

Introduction to Physical Science

Compounds and Nomenclature
Presented by Robert Wagner

Chemical Reactions

- In chemical reactions, the nucleus remains unchanged
- Electrons can be added, lost or shared with other atoms
- Ions - electrically charged particles formed when atoms either gain or lose electrons.

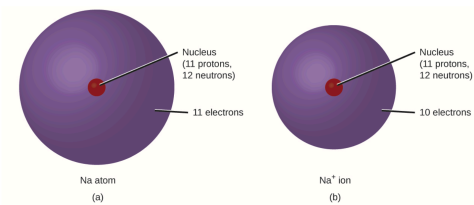


Image Credit: Nauka, Public domain, via Wikimedia Commons

Anions and Cations

- Cations - positive charge - lose electrons
- Anions - negative charge - gain electrons
- Examples
 - Group 1 - lose 1 electron
 - Group 2 - lose 2 electrons
 - Group 17 - gain 1 electron

Periodic Table of the Elements

Period	Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1		H	He																	
2		Li ⁺	Be ²⁺											B ³⁺	C ⁴⁺	N ³⁻	O ²⁻	F ⁻	Ne	
3		Na ⁺	Mg ²⁺											Al ³⁺	Si ⁴⁺	P ³⁻	S ²⁻	Cl ⁻	Ar	
4		K ⁺	Ca ²⁺																	
5		Rb ⁺	Sr ²⁺																	
6		Cs ⁺	Ba ²⁺																	
7		Fr ⁺	Ra ²⁺																	

Image Credit: OpenStax Chemistry - Figure 2.29 CC BY 4.0

Example

- Known: contains 13 protons and 10 electrons
- 13 protons implies that the atomic number is 13
- From the periodic table, this is Aluminum (Al)
- Charge: 13 positive and 10 negative means a net charge of 3+
- Al³⁺

- An ion found in some compounds used as antiperspirants contains 13 protons and 10 electrons. What is its symbol?

Example

- Magnesium and nitrogen react to form an ionic compound. Predict which forms an anion, which forms a cation, and the charges of each ion. Write the symbol for each ion and name them.

Known: Magnesium and nitrogen

Magnesium - group 2 (metal) - form positive ion (cation)

Mg - loses 2 electrons - charge 2+

Mg^{2+} Magnesium ion

Nitrogen - group 15 (nonmetal) - form negative ion (anion)

Nitrogen - gains 3 electrons - charge 3-

N^{3-} Nitride ion

Monatomic & Polyatomic Ions

- Monatomic ions - formed from only one atom
- Polyatomic ions - electrically charged molecules
- Oxyanions - polyatomic ions that contain one or more oxygen atoms

Naming - Prefixes

- Suffixes:
 - -ate and -ite refer to ions containing more or fewer oxygen atoms
- Prefixes:
 - Per- means more oxygen atoms than -ate
 - Hypo- means fewer oxygen atoms than -ite
- Examples:

Perchlorate: ClO_4^-

Chlorate: ClO_3^-

Chlorite: ClO_2^-

Hypochlorite: ClO^-

Ionic and Covalent Bonds

- Ionic bonds - electrons are transferred. Bonded by the electrostatic force
- Covalent (molecular) bonds - electrons are shared. Bonded by forces between nuclei and the shared electrons

Ionic Compounds

- Generally forms between a nonmetal and a metal.
 -
 -
- Properties of ionic compounds
 - Solids
 - Melt and boil at high temperatures
 - Molten - conduct electricity

Example

- The gemstone sapphire is mostly a compound of aluminum and oxygen that contains aluminum cations, , and oxygen anions, . What is the formula of this compound?

Compounds : Al^{3+} & O^{2-}

Need to match positive and negative charges

$2 \times Al^{3+} = 6$ positive charges

$3 \times O^{2-} = 6$ negative charges

Al_2O_3

Example

- Baking powder contains calcium dihydrogen phosphate, and ionic compound composed of the ions
What is the formula of this compound?

Compounds : Ca^{2+} & $H_2PO_4^-$

Need to match positive and negative charges

$1 \times Ca^{2+} = 2$ positive charges

$2 \times H_2PO_4^- = 2$ negative charges

$Ca(H_2PO_4)_2$

Molecular Compounds

- Atoms are sharing rather than transferring electrons
 - Combination of nonmetals
- Properties of molecular compounds
 - Liquids or gases
 - Melt and boil at low temperatures
 - Non-conductive

Example

- Predict whether the following compounds are ionic or molecular:

- the source of iodine in table salt
- Hydrogen peroxide
- Chloroform
- Used in antidepressants

Compounds : KI , H_2O_2 , $CHCl_3$, & Li_2CO_3

KI : Potassium(K) is a metal, Iodine(I) is a nonmetal - Ionic

H_2O_2 : Hydrogen(H) is a nonmetal and Oxygen(O) is a nonmetal - Molecular

$CHCl_3$: Carbon(C) is a nonmetal, Hydrogen(H) is a nonmetal, and Chlorine(Cl) is a nonmetal - Molecular

Li_2CO_3 : Lithium(Li) is a metal, Carbonate(CO_3) is a polyatomic ion - Ionic

Naming - Ionic Compounds (Monatomic)

- Nomenclature - collection of rules for naming things
- Monatomic ions
 - Name of cation (metal)
 - Name of anion (nonmetal) using suffix -ide

NaCl, sodium chloride	Na_2O , sodium oxide
KBr, potassium bromide	CdS, cadmium sulfide
CaI_2 , calcium iodide	Mg_3N_2 , magnesium nitride
CsF, cesium fluoride	Ca_3P_2 , calcium phosphide
LiCl, lithium chloride	Al_4C_3 , aluminum carbide

Table 2.6

Image Credit: OpenStax Chemistry - Table 2.7 CC BY 4.0

Naming - Ionic Compounds (Polyatomic)

- Monatomic ions
 - Name of cation
 - Name of anion

Names of Some Polyatomic Ionic Compounds

$KC_2H_3O_2$, potassium acetate	NH_4Cl , ammonium chloride
$NaHCO_3$, sodium bicarbonate	$CaSO_4$, calcium sulfate
$Al_2(CO_3)_3$, aluminum carbonate	$Mg_3(PO_4)_2$, magnesium phosphate

Table 2.7

Image Credit: OpenStax Chemistry - Table 2.8 CC BY 4.0

Naming - Metal Ions

- Metal ions
 - Metal ion with charge in parentheses after the metal
 - Name of anion with -ide suffix

Some Ionic Compounds with Variably Charged Metal Ions

Compound	Name
$FeCl_2$	iron(II) chloride
$FeCl_3$	iron(III) chloride
Hg_2O	mercury(I) oxide
HgO	mercury(II) oxide
SnF_2	tin(II) fluoride
SnF_4	tin(IV) fluoride

Table 2.9

Image Credit: OpenStax Chemistry - Table 2.9 CC BY 4.0

Example

- Name the following ionic compounds:

-
-
-
-

Anions : S^{2-} , Se^{2-} , N^{3-} , & SO_4^{2-}

Cations : Fe^{3+} , Cu^{2+} , Ga^{3+} , & Ti^{3+}

- 1) Iron(III) Sulfide
- 2) Copper(II) Selenide
- 3) Gallium(III) Nitride
- 4) Titanium(III) Sulfate

Molecular (Covalent) Compounds

- Different ratios are possible ()
 - Use prefixes to specify the number of atoms of each element
 - Mono- is not included if the first element has only one atom

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

Table 2.10

Image Credit: OpenStax Chemistry - Table 2.10 CC BY 4.0

Molecular (Covalent) Compounds

- Different ratios are possible ()
 - Use prefixes to specify the number of atoms of each element
 - Mono- is not included if the first element has only one atom
- Exceptions (Nitrous oxide)

Compound	Name	Compound	Name
SO ₂	sulfur dioxide	BCl ₃	boron trichloride
SO ₃	sulfur trioxide	SF ₆	sulfur hexafluoride
NO ₂	nitrogen dioxide	PF ₅	phosphorus pentafluoride
N ₂ O ₄	dinitrogen tetroxide	P ₄ O ₁₀	tetraphosphorus decaoxide
N ₂ O ₅	dinitrogen pentoxide	IF ₇	iodine heptafluoride

Table 2.11

Image Credit: OpenStax Chemistry - Table 2.11 CC BY 4.0

Example

- Name the following ionic compounds:

-
-
-
-

- 1) Sulfur Hexafluoride
- 2) Dinitrogen Trioxide
- 3) Dichlorine Heptoxide
- 4) Tetraphosphorus Hexoxide

Binary Acids

- Consists of hydrogen and one nonmetallic element
 - Hydrogen is changed to hydro-
 - The nonmetallic element name adds the -ic suffix
 - The word acid is added

Names of Some Simple Acids

Name of Gas	Name of Acid
HF(g), hydrogen fluoride	HF(aq), hydrofluoric acid
HCl(g), hydrogen chloride	HCl(aq), hydrochloric acid
HBr(g), hydrogen bromide	HBr(aq), hydrobromic acid
HI(g), hydrogen iodide	HI(aq), hydroiodic acid
H ₂ S(g), hydrogen sulfide	H ₂ S(aq), hydrosulfuric acid

Table 2.12

Image Credit: OpenStax Chemistry - Table 2.12 CC BY 4.0

Oxyacids

- Contain hydrogen, oxygen and at least one other element
 - Omit hydrogen
 - Start with root name of anion
 - Replace -ate with -ic or -ite with -ous
 - Add "acid"

Names of Common Oxyacids

Formula	Anion Name	Acid Name
HC ₂ H ₃ O ₂	acetate	acetic acid
HNO ₃	nitrate	nitric acid
HNO ₂	nitrite	nitrous acid
HClO ₄	perchlorate	perchloric acid
H ₂ CO ₃	carbonate	carbonic acid
H ₂ SO ₄	sulfate	sulfuric acid
H ₂ SO ₃	sulfite	sulfurous acid
H ₃ PO ₄	phosphate	phosphoric acid

Table 2.13

Image Credit: OpenStax Chemistry - Table 2.13 CC BY 4.0

Summary

- Ionic compounds are formed when electrons are transferred between atoms
- Molecular (covalent) compounds are formed when electrons are shared between atoms
- Naming conventions for compounds vary depending on the specific types of bonds and the compounds