Compounds (p30-32)

Atoms form compounds so it may acquire a valence energy level like that of the closet noble gas. List the 3 ways this can occur:

1. Metalic atoms will give up electrons to other atoms forming cations

2. Non-metallic atoms will tend to accepts electrons from other atoms forming anions.

3. Non-metallic atoms may share electrons with each other

There are two types of compounds we will be looking at:

1. Ionic Compounds- Composed of _IONS_.

Binary Ionic Compound are made of __2_ elements. They form when a __METAL_ reacts with a _NON-METAL_. When the 2 elements react __VALENCE_ electrons from the metal are _TRANSFERED_ to the non-metal. This forms an _IONIC__ bond. These bonds are very __STRONG_ because they result from strong forces of _ATTRACTION_ between _OPPOSITELY_ charged ions.

What is a CRYSYTAL LATTICE? How does it relate to IONIC COMPOUNDS?

Regular repeating pattern of ions in an ionic compound.

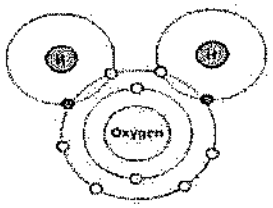
2. Molecular (Covalent) Compounds

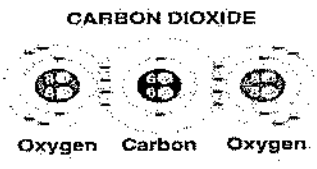
Made up of two or more non-metals that form molecules by _SHARING_ electrons.

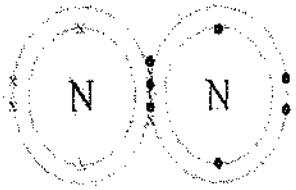
Atoms in molecules are joined by _COVALENT_ bonds. These bonds are different from _IONIC_ bonds. Neither atom wants to give up its _ELECTRONS_. Therefore there is no electron _TRANSFER_. Instead they __SHARE_ valence electrons in a _COVALENT_ bond.

An atom can form enough _COVALENT_ bonds to complete its _VALENCE_ energy level.

Draw electron dot diagrams of the following covalent bonds between elements: (see figure 1.29)



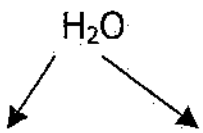




Single Bond Double Bond Triple Bond

Compounds are made up of atoms chemically bonded together.

Compounds are represented by chemical formulas, which tell us how many and what type of each atom is present in the compound. Chemical formulas make use of chemical symbols and subscripts:



- 2 atoms of hydrogen
- 1 atom of oxygen

Chemical symbol (= element) Subscript (= # of atoms)

Name the elements and how many atoms of each are in the following compounds:

H_3PO_4	NaCl	$CuSO_4$	$K_2Cr_2O_7$	$NaHCO_3$
hydrogen-3	sodium-1	copper-1	potassium-2	sodium-1
phosphorous-1	chlorine-1	sulfur-1	chromium-2	hydrogen-1
oxygen-4		oxygen-4	oxygen-7	carbon-1
				oxygen-3

For each of the following, indicate...

a) if it is a compound or an element
b) how many different atoms are present
c) how many atoms in total
d) which atoms and how many of each

Example:

H_2O a) Compound
b) 2
c) 3
d) 2 hydrogen & 1 oxygen

1. H_2SO_4 a)compound
   b)3
   c)7
   d) Hydrogen-2,Sulfur-1,oxygen-4

2. $KMnO_4$ a)compound
   b)3
   c)6
   d)potassium-1,Manganese-1,oxygen-4

3. H_2 a)Element
   b)1
   c)2
   d)hydrogen-2

4. H_2O_2 a)compound
   b) 2
   c)4
   d)hydrogen-2, oxygen-2

5. $C_6H_{12}O_6$ a)compound
   b)3
   c)24
   d) carbon-6, hydrogen-12, oxygen-6

6. Mg a)element
   b)1
   c)1
   d) magnesium-1

7. P_4 a)element
   b) 1
   c) 4
   d) phosphorus-4

8. NaCl a)compound
   b)2
   c)2
   d) sodium-1, chlorine-1

Ionic Compounds

Compounds, like atoms, are **electrically neutral**, which means they have no overall charge.

With ionic compounds, we are looking at charged species (ions) making up the compound. In order for the compound to be neutral, the charges on each ion must cancel out. This is important to keep in mind when writing the chemical formulas for ionic compounds.

Writing Formulas for Ionic Compounds

Step 1: Write the symbols, with the metal first

Step 2: Write the ionic charge above each symbol to indicate the stable ion that each element forms

Step 3: Determine how many ions of each type you need so that the total ionic charge is ZERO

Step 4: Write the formula using subscripts to indicate the number of each type of ion (1 as a subscript is not written)

Examples:
Write the formula of the compound formed from the following:

Lithium + Fluorine

Li^{+} F^{-}

1+ = 1-

LiF

Magnesium + Bromine

Mg^{2+} Br^{-}

2+ ≠ 1-

Mg^{2+} = Br^{-} Br^{-}

$MgBr_2$

Calcium + Phosphorus

Ca^{2+} P^{3-}

2+ ≠ 3-

Ca^{2+} Ca^{2+} Ca^{2+} = P^{3-} P^{3-}

Ca_3P_2

Cesium + Oxygen

Cs^{1+} O^{2-}

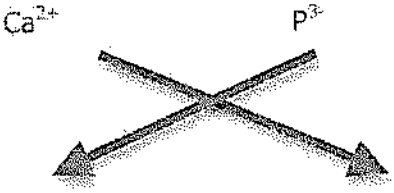
1+ ≠ 2-

Cs^{1+} Cs^{1+} = O^{2-}

Cs_2O

We can replace steps 2, 3, and 4 with the **Criss-Cross Rule**: write the ionic charges above the symbols and cross them down. Here, you need to ensure that the formula has the lowest number of ions that will produce an electrically neutral compound.

Examples:



Ca_3 P_2

Some metals, found in the middle of the Periodic Table are able to form more than one kind of ion. To distinguish between the different ions, we write a Roman numeral in brackets after the name of the metal in the compound to indicate its ionic charge:

Cu^{2+}	Cu^{+}	Sn^{2+}	Sn^{4+}
Copper (II)	Copper (I)	Tin (II)	Tin (IV)

Naming Ionic Compounds

The name of the metal always comes first, followed by the name of the non-metal, ending in "ide". If the metal can have more than one charge, indicate which charged state the metal is in using Roman numerals in brackets.

Examples:

NaCl	CaS	SnO	SnO_2
Sodium Chloride	Calcium Sulfide	Tin (2) oxide	Tin (4) oxide

Writing Names and Formulas of Binary Ionic Compounds

In the spaces below, record your answers to the questions in Investigation 2-A: Writing Names and Formulas of Binary Ionic Compounds.

1. Circle the binary compounds in the following list.

   (a) HCl

   (b) SO_3

   (c) $MgCO_3$

   (d) hydrogen sulfide

   (e) sodium bicarbonate

2. (a) Which types of elements combine to form binary ionic compounds?

   1 METAL AND 1 NON-METAL

   (b) Which types of elements combine to form binary molecular compounds?

   2 NON-METALS

3. Identify whether each name or formula represents an ionic or molecular substance.

   (a) sodium sulfide — IONIC

   (b) PCl_3 — MOLECULAR

   (c) nitrogen dioxide — MOLECULAR

   (d) zinc oxide — IONIC

   (e) MgI_2 — IONIC

4. Complete the following table.

Element		**Anion**	
Name	***Symbol***	***Name***	***Symbol***
fluorine	F	fluoride	F^-
Chlorine	Cl	chloride	Cl^-
Bromine	Br	bromide	Br^-
Oxygen	O	oxide	O^{2-}
Sulfur	S	sulfide	S^{2-}
Nitrogen	N	nitride	N^{3-}

5. Complete the following table.

Formula	Total charge on cation(s)	Total charge on anion(s)	Correct (√) or incorrect (X) formula?	Correct formula and name of compound
(a) LiO	1+	2-	X	Li_2O Lithium oxide
(b) MgO	2+	2-	√	Magnesium oxide
(c) K_2S	2+	2-	√	Potassium sulfide
(d) $AlBr_3$	3+	3-	√	Aluminum bromide
(e) NaN_3	1+	9-	X	Na_3N Sodium nitride

6. Complete the following table to write the formula of each compound.

Name of compound	Cation	Anion	Formula
(a) beryllium fluoride	Be^{2+}	F^-	BeF_2
(b) sodium nitride	Na^+	N^{3-}	Na_3N
(c) calcium sulfide	Ca^{2+}	S^{2-}	CaS
(d) aluminum chloride	Al^{3+}	Cl^-	$AlCl_3$
(e) lithium oxide	Li^+	O^{2-}	Li_2O
(f) magnesium nitride	Mg^{2+}	N^{3-}	Mg_3N_2
(g) gallium sulfide	Ga^{3+}	S^{2-}	Ga_2S_3
(h) barium bromide	Ba^{2+}	Br^-	$BaBr_2$

Ionic Compounds—Univalent Metal Ions

1. If the following pairs of elements were mixed and heated, they would combine into solid ionic compounds. Write the name and formula of each compound formed.

	Name	Formula
a) silver and iodine	silver iodide	$AgI_{(s)}$
b) magnesium and oxygen	Magnesium oxide	MgO
c) magnesium and bromine	Magnesium bromide	$MgBr_2$
d) calcium and nitrogen	Calcium nitride	Ca_3N_2
e) zinc and selenium	Zinc Selenide	ZnSe
f) sodium and sulfur	Sodium sulfide	Na_2S
g) barium and phosphorus	Barium phosphide	Ba_3P_2
h) aluminium and fluorine	Aluminum fluoride	AlF_3
i) potassium and chlorine	Potassium chloride	KCl
j) silver and oxygen	Silver oxide	Ag_2O

Ionic Compounds—Multivalent Metal Ions

1. If the following pairs of elements were mixed and heated, they would combine into solid ionic compounds. In this worksheet, use the most common ionic form of the multivalent metal ion. **The most common form is listed first in the periodic table.** For example, iron exists as both 2+ and 3+ ions, with iron(III) being the most common.

	Name	Formula
a) iron and sulfur	iron(III) sulfide	$Fe_2S_{3(s)}$
b) copper and oxygen	Copper(II) oxide	CuO
c) manganese and fluorine	Manganese (II) fluoride	MnF_2
d) gold and nitrogen	Gold (III) nitride	AuN
e) chromium and chlorine	Chromium (III) chloride	$CrCl_3$
f) platinum and phosphorus	Platinum (4) phosphide	Pt_3P_4
g) nickel and oxygen	Nickel (II) oxide	NiO
h) cobalt and bromine	Cobalt(II) bromide	$CoBr_2$
i) tungsten and iodine	Tungsten (6) iodide	WI_6
j) manganese and sulfur	Manganese(II) sulfide	MnS

Ionic Compounds:
Names and Formulas

1. Write the formulas for the following compounds:

a) magnesium oxide	___MgO___	k) copper (I) bromide	____CuBr___
b) sodium fluoride	__NaF__	l) tin (II) iodide	___SnI_2___
c) aluminum nitride	__AlN____	m) iron (III) chloride	____$FeCl_3$____
d) potassium sulfide	___K_2S____	n) calcium phosphide	___Ca_3P_2____
e) lithium iodide	__LiI___	o) lead (II) oxide	___PbO____
f) calcium bromide	__$CaBr_2$__	p) lead (IV) fluoride	___PbF_4___
g) beryllium oxide	_BeO___	q) tin (IV) bromide	___$SnBr_4$_____
h) nickel chloride	___$NiCl_2$____	r) copper (II) sulfide	____CuS__
i) magnesium nitride	____Mg_3N_2__	s) iron (II) oxide	_FeO___
j) aluminum sulfide	___Al_2S_3___	t) calcium nitride	___Ca_3N_2___

2. Write the names for the following compounds:

a) Li_2O	__Lithium oxide___	k) PbS	__Lead (II) sulfide__
b) $AlCl_3$	_Aluminum chloride__	l) SnO_2	__Tin (4) oxide__
c) MgS	_Magnesium sulfide___	m) Na_2S	__Sodium sulfide__
d) CaO	__Calcium oxide__	n) Mg_3P_2	__Magnesium phosphide___
e) KBr	__Potassium bromide__	o) NiO	__Nickel (II) oxide__
f) BeF	_Beryllium flouride__	p) CuI	__Copper (I) iodide__
g) Na_3N	__Sodium nitride__	q) $PbCl_4$	__Lead (4) chloride__
h) Al_2O_3	_Aluminum oxide___	r) FeP	__Iron (III) phosphide_
i) $CuCl_2$	__Copper (II) chloride__	s) CaF_2	__Calcium flouride__
j) $FeBr_3$	__Iron (III) bromide__	t) K_3P	_Potassium phosphide__

Ionic Compounds—Polyatomic Ions

The names and charges of polyatomic ions can be found in lists and need not be memorized. It is a good idea, however, to get to know the more common ones introduced in the practice below. Remember to form the name by combining the positive and negative ion:

name = positive ion + negative ion

COMBINE	IONS	FORMULA	NAME
iron(II) & nitrate	Fe^{2+} NO_3^-	$Fe(NO_3)_{2(s)}$	Iron(II) nitrate
aluminium & nitrate	Al^{3+} NO_3^-	$Al(NO_3)_{3(s)}$	Aluminium nitrate
sodium & sulfate	Na^+ SO_4^{2-}	$Na_2(SO_4)$	Sodium sulfate
lead(IV) & sulfate	Pb^{4+} SO_4^{2-}	$Pb(SO_4)_2$	Lead (IV) sulfate(
magnesium & carbonate	Mg^{2+} CO_3^{2-}	$Mg(CO_3)$	Magnesium carbonate
gold(III) & sulfite	Au^{3+} SO_3^{2-}	$Au_2(SO_3)_3$	Gold (III) sulfite
zinc & hydrogencarbonate	Zn^{2+} HCO_3^-	$Zn(HCO_3)_2$	Zinc hydrogencarbonate
ammonium & nitrate	NH_4^+ NO_3^-	NH_4NO_3	Ammonium nitrate
copper(I) & phosphate	Cu^{1+} PO_4^{3-}	$Cu_3(PO_4)$	Copper(I) phosphate
silver & hydroxide	Ag^{1+} OH^{1-}	AgOH	Silver hydroxide
aluminium & hydroxide	Al^{3+} OH^-	$Al(OH)_3$	Aluminum hydroxide
lead(II) & phosphate	Pb^{2+} PO_4^{3-}	$Pb_3(PO_4)_2$	Lead(II) phosphate
potassium & acetate	K^+ CH_3COO^-	$K(CH_3COO)$	Potassium acetate
manganese(IV) & sulfate	Mn^{4+} SO_4^{2-}	$Mn(SO_4)_2$	Manganese (IV) sulfate

COVALENT COMPOUNDS

Made up of non-metals; **no charged species are involved.**

When naming covalent compounds we use a system of prefixes:

Subscript	1	2	3	4	5	6	7	8	9	10
Prefix	Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca

Writing Formulas for Covalent Compounds

Step 1: Write the chemical symbol for the first element in the name
Step 2: Write the appropriate subscript according to the prefix given in the name
Step 3: Repeat steps 1 and 2 for the second element

Examples:

Dihydrogen monoxide

H_2O

Carbon dioxide

CO_2

Tetraphosphorus decaoxide

P_4O_6

Nitrogen trichloride

HCl_3

Naming Covalent Compounds

Step 1: Look at the subscript on the first atom; write the proper prefix (mono is not used as a prefix on the first atom in the compound)

Step 2: Write the name of the first atom as all one word with the prefix

Step 3: Repeat steps 1 and 2 for the second atom, except here the ending of the name is "ide"

Examples:

PCl_5

Phosphorous pentachloride

I_3F_7

Triodide heptaflouride

S_2O_6

Disulfur hexaoxide

Answer the following questions:

1. How can you tell the difference between an ionic compound and a covalent compound?

   IONIC COMPOUND WILL ALWAYS HAVE 1 METAL (ONLY)
   MOLECULAR COMPOUNDS ARE ONLY NON-METALS

2. Name the following compounds:

   a) CBr_4 — Carbon tetrabromide

   b) NI_3 — Nitrogen triodide

   c) OF_2 — Oxygen diflouride

   d) $SiCl_4$ — Silicon tetrachloride

Binary Molecular Compounds

A. Write the correct name for each compound below. Use prefixes to indicate the number of atoms of each element in the name of the molecular compound. (Remember: The prefix "mono-" is not used with the name of the first element.)

1 atom: mono-	3 atoms: tri-	5 atoms: penta-	7 atoms: hepta	9 atoms: nona-
2 atoms: di-	4 atoms: tetra-	6 atoms: hexa	8 atoms: octa-	10 atoms: deca-

1) $BrCl_3$ Bromide trichloride

2) BN Boron mononitride

3) N_2O_3 Dinitrogen trioxide

4) NI_3 Nitrogen triodide

5) SF_6 Sulfur hexaflouride

6) XeF_4 Xenon tetraflouride

7) PCl_3 Phosphorous trichloride

8) CH_4 Carbon tetrahydride

9) PCl_5 Phosphorous pentachloride

10) P_2O_5 Diphosphorous pentaoxide

11) S_2Cl_2 Disulfur dichloride

12) ICl_2 Iodine dichloride

13) NH_3 Nitrogen trihydride

14) P_4O_{10} Tetraphosphorous decaoxide

15) H_2O Dihydrogen monoxide

16) OF_2 Oxygen diflouride

B. Write the correct formula for each compound below. Use subscripts to indicate the number of atoms of each element in the formula (**never reduce**).

1) chlorine monoxide ClO

2) sulfur hexachloride SCl_6

3) dinitrogen monoxide N_2O

4) nitrogen trifluoride NF_3

5) sulfur tetrachloride SCl_4

6) xenon trioxide XeO_3

7) carbon dioxide CO_2

8) boron trichloride BCl_3

9) diphosphorus pentoxide P_2O_5

10) phosphorus trichloride PCl_3

11) sulfur dioxide SO_2

12) bromine pentafluoride BrF_5

13) disulfur dichloride S_2Cl_2

14) boron trifluoride BF_3

15) tetraarsenic decoxide As_4O_{10}

16) silicon tetrachloride $SiCl_5$

Properties of Substances

Use your text to help you fill in the following table:

Property	Ionic Substances	Covalent Substances
Melting Point	High	Low
Solubility in Water	Yes	Most of time
Conductivity as a Solid	NO	No
Conductivity in Solution	YES	No
Bond Strength	High	Strong within molecule Weak between

A substance that conducts electricity in solution is called an __electrolyte___, while a substance that does not conduct electricity in solution is called a __non-electrolyte_.

Activity: Qualitative Analysis

A student was given 4 unknowns to analyze and identify. She knew that the substances were (in no particular order), a solution of ***potassium chloride***, a solution of ***barium hydroxide***, ***acetic acid***, and a solution of ***sugar***.

As all substances were soluble in water, she tested each substance with litmus and for conductivity. Her results are summarized in the following table:

Chemical	Name	Formula	Conductivity	Effect on Litmus
1	Acetic acid	CH_3COOH	High	blue to red
2	Sugar	$C_6H_{12}O_6$	None	no change
3	Potassium chloride	KCl	High	no change
4	Barium hydroxide	$Ba(OH)_2$	High	red to blue

Using her results, complete the table by identifying and giving the formula for each solid.

Acids and Bases

Arrhenius's Theory

Svante Arrhenius defined an acid as __substance that reacts and releases hydrogen ions (H+) in a water solution__.

In the space below, show the equation representing hydrogen chloride gas dissolving in water to form an acid:

$HCl_{(g)}$ ⟹ $H^+_{(aq)} + Cl^-_{(aq)}$

He defined a base as __substance that dissolves in water and releases hydroxide ions $OH^-_{(aq)}$ __.

In the space below, write the equation representing sodium hydroxide dissolving in water to form a base:

$NaOH_{(s)}$ ⟹ $Na^+_{(aq)} + OH^-_{(aq)}$

Complete the following table:

Property	Acids	Bases
Taste	Sour	Bitter
Feel	Burn your skin	Slippery
pH	Less than 7	Greater than 7
Conductivity	Yes	Yes
2 Indicator Tests	Litmus=red Phenolphthalein=clear Bromothymol blue=yellow	Litmus=blue Phenolphthalein=pink Bromothymol blue=blue
Common Examples	Sulfuric acid Hydrochloric acid Nitric acid Acetic acid	Sodium hydroxide Potassium hydroxide Calcium hydroxide Ammonium hydroxide

Naming Acids

Hydrogen _____ide → Hydro_____ic acid
Hydrogen _____ate → _____ic acid
Hydrogen _____ite → _____ous acid

Practice

Hydrosulfuric acid	$H_2S_{(aq)}$	$HBr_{(aq)}$	hydrobromic acid
Sulfuric acid	$H_2SO_{4\,(aq)}$	$H_3PO_{4(aq)}$	phosphoric acid
Sulfurous acid	$H_2SO_{3\,(aq)}$	$HNO_{2(aq)}$	nitrous acid

Naming Acids

A. Using IUPAC rules name the following acids:

1. $HCl_{(aq)}$	hydrochloric acid
2. $H_2SO_{4(aq)}$	sulfuric acid
3. $H_3BO_{3(aq)}$	boric acid
4. $HNO_{2(aq)}$	nitrous acid
5. $HBr_{(aq)}$	hydrobromic acid
6. $H_3PO_{4(aq)}$	phosphoric acid
7. $H_2CO_{3(aq)}$	carbonic acid
8. $H_2CrO_{4(aq)}$	chromic acid
9. $CH_3COOH_{(aq)}$	acetic acid (ethanoic acid)
10. $HCN_{(aq)}$	cyanic acid

B. Using IUPAC rules write the formula for each of the following acids:

1. hydrofluoric acid	$HF_{(aq)}$
2. nitric acid	$HNO_{3\ (aq)}$
3. sulfurous acid	$H_2SO_{3\ (aq)}$
4. phosphorus acid	$H_3PO_{3\ (aq)}$
5. hypochlorous acid	$HClO_{(aq)}$
6. chloric acid	$HClO_{3\ (aq)}$
7. hydroiodic acid	$HI_{(aq)}$
8. perchloric acid	$HClO_{4\ (aq)}$

Classifying and Naming Compounds

Ionic compounds begin with a metal or the ammonium ion. Molecular compounds contain only non-metals. Acids begin with H or end with COOH.

1. Classify each of the following as an ionic compound, a molecular compound, or an acid. Name each one.

	Type	Name
a) $NaCl_{(s)}$	IONIC	Sodium chloride
b) $N_2O_{(g)}$	MOLECULAR	Dinitrogen monoxide
c) $HCl_{(aq)}$	ACID	Hydrochloric acid
d) $NH_4Br_{(s)}$	IONIC	Ammonium bromide
e) $KOH_{(s)}$	IONIC	Potassium hydroxide
f) $CH_3COOH_{(aq)}$	ACID	Acetic acid
g) $XeF_{2(s)}$	MOLECULAR	Xenon difluoride
h) $SCl_{3(g)}$	MOLECULAR	Sulfur trichloride
i) $NiCl_{3(g)}$	IONIC	Nickel (III) chloride
j) $H_3PO_{4(aq)}$	ACID	Phosphoric acid
k) $K_2Cr_2O_{7(s)}$	IONIC	Potassium dichromate
l) $NH_4NO_{3(s)}$	IONIC	Ammonium nitrate
m) $CH_3OH_{(l)}$	MOLECULR	Carbon trihydrogen monoxide hydride (methanol)
n) $Fe_2O_{3(s)}$	IONIC	Iron (III) oxide

2. Classify each of the following as an ionic compound, a molecular compound, or an acid. Write the formula for each one.

	Type	Formula
a) solid sodium sulfate	IONIC	$Na_2(SO_4)_{(s)}$
b) aqueous hydrogen nitrate	ACID	$HNO_{3(aq)}$
c) gaseous sulfur trioxide	MOLECULAR	$SO_{3(g)}$
d) gaseous dinitrogen trioxide	MOLECULAR	$N_2O_{3(g)}$
e) solid manganese(IV) bromide	IONIC	$MnBr_{4(s)}$
f) solid ammonium phosphate	IONIC	$(NH_4)_3PO_{4(s)}$
g) aqueous hydrogen sulfate	ACID	$H_2SO_{4(aq)}$