

Elements and Compounds

- elements combine together to make an almost limitless number of compounds
- the properties of the compound are totally different from the constituent elements

Selected Properties

Selected Properties of Water

Boiling point, -
Gas at room temperature
Explosive

Boiling point, 100 °C
Liquid at room temperature
Used to extinguish flame

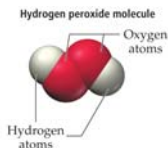
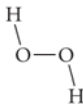


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Chemical Bonds

- compounds are made of atoms held together by **chemical bonds**
- bonds are forces of attraction between atoms



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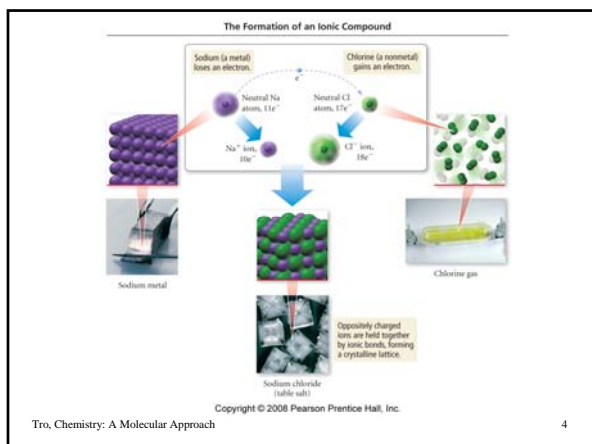
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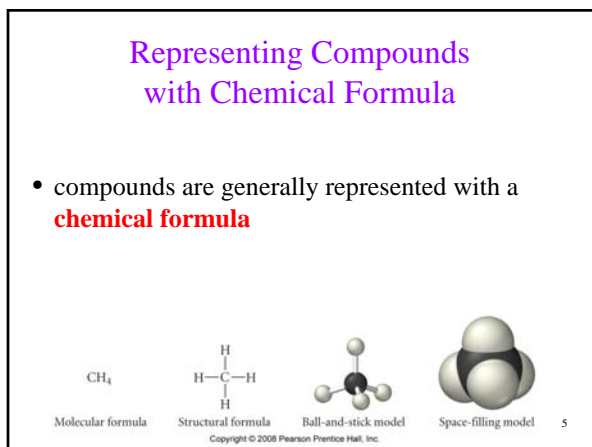
Bond Types

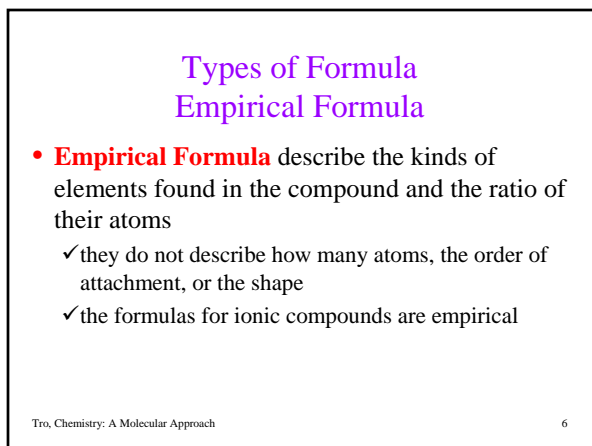
- two general types of bonding between atoms found in compounds, **ionic** and **covalent**
- **ionic bonds** result when electrons have been transferred between atoms, resulting in oppositely charged ions that attract each other
 - ✓ generally found when metal atoms bonded to nonmetal atoms
- **covalent bonds** result when two atoms share some of their electrons
 - ✓ generally found when nonmetal atoms bonded together

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Types of Formula Molecular Formula

- **Molecular Formula** describe the kinds of elements found in the compound and the numbers of their atoms
 - ✓ they do not describe the order of attachment, or the shape

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Chemical Formulas

Hydrogen Peroxide

Molecular Formula = H_2O_2

Empirical Formula = HO

Benzene

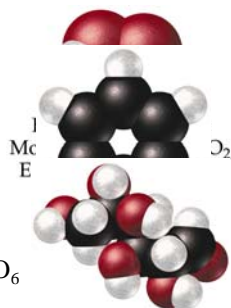
Molecular Formula = C_6H_6

Empirical Formula = CH

Glucose

Molecular Formula = $C_6H_{12}O_6$

Empirical Formula = CH_2O



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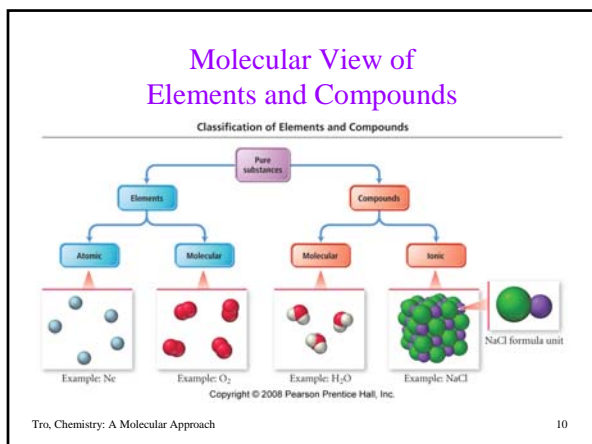
TABLE 3.1 Benzene, Acetylene, Glucose, and Ammonia

Name of Compound	Empirical Formula	Molecular Formula	Structural Formula	Ball-and-Stick Model	Space-Filling Model
Benzene	CH	C_6H_6			
Acetylene	CH	C_2H_2	$H-C\equiv C-H$		
Glucose	CH_2O	$C_6H_{12}O_6$			
Ammonia	NH_3	NH_3			

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- ### Classifying Materials
- **atomic elements** = elements whose particles are single atoms
 - **molecular elements** = elements whose particles are multi-atom molecules
 - **molecular compounds** = compounds whose particles are molecules made of only nonmetals
 - **ionic compounds** = compounds whose particles are cations and anions
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Molecular Elements

- Certain elements occur as 2 atom molecules
 - ✓ Rule of 7's
- Other elements occur as polyatomic molecules
 - ✓ P₄, S₈, Se₈

H₂

N₂

O₂

F₂

7A

Cl₂

Br₂

I₂

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Writing Formulas for Ionic Compounds

1. Write the symbol for the metal cation and its charge
2. Write the symbol for the nonmetal anion and its charge
3. Charge (without sign) becomes subscript for other ion
4. Reduce subscripts to smallest whole number ratio
5. Check that the sum of the charges of the cation cancels the sum of the anions

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Write the formula of a compound made from aluminum ions and oxide ions

1. Write the symbol for the metal cation and its charge Al^{+3} column 3A
2. Write the symbol for the nonmetal anion and its charge O^{2-} column 6A
3. Charge (without sign) becomes subscript for other ion $Al^{+3} O^{2-}$
4. Reduce subscripts to smallest whole number ratio $Al_2 O_3$
5. Check that the total charge of the cations cancels the total charge of the anions
 $Al = (2) \cdot (+3) = +6$
 $O = (3) \cdot (-2) = -6$

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Practice - What are the formulas for compounds made from the following ions?

- potassium ion with a nitride ion
- calcium ion with a bromide ion
- aluminum ion with a sulfide ion

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Naming Binary Ionic Compounds for Metals with Invariant Charge

- Contain Metal Cation + Nonmetal Anion
 - Metal listed first in formula and name
1. name metal cation first, name nonmetal anion second
 2. cation name is the metal name
 3. nonmetal anion named by changing the ending on the nonmetal name to **-ide**



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Name the following compounds

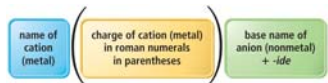
1. KCl
2. MgBr₂
3. Al₂S₃

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Naming Binary Ionic Compounds for Metals with Variable Charge

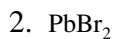
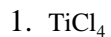
- Contain Metal Cation + Nonmetal Anion
 - Metal listed first in formula and name
1. name metal cation first, name nonmetal anion second
 2. metal cation name is the metal name followed by a Roman numeral in parentheses to indicate its charge
 - ✓ determine charge from anion charge
 - ✓ common ions Table 3.4
 3. nonmetal anion named by changing the ending on the nonmetal name to **-ide**



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Name the following compounds



Example – Writing Formula for Binary Ionic Compounds Containing Variable Charge Metal
manganese(IV) sulfide

1. Write the symbol for the cation and its charge Mn^{+4}
2. Write the symbol for the anion and its charge S^{2-}
3. Charge (without sign) becomes subscript for other ion $\text{Mn}^{+4} \text{S}^{2-} \rightarrow \text{Mn}_2\text{S}_4$
4. Reduce subscripts to smallest whole number ratio MnS_2
5. Check that the total charge of the cations cancels the total charge of the anions
 $\text{Mn} = (1) \cdot (+4) = +4$
 $\text{S} = (2) \cdot (-2) = -4$

Practice - What are the formulas for compounds made from the following ions?

1. copper(II) ion with a nitride ion

2. iron(III) ion with a bromide ion

Compounds Containing Polyatomic Ions

- Polyatomic ions are single ions that contain more than one atom
- Often identified by (ion) in formula
- Name and charge of polyatomic ion do not change
- Name any ionic compound by naming cation first and then anion

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Some Common Polyatomic Ions

Name	Formula	Name	Formula
acetate	$C_2H_3O_2^-$	hypochlorite	ClO^-
carbonate	CO_3^{2-}	chlorite	ClO_2^-
hydrogen carbonate (aka bicarbonate)	HCO_3^-	chlorate	ClO_3^-
hydroxide	OH^-	perchlorate	ClO_4^-
nitrate	NO_3^-	sulfate	SO_4^{2-}
nitrite	NO_2^-	sulfite	SO_3^{2-}
chromate	CrO_4^{2-}	hydrogen sulfate (aka bisulfate)	HSO_4^-
dichromate	$Cr_2O_7^{2-}$	hydrogen sulfite (aka bisulfite)	HSO_3^-
ammonium	NH_4^+		

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Example – Naming Ionic Compounds Containing a Polyatomic Ion



1. Identify the ions
 $Na = Na^+$ because in Group 1A
 $SO_4 = SO_4^{2-}$ a polyatomic ion
2. Name the cation
 Na^+ = sodium, metal with invariant charge
3. Name the anion
 SO_4^{2-} = sulfate
4. Write the name of the cation followed by the name of the anion
 sodium sulfate

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Name the following

1. NH_4Cl
2. $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$
3. $\text{Cu}(\text{NO}_3)_2$

Practice - What are the formulas for compounds made from the following ions?

1. aluminum ion with a sulfate ion
2. chromium(II) with hydrogen carbonate

Hydrates

- hydrates are ionic compounds containing a specific number of waters for each formula unit
- water of hydration often "driven off" by heating
- in formula, attached waters follow
 - ✓ $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$
- in name attached waters indicated by suffix *-hydrate* after name of ionic compound
 - ✓ $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ = cobalt(II) chloride hexahydrate
 - ✓ $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ = calcium sulfate hemihydrate

Hydrate
 $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$



Anhydrous
 CoCl_2

Prefix	No. of Waters
hemi	1/2
mono	1
di	2
tri	3
tetra	4
penta	5
hexa	6
hepta	7
octa	8

Practice

1. What is the formula of magnesium sulfate heptahydrate?
2. What is the name of $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$?

Writing Names of Binary Molecular Compounds of 2 Nonmetals

1. Write name of first element in formula
 - ✓ element furthest left and down on the Periodic Table
 - ✓ use the full name of the element
2. Write name the second element in the formula with an **-ide** suffix
 - ✓ as if it were an anion, *however, remember these compounds do not contain ions!*
3. Use a prefix in front of each name to indicate the number of atoms

a) Never use the prefix *mono-* on the first element



Subscript - Prefixes

- 1 = mono-
 - ✓ not used on first nonmetal
 - 2 = di-
 - 3 = tri-
 - 4 = tetra-
 - 5 = penta-
 - 6 = hexa-
 - 7 = hepta-
 - 8 = octa-
 - 9 = nona-
 - 10 = deca-
- drop last "a" if name begins with vowel

Example – Naming Binary Molecular



1. Name the first element
boron
2. Name the second element with an *-ide*
fluorine \Rightarrow fluoride
3. Add a prefix to each name to indicate the subscript
monoboron, trifluoride
4. Write the first element with prefix, then the second element with prefix
✓ Drop prefix *mono* from first element
boron trifluoride

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Name the following

1. NO_2
2. PCl_5
3. I_2F_7

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Write formulas for the following

1. dinitrogen tetroxide
2. sulfur hexafluoride
3. diarsenic trisulfide

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