.3 Naming and Writing Formulas for Molecular Compounds

- OBJECTIVES:
  - Apply the rules for naming and writing formulas for binary molecular compounds.
Molecular compounds are…
- made of just **nonmetals**
- smallest piece is a **molecule**
- can’t be held together because of opposite charges.
- can’t use charges to figure out how many of each atom

Molecular compounds are easier!
- Ionic compounds use charges to determine how many of each.
  - Have to figure out charges.
  - May need to criss-cross numbers.
- Molecular compounds: the **name** tells you the number of atoms.
- Uses **prefixes** to tell you the exact number of each element present!

**Prefixes (Table 9.4, p.269)**
- 1 = mono-
- 2 = di-
- 3 = tri-
- 4 = tetra-
- 5 = penta-
- 6 = hexa-
- 7 = hepta-
- 8 = octa-

**Prefixes**
- 9 = nona-
- 10 = deca-

To write the name, write two words:

```
Prefix name   Prefix name -ide
```

One exception is we don’t write mono- if there is only one of the first element.

**Prefixes**
- 9 = nona-
- 10 = deca-

To write the name, write two words:

```
Prefix name   Prefix name -ide
```

One exception is we don’t write mono- if there is only one of the first element.
- Normally do not have double vowels when writing names (oa oo)
Practice by naming these:
- $\text{N}_2\text{O}$
- $\text{NO}_2$
- $\text{Cl}_2\text{O}_7$
- $\text{CBr}_4$
- $\text{CO}_2$
- $\text{BaCl}_2$

Write formulas for these:
- diphosphorus pentoxide
- tetraiodine nonoxide
- sulfur hexafluoride
- nitrogen trioxide
- carbon tetrahydride
- phosphorus trifluoride
- aluminum chloride

Section 9.4
Naming and Writing Formulas for Acids and Bases

OBJECTIVES:
- Apply three rules for naming acids.

Section 9.4
Naming and Writing Formulas for Acids and Bases

OBJECTIVES:
- Apply the rules in reverse to write formulas of acids.

Section 9.4
Naming and Writing Formulas for Acids and Bases

OBJECTIVES:
- Apply the rules for naming bases.

Acids are...
- Compounds that give off hydrogen ions when dissolved in water.
- Will start the formula with H.
- There will always be some Hydrogen next to an anion.
- The anion determines the name.
Rules for Naming acids

1) If the anion attached to hydrogen ends in -ide, put the prefix hydro- and change -ide to -ic acid
   - HCl - hydrogen ion and chloride ion = hydrochloric acid
   - H₂S hydrogen ion and sulfide ion = hydro sulfuric acid

Naming Acids

- If the anion has oxygen in it, then it ends in -ate or -ite
  1) change the suffix -ate to -ic acid (use no prefix)
     - Example: HNO₃, Hydrogen and nitrate ions = Nitric acid
  1) change the suffix -ite to -ous acid (use no prefix)
     - Example: HNO₂, Hydrogen and nitrite ions = Nitrous acid

Naming Acids

- Normal ending
- _____-ide    • hydro-_____ -ic acid
- _____-ate    • _____-ic acid
- _____-ite    • _____-ous acid

Practice by naming these:
- HF
- H₃P
- H₂SO₄
- H₂SO₃
- HCN
- H₂CrO₄

Writing Acid Formulas – in reverse!
- Hydrogen will always be listed first
- The name will tell you the anion
- Be sure the charges cancel out.
- Starts with prefix hydro? - there is no oxygen, -ide ending for anion
- no hydro?, -ate anion comes from -ic, -ite anion comes from -ous

Write formulas for these:
- hydroiodic acid
- acetic acid
- carbonic acid
- phosphorous acid
- hydro bromic acid
Names and Formulas for Bases

- A base is an ionic compound that produces hydroxide ions (OH⁻) when dissolved in water.
- Bases are named the same way as other ionic compounds:
  - The name of the cation (which is a metal) is followed by the name of the anion (which is hydroxide).

Names and Formulas for Bases

- NaOH is sodium hydroxide
- Ca(OH)₂ is calcium hydroxide
- To write the formula:
  1) Write the symbol for the metal cation
  2) followed by the formula for the hydroxide ion (OH⁻)
  3) then use the criss-cross method to balance the charges.

Section 9.5
The Laws Governing Formulas and Names

OBJECTIVES:
- Define the laws of definite proportions and multiple proportions.

Section 9.5
The Laws Governing Formulas and Names

OBJECTIVES:
- Apply the rules for naming chemical compounds by using a flowchart.

Section 9.5
The Laws Governing Formulas and Names

OBJECTIVES:
- Apply the rules for writing the formulas of chemical compounds by using a flowchart.

Some Laws:

1. Law of Definite Proportions-
   - in a sample of a chemical compound, the masses of the elements are always in the same proportions.
   - H₂O (water) and H₂O₂ (hydrogen peroxide)
Some Laws:

2. Law of Multiple Proportions - Dalton stated that whenever two elements form more than one compound, the **different masses of one element** that combine with the **same mass of the other element** are in the ratio of small whole numbers.

Summary of Naming and Formula Writing

- For naming, follow the flowchart - Figure 9.20, page 277
- For writing formulas, follow the flowchart from Figure 9.22, page 278

Helpful to remember...

- 1. In an ionic compound, the net ionic charge is **zero** (criss-cross method)
- 2. An **-ide** ending generally indicates a binary compound
- 3. An **-ite** or **-ate** ending means there is a polyatomic ion that has oxygen
- 4. Prefixes generally mean molecular; they show the number of each atom

5. A Roman numeral after the name of a cation is the **ionic charge** of the cation
- Use the **handout sheets** provided by your teacher!