Chapter 5A

Compounds and Their Bonds

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CHAPTER OUTLINE

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OCTET RULE & IONS

- Most elements, except noble gases, combine to form compounds. Compounds are the result of the formation of chemical bonds between two or more different elements.
- In the formation of a chemical bond, atoms lose, gain or share valence electrons to complete their outer shell and attain a noble gas configuration.
- This tendency of atoms to have eight electrons in their outer shell is known as the octet rule.

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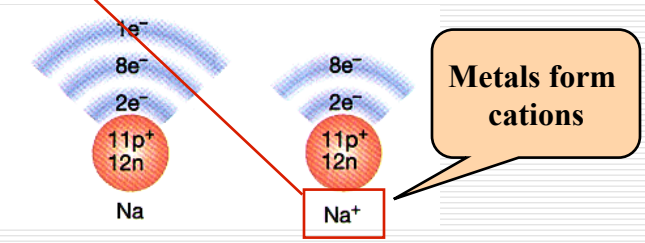
FORMATION OF IONS

- An ion (charged particle) can be produced when an atom gains or loses one or more electrons.



A cation (+ ion) is formed when a neutral atom loses an electron

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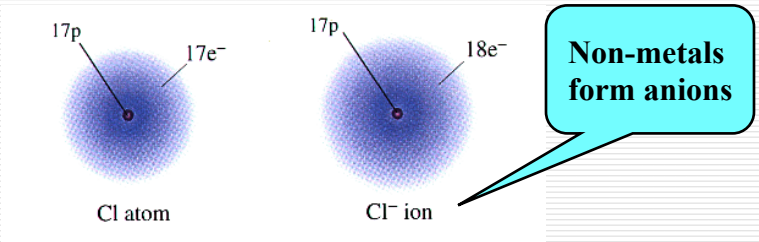
5.1

FORMATION OF IONS

- **An anion (- ion) is formed when a neutral atom gains an electron.**



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5.1

IONIC CHARGES

- **The most common ionic charges can be determined from the group number of the element.**

Noble Gases		Metals Lose Valence Electrons 1A (1)	2A (2)	3A (13)	Nonmetals Gain Valence Electrons 5A (15)	6A (16)	7A (17)		Noble Gases
He	⇦	Li^+							
Ne	⇦	Na^+	Mg^{2+}	Al^{3+}	N^{3-}	O^{2-}	F^-	⇨	Ne
Ar	⇦	K^+	Ca^{2+}		P^{3-}	S^{2-}	Cl^-	⇨	Ar
Kr	⇦	Rb^+	Sr^{2+}				Br^-	⇨	Kr
Xe	⇦	Cs^+	Ba^{2+}				I^-	⇨	Xe

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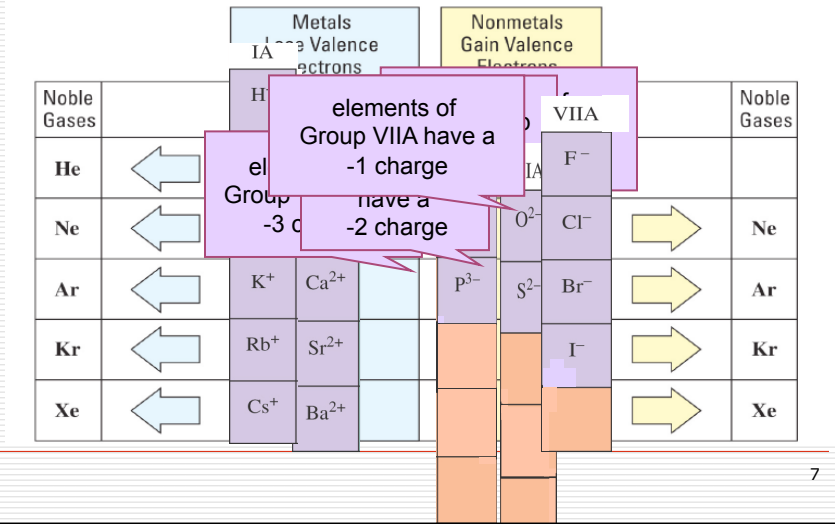
IONIC CHARGES



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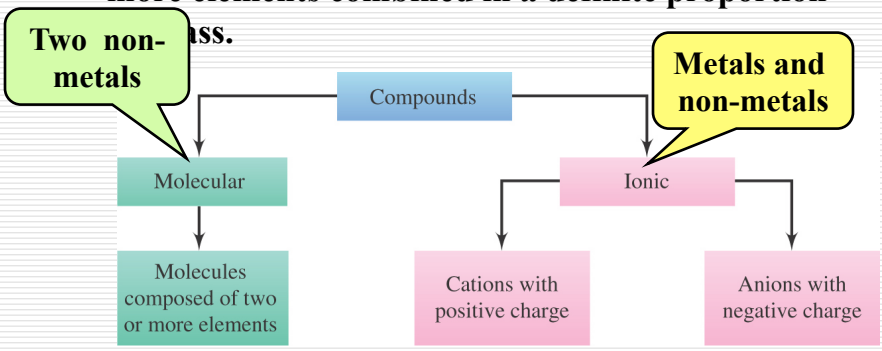
COMPOUNDS

- **Compounds are pure substances that contain 2 or more elements combined in a definite proportion by mass.**



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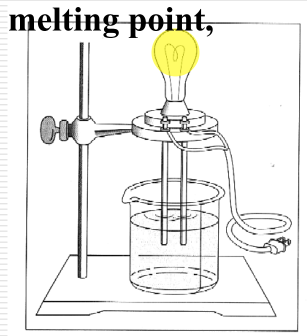
CHEMICAL BOND

- The nature and type of the chemical bond is directly responsible for many physical and chemical properties of a substance: (e.g. melting point, conductivity)
- When the conductivity apparatus is placed in salt solution, the bulb will light.
- But when it is placed in sugar solution, the bulb does not light.

This difference is due to different types of bonds between their atoms.



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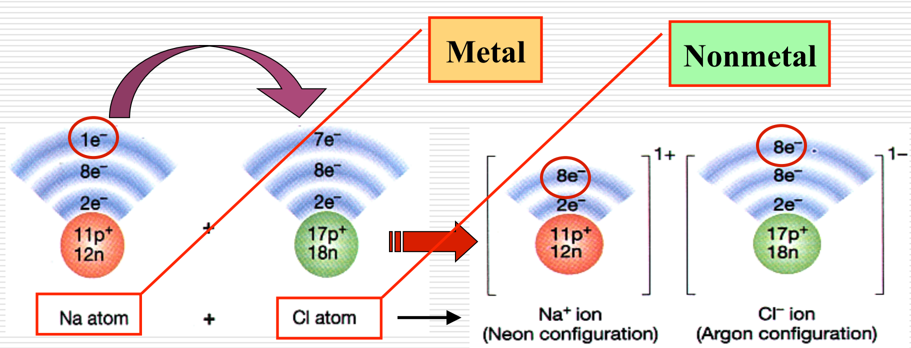
IONIC COMPOUNDS

- Ionic bonding: electrons are transferred between two atoms. (noble gas configuration)



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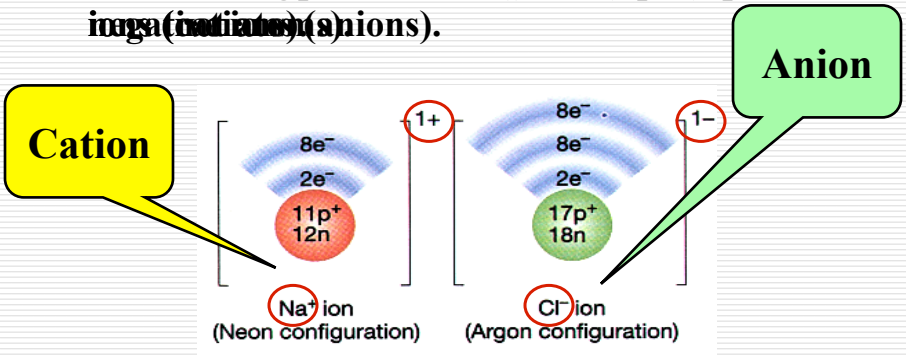
IONIC COMPOUNDS

- [illegible] (positive ions) and [illegible] (negative ions).



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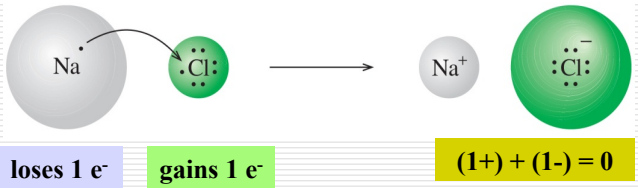
IONIC CHARGES AND FORMULAS

- [illegible] charges.



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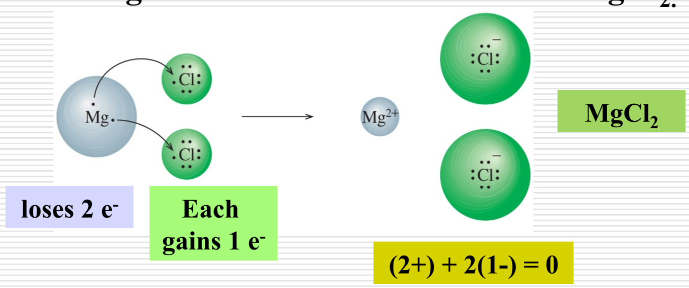
IONIC CHARGES AND FORMULAS

- When charges between the ions do not balance, subscripts are used to balance the charge.
- For example, since each magnesium loses 2 electrons, and each chloride gains one electron, 2 chlorides are needed to balance the charge of the magnesium ion.
- Therefore magnesium chloride is written as $MgCl_2$.



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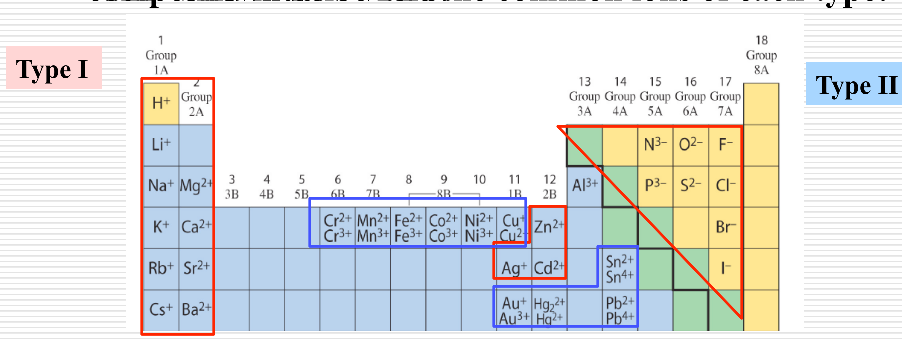
NAMING AND WRITING IONIC FORMULAS

- When writing ionic formulas, knowing the charge of the ions is important since the overall charge of the compound must be zero.
- Some metals only produce one type of ion (Type I) while others produce more than one type (Type II). Shown below are the common ions of each type:



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BINARY IONIC COMPOUNDS (TYPE I)

- **Binary compounds contain only two elements.**
- **Type I ions are those cations that form only one ion.**
- **In these compounds, charges of the cations must equal the charges of the anions since the net charge is zero.**
- **Subscripts are used to balance the charges between cations and anions.**

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BINARY IONIC COMPOUNDS (TYPE I)

- **Subscripts are used to balance the charges between cations and anions.**

sodium bromide

Na^+ Br^-

No subscripts needed

+1 -1 = 0

NaBr

potassium sulfide

K_2^+ S^{2-}

+2 -2 = 0

K_2S

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Example 1:

Write formulas for the following ionic compounds:

calcium chloride	sodium sulfide
Ca^{2+} Cl_2^-	Na_2^+ S^{2-}
+2 -2 = 0	+2 -2 = 0
$CaCl_2$	Na_2S

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BINARY IONIC COMPOUNDS (TYPE I)

- **When naming ionic compounds, name the cation first and the anion last.**
- **The cation name is the same as the name of the metal it forms from.**
- **The anion name takes the root of non-metal and the ending "-ide".**

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BINARY IONIC COMPOUNDS (TYPE I)

$MgCl_2$	magnesium chloride
NaI	sodium iodide
AlF_3	aluminum fluoride

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Example 2:

Name the following ionic compounds:

Na_3P	sodium phosphide
$BaCl_2$	barium chloride

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COMMON MISTAKES TO AVOID

When naming ionic compounds DO NOT use prefixes

$MgCl_2$	~~**magnesium dichloride**~~
AlF_3	~~**aluminum trifluoride**~~

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BINARY IONIC COMPOUNDS (TYPE II)

- **Type II ions are those cations that form more than one ion.**
- **When naming compounds formed from these ions, include the ionic charge as Roman numeral, in parentheses, after the metal's name.**
- **This method of nomenclature is called the "stock" system.**

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BINARY IONIC COMPOUNDS (TYPE II)

+2 -1

$FeCl_2$

iron (II) chloride

? -2 = 0

+3 -1

$FeCl_3$

iron (III) chloride

? -3 = 0

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BINARY IONIC COMPOUNDS (TYPE II)

+1 -2

Cu_2O

copper (I) oxide

2? -2 = 0

Roman numeral DOES NOT represent the

+2 -2

CuO

copper (II) oxide

? -2 = 0

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BINARY IONIC COMPOUNDS (TYPE II)

- **Type II cations can also be named by an older method (classical).**
- **In this system, cations with the higher charge end in –ic, while cations with the lower charge end in –ous.**
- **In this system, some cations are named based on their Latin roots.**

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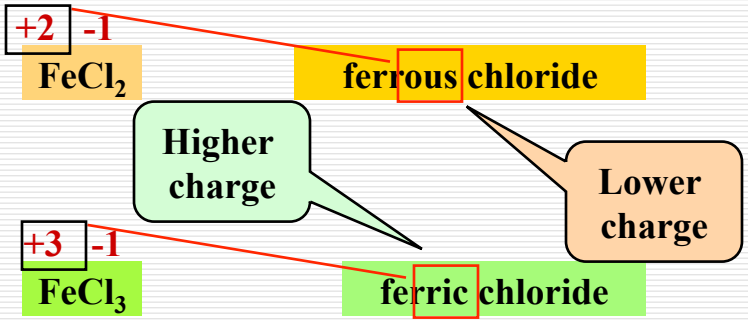
BINARY IONIC COMPOUNDS (TYPE II)



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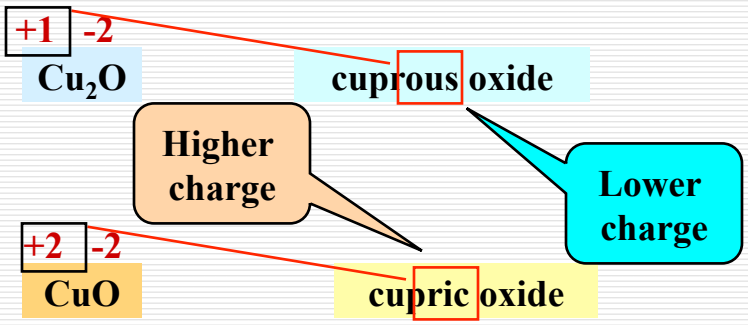
BINARY IONIC COMPOUNDS (TYPE II)



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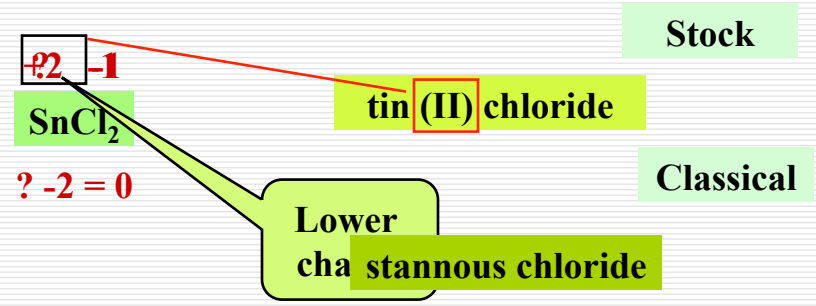
Example 1:

Name each of the following compounds using the stock and classical nomenclature system:



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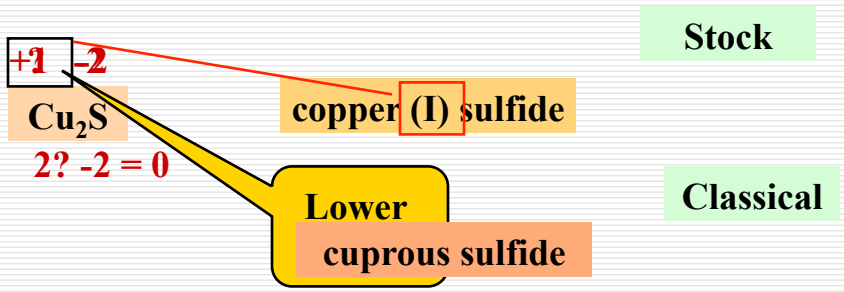
Example 1:

Name each of the following compounds using the stock and classical nomenclature system:



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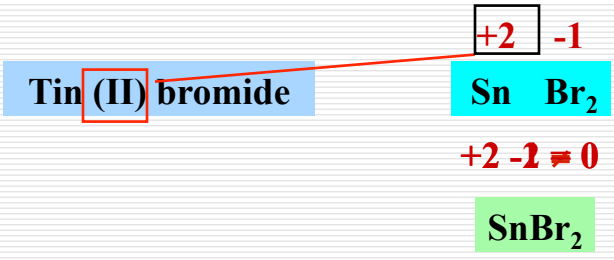
Example 2:

Write formulas for each of the following compounds:



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Example 2:

Write formulas for each of the following compounds:

Stannic oxide

+4 -2

Sn O_2

+4 -4 ≠ 0

SnO_2

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COMMON MISTAKES TO AVOID

DO NOT name type I elements with type II rules or vice versa:

+2 -1

$MgCl_2$

Pb is type II

magnesium chloride

+2 -1

PbI_2

Mg is type I

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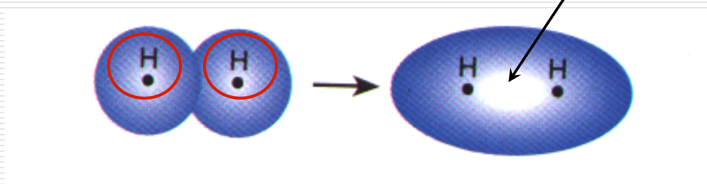
COVALENT COMPOUNDS

- Covalent bonds form when electrons are shared between two atoms. The smallest particles of covalent compounds are molecules.
- Covalent bonds form between two non-metals.

Electrons shared



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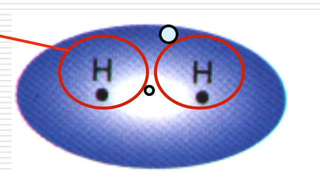
POLAR & NON-POLAR BONDS

- Two types of covalent bonds exist:

Polar & Nonpolar

Electrons shared equally

- Non-polar covalent bonds occur between similar atoms.
- In these bonds the electron pair is shared equally between the two protons.



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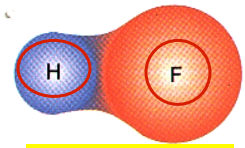
POLAR & NON-POLAR BONDS

- Polar covalent bonds occur between different atoms.
- In these bonds the electron pair is shared unequally between the two protons.
- As a result there is a charge separation in the molecule, and partial charges on each atom.

(Video on polarity of water)



H⟶F

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Examples:

Identify each of the following substances as ionic, polar covalent or non-polar covalent:

1. PCl_3 — Polar covalent — 2 Different non-metals
2. MgF_2 — Ionic — Metal & non-metal
3. O_2 — Non-polar covalent — Same non-metals
4. SO_2 — Polar covalent — 2 Different non-metals

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NAMING & WRITING COVALENT FORMULAS

Binary Covalent Compounds

- **These compounds are named similar to ionic compounds, with the second element named based on its root and suffix "-ide".**
- **Greek prefixes are used to indicate the number of atoms in these compounds.**

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BINARY MOLECULAR COMPOUNDS

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

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Examples:

Name the following binary molecular compounds:

carbon disulfide

CS_2

First atom uses a prefix only when more than one atom is present

indicates 1 carbon atom

indicates 2 sulfur atoms

Second atom always uses a prefix

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Examples:

Name the following binary molecular compounds:

phosphorous pentachloride

PCl_5

indicates 1 phosphorous atom

indicates 5 chlorine atoms

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Examples:

Name the following binary molecular compounds:

dinitrogen tetroxide

N_2O_4

indicates 2 nitrogen atoms

indicates 4 oxygen atoms

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Examples:

Name the following binary molecular compounds:

tetraphosphorous decoxide

P_4O_{10}

indicates 4 phosphorous atoms

indicates 10 oxygen atoms

42

Example 1:

Name the following binary molecular compounds:

diphosphorous pentoxide

P_2O_5

indicates 2 phosphorous atoms

indicates 5 oxygen atoms

43

Example 1:

Name the following binary molecular compounds:

iodine heptafluoride

IF_7

indicates 1 iodine atom

indicates 7 fluorine atoms

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Example 2:

Write formulas for the following binary molecular compounds:

carbon tetrachloride

CCl_4

indicates 1 carbon atom

indicates 4 chlorine atoms

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Example 2:

Write formulas for the following binary molecular compounds:

dichlorine monoxide

Cl_2O

indicates 2 chlorine atoms

indicates 1 oxygen atom

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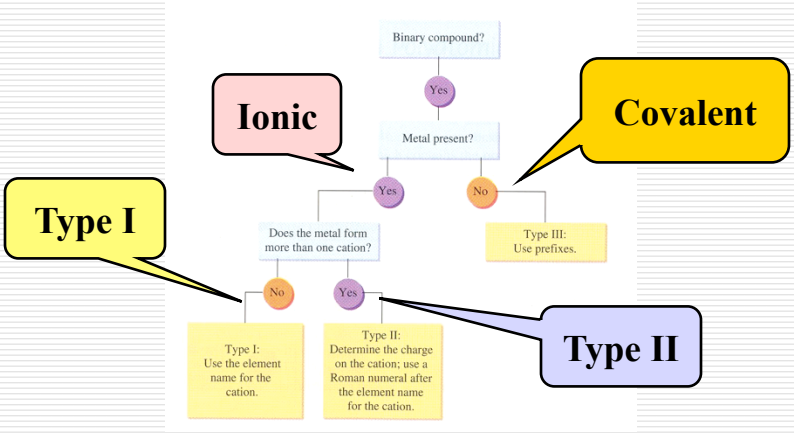
SUMMARY OF NAMING BINARY COMPOUNDS



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POLYATOMIC IONS

- **Some ionic compounds contain polyatomic ions, an ion composed of several atoms bound together.**

NH_4^+	ammonium	OH^-	hydroxide
NO_3^-	nitrate	CN^-	cyanide
SO_4^{2-}	sulfate	$C_2H_3O_2^-$	acetate
PO_4^{3-}	phosphate	HCO_3^-	bicarbonate
CO_3^{2-}	carbonate		

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POLYATOMIC COMPOUNDS

- **When writing formulas for polyatomic compounds, treat the polyatomic ion as one group.**

potassium nitrate	calcium hydroxide
K^+ NO_3^-	Ca^{2+} $(OH^-)_2$
+1 -1 = 0	+2 -2 = 0
KNO_3	$Ca(OH)_2$

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POLYATOMIC COMPOUNDS

ammonium acetate	sodium sulfate
NH_4^+ $C_2H_3O_2^-$	Na_2^+ SO_4^{2-}
+1 -1 = 0	+1 -2 = 0
$NH_4C_2H_3O_2$	Na_2SO_4

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POLYATOMIC COMPOUNDS

copper (II) nitrate

Cu^{2+} $(NO_3^-)_2$

+2 -2 +2 0

$Cu(NO_3)_2$

Alternate name : cupric nitrate

Type II Roman numeral represents charge of ion

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Example 1:

Write formulas for the following polyatomic compounds:

sodium carbonate

Na^+ CO_3^{2-}

Na_2CO_3

ammonium sulfide

NH_4^+ S^{2-}

$(NH_4)_2S$

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Example 1:

Write formulas for the following polyatomic compounds:

magnesium bicarbonate

Mg^{2+} **HCO_3^-**

$Mg(HCO_3)_2$

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POLYATOMIC COMPOUNDS

- **Polyatomic ionic compounds are named by naming the cation first, followed by the polyatomic ion.**

Na_3PO_4 **sodium phosphate**

Name as one group

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POLYATOMIC COMPOUNDS

NH_4Br — ammonium bromide

+1

$CuNO_3$ — copper (I) nitrate

+4

$Pb(CO_3)_2$ — lead (IV) carbonate

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Example 2:

Name the following polyatomic compounds:

$Mg(OH)_2$ — magnesium hydroxide

NaCN — [illegible]de

Type II ion (Requires roman numeral)

$Fe_2(SO_4)_3$ — iron (III) sulfate

+3 [illegible]2

ferric sulfate

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NAMING ACIDS

- **Acids are molecular compounds that form ions when dissolved in water.**

Binary Acids

- **Formulas are written similar to binary ionic compounds, assigning a +1 charge to hydrogen.**

+1 -1 **HCl**

+1 -2 **H_2S**

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NAMING BINARY ACIDS

- **When naming the acids, use hydro- prefix, followed by the name of the non-metal with an –ic ending, followed with the word acid.**

HCl — **hydrochloric acid**

H_2S — **hydrosulfuric acid**

HF — **hydrofluoric acid**

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POLYATOMIC ACIDS

- **Several polyatomic acids are important in the study of chemistry, and their names must be learned.**
- **These acids and the polyatomic ions that form from their ionization are as follows:**

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POLYATOMIC ACIDS

nitric acid	**HNO_3**	**NO_3^- nitrate**
sulfuric acid	**H_2SO_4**	**SO_4^{2-} sulfate**
phosphoric acid	**H_3PO_4**	**PO_4^{3-} phosphate**

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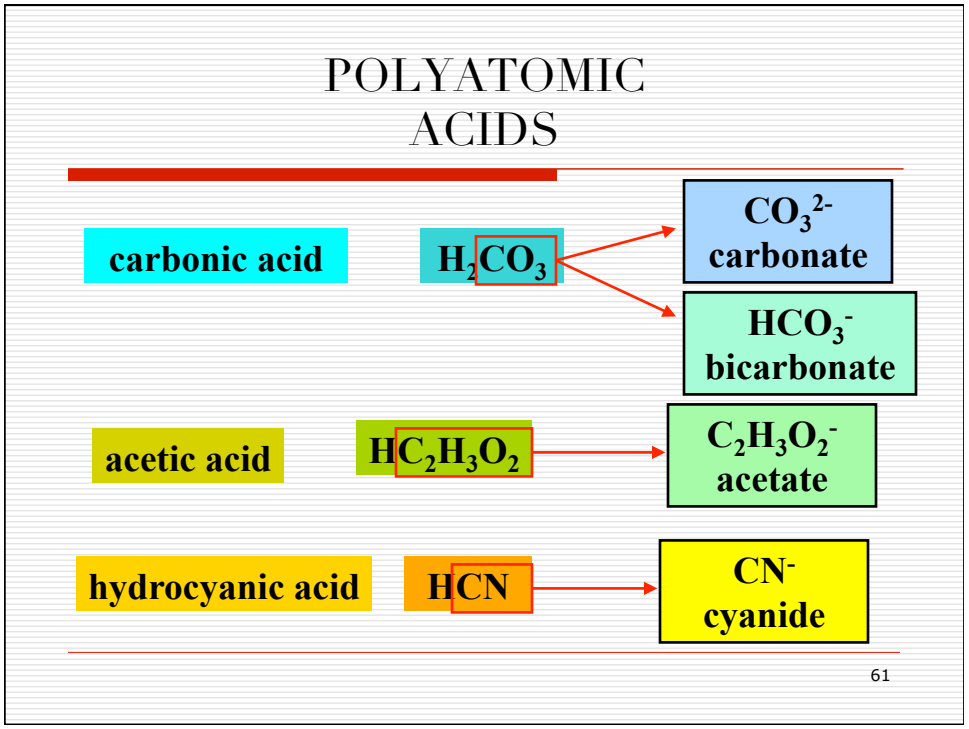
POLYATOMIC ACIDS
carbonic acid
H_2CO_3
CO_3^{2-} carbonate
HCO_3^- bicarbonate
acetic acid
$HC_2H_3O_2$
$C_2H_3O_2^-$ acetate
hydrocyanic acid
HCN
CN^- cyanide
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THE END
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