Chapter 3 Slides

3.1-3.9

Molecules, Compounds, and Formulas

A compound is a combination of 2 or more elements in definite ratios by mass.
The character of each element is lost when forming a compound.

A molecule is a smallest unit of material that has unique identifiable physical and chemical properties

AB AB_2 A_3B

Ionic Solid (NaCl)

Molecular Formulas

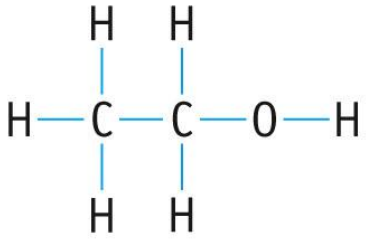
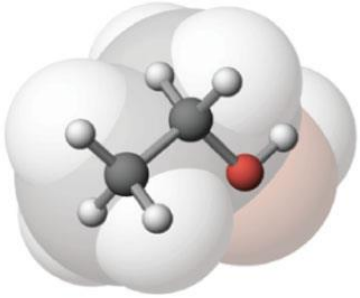
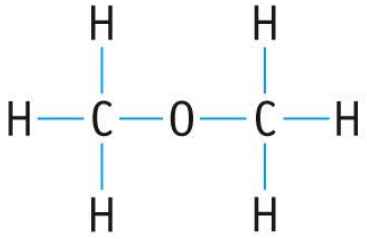
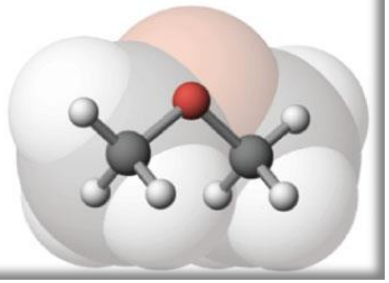
Molecular Formula: number and types of each atom.

Condensed Formula: provides additional structural information

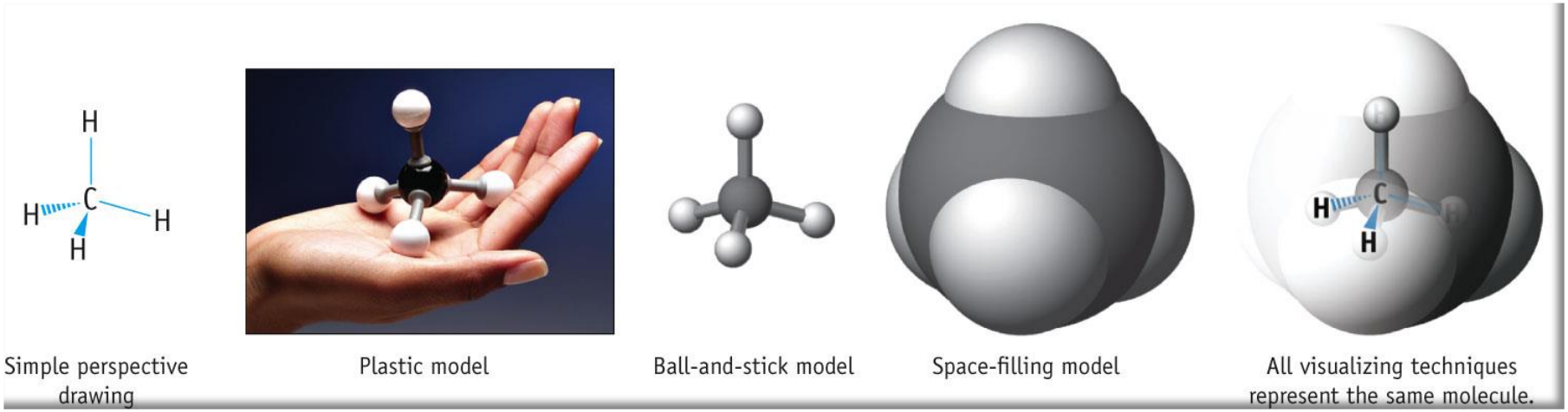
Structural Formula: explicit structural information, the connections between atoms

Molecular Model: provides a three-dimensional perspective of structure

Molecular Formulas

NAME	MOLECULAR FORMULA	CONDENSED FORMULA	STRUCTURAL FORMULA	MOLECULAR MODEL
Ethanol	C_2H_6O	CH_3CH_2OH		
Dimethyl ether	C_2H_6O	CH_3OCH_3		

Molecular Models



Simple perspective drawing

Plastic model

Ball-and-stick model

Space-filling model

All visualizing techniques represent the same molecule.

Naming Binary Molecular (Covalent) Compounds

1. Name the "more cation-like" of the two elements.

   This is usually the first element if you have the formula written.

2. Name the second element in the formula with an ***–ide,*** 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.

   Never use the prefix ***mono-*** on the first element.

Naming Binary Molecular (Covalent) Compounds

Drop the a if the prefix is used with an element that begins with a vowel!

Prefix List:

1- mono	5- penta
2- di	6- hexa
3- tri	7- hepta
4- tetra	8- octa

Example—Naming Binary Molecular, BF_3 , Continued

4. Pick the more cation-like element.

   boron.

5. Name the second element with an ***–ide.***

   Fluorine $\Rightarrow$ fluoride.

6. Add a prefix to each name to indicate the subscript.

   monoboron, trifluoride.

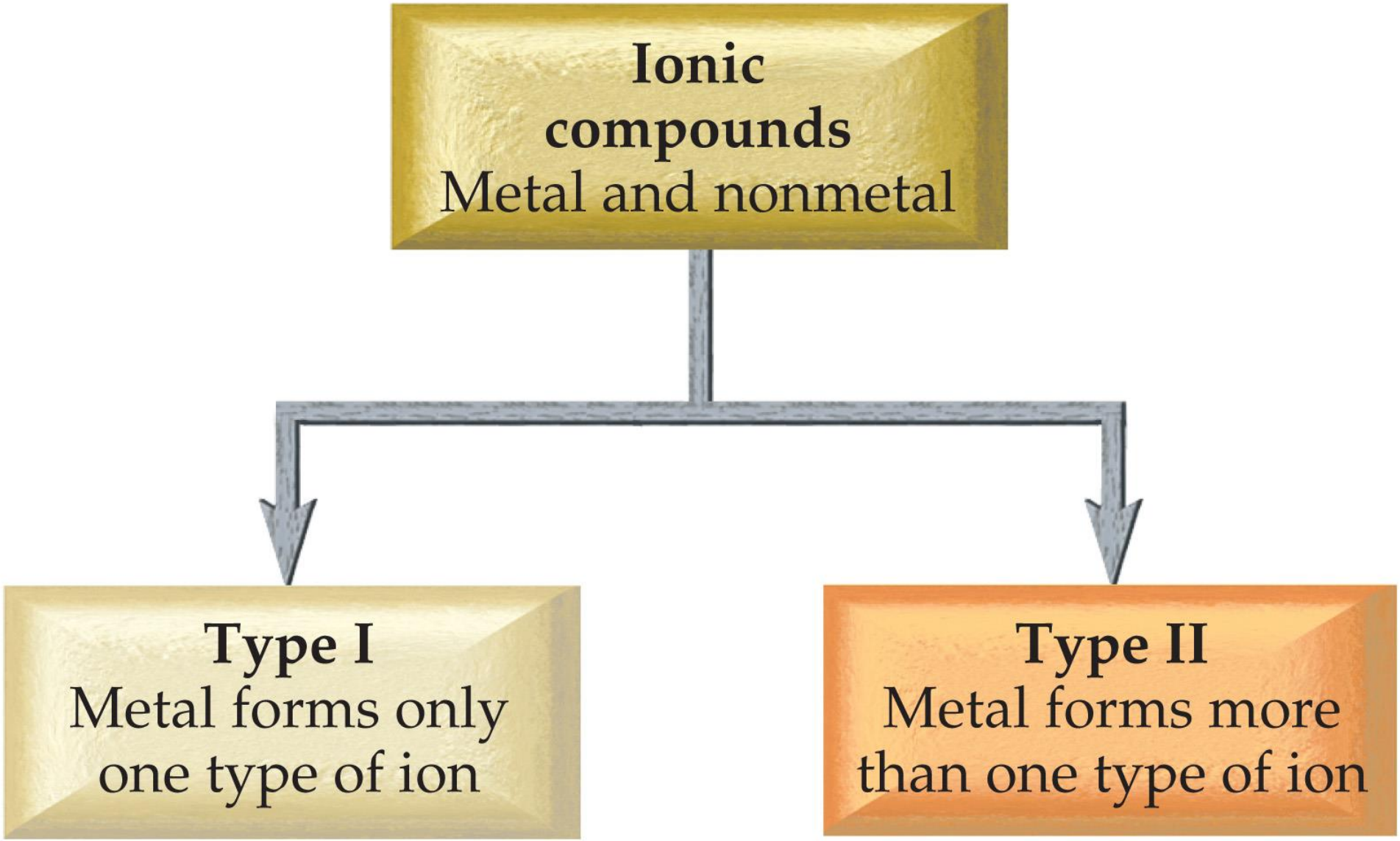
7. Write the first element with prefix, then the second element with prefix.
   - Drop prefix ***mono-*** from first element.

     boron trifluoride.

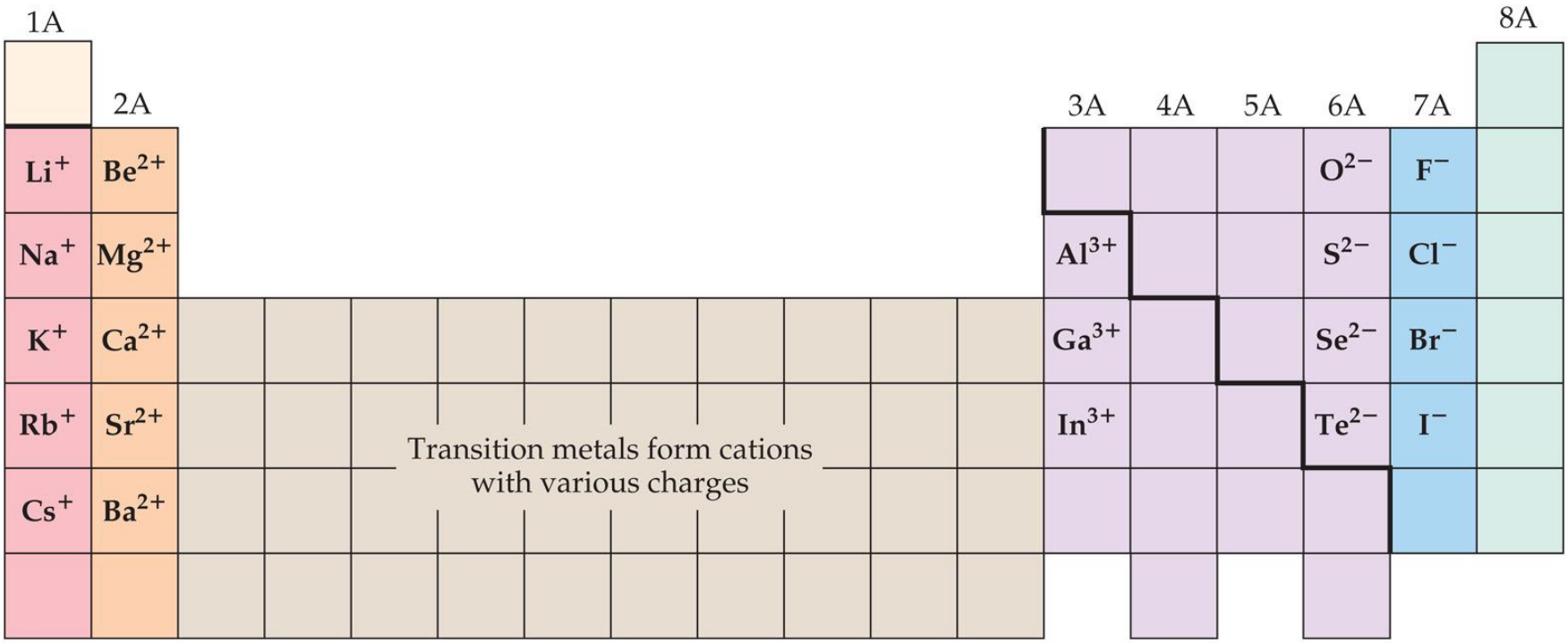
Practice – Naming Covalent Compounds

- NO
- NO_2
- N_2O_5

Ionic Solid (NaCl)



Type I: Main Group Cations and Anions



Some Common Polyatomic Ions

Name	Formula
Acetate	$C_2H_3O_2^-$
Carbonate	CO_3^{2-}
Hydrogencarbonate (aka bicarbonate)	HCO_3^-
Hydroxide	OH^-
Nitrate	NO_3^-
Nitrite	NO_2^-
Chromate	CrO_4^{2-}
Dichromate	$Cr_2O_7^{2-}$
Ammonium	NH_4^+
Phosphate	PO_4^{3-}
Dihydrogen Phosphate	$H_2PO_4^-$

Hypochlorite	ClO^-
Chlorite	ClO_2^-
Chlorate	ClO_3^-
Perchlorate	ClO_4^-
Sulfate	SO_4^{2-}
Sulfite	SO_3^{2-}
Thiosulfate	$S_2O_3^{2-}$
Hydrogen phosphate	HPO_4^{2-}
Hydrogen sulfate (aka bisulfate)	HSO_4^-
Hydrogen sulfite (aka bisulfite)	HSO_3^-
Cyanide	CN^-
Permanganate	MnO_4^-

Naming Type I Binary Ionic Compounds

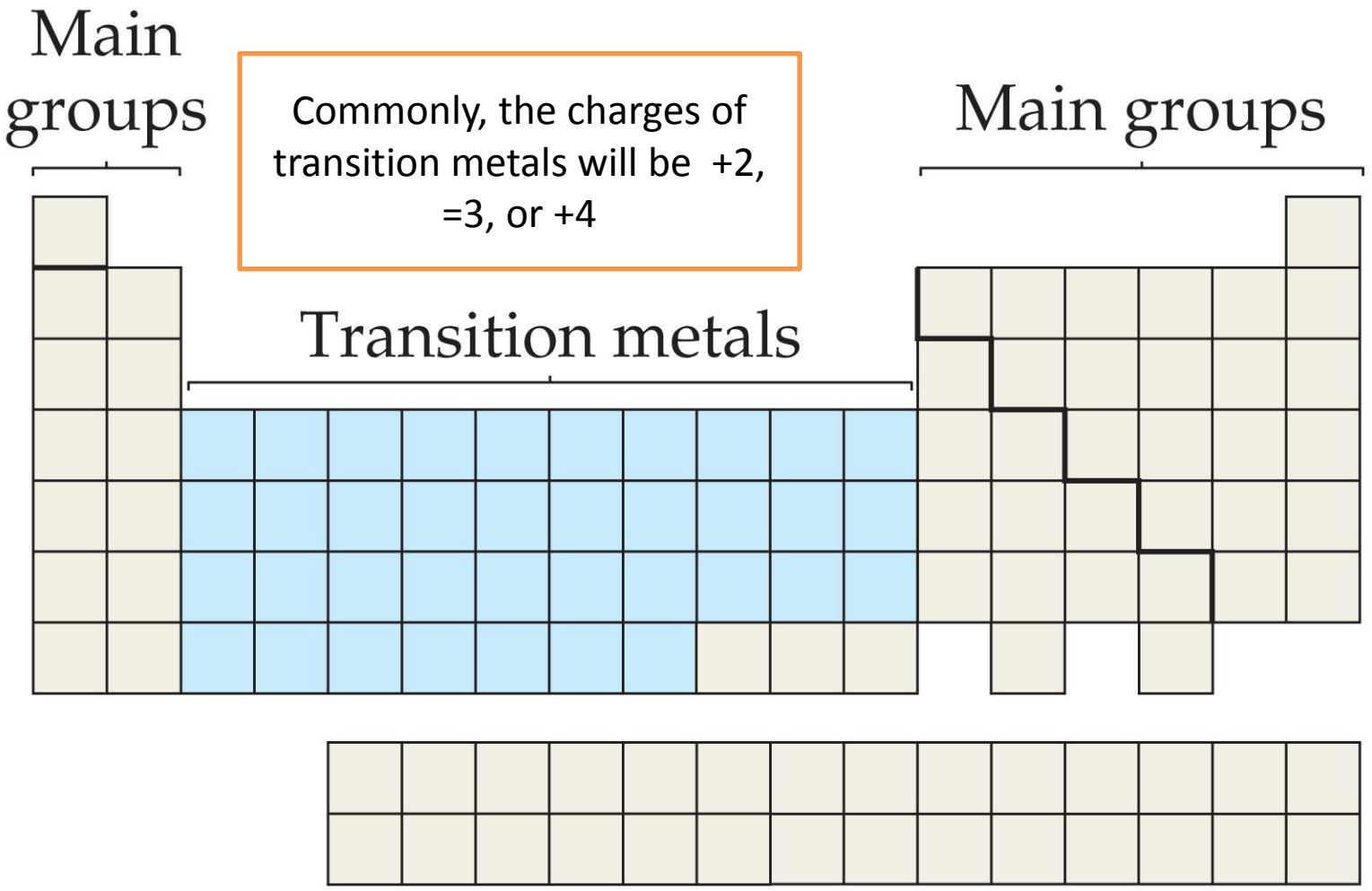
name of cation (metal)

base name of anion (nonmetal) + *-ide*

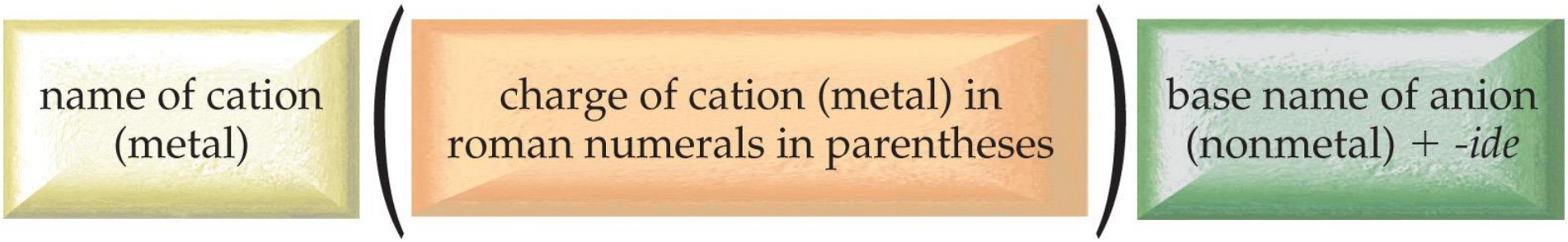
Name the Following:

- $CsBr_2$
- Al_2O_3
- $KMnO_4$
- NH_4NO_3

Type II: Metal could form more than one cation



Naming a Type II Binary Ionic Compound



Practice–Name the Following Compounds.

- $TiCl_4$
- $PbBr_2$
- Fe_2S_3

Practice–Name the Following

1. NH_4Cl

2. $Ca(C_2H_3O_2)_2$

3. $Cu(NO_3)_2$

Practice–Name the Following, Continued

1. NH_4Cl Ammonium chloride.

2. $Ca(C_2H_3O_2)_2$ Calcium acetate.

3. $Cu(NO_3)_2$ Copper(II) nitrate.

$NO_3 = 2(-1) = -2$

$Cu = +2 = 1(2+)$

Writing Formulas from the Names of Ionic Compounds

Iron (III) phosphate

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

Fe^{+3}

PO_4^{3-}

$Fe^{+3}\ PO_4^{3-}$ $Fe_3(PO_4)_3$

$FePO_4$

$Fe = (1)\cdot(+3) = +3$

$PO_4 = (1)\cdot(-3) = -3$

Practice—What Are the Formulas for Compounds Made from the Following Ions?

1. Aluminum ion with a sulfate ion.

2. Chromium(II) with hydrogencarbonate.

Practice—What Are the Formulas for Compounds Made from the Following Ions?, Continued

1. Al^{+3} with SO_4^{2-} $Al_2(SO_4)_3$

2. Cr^{+2} with HCO_3^- $Cr(HCO_3)_2$

Hydrates

A hydrate is a substance composed of an inorganic salt and physically bound water.

$$MX \cdot nH_2O$$

salt *water*

n = is the ratio of moles of water to 1 mole of the salt

$$n = \frac{mols\,H_2O}{mols\,MX}$$

Naming Hydrates

Salt name + prefix hydrate

prefix: mono, di, tri etc…

sodium sulfate pentahydrate $Na_2SO_4 \cdot 5H_2O$

Molecular Weight

Molecular weight is sum of the atomic weights of all atoms in the molecule.

Molar mass is the molecular weight in grams

1 mol of ethanol C_2H_6O contains:

2 mol $\times$ C (12.01 g C/1 mol) = 24.02 g C

6 mol $\times$ H (1.01 g H/1 mol) = 6.06 g H

1 mol $\times$ O (16.00 g O/1 mol) = 16.00 g O

TOTAL = molar mass = 46.08 g/mol

Molecular Weights and Moles

One mole of			Contains
Br_2	or	159.80 g	6.022×10^{23} Br_2 molecules
			$2 \times (6.022 \times 10^{23})$ Br atoms
C_6H_6O	or	94.07 g	6.022×10^{23} C_6H_6O molecules
			$6 \times (6.022 \times 10^{23})$ C atoms
			$6 \times (6.022 \times 10^{23})$ H atoms
			$1 \times (6.022 \times 10^{23})$ O atoms

Using the Molecular Formula as a Conversion Factor

Percent Composition

Given a chemical formula it is straightforward to find mass percentages

Find the molar mass and the mass from each element

Ethanol, C_2H_6O

%C = (24.02 g C)/(46.08 g total) x 100 = 52.13% C

13.15% H

34.72% O

Formulas from Elemental Composition

Given the relative percentages of each element in a compound one can find the *empirical formula* of the compound

The empirical formula of a compound or molecule represents the simplest ratio of each element in 1 mol of the compound or molecule.

Benzene:

CH	empirical formula
C_6H_6	molecular formula