

Chemistry 151: Basic Chemistry

Chapter 3 Part I: Nomenclature



Time For a (*relevant*) Joke!

Two chemists walk into a bar.
The first chemist says, "I'll have some H Two O"
A clear liquid in a glass arrives... *i.e. H₂O, water*
They drink it down... very satisfying.

The second chemist says, "I'll have some H Two O
Too"
A clear liquid in a glass arrives... *i.e. H₂O₂*
They drink it down...
...and die!

H₂O = **water**, good to drink!
H₂O₂ = **hydrogen peroxide**, looks like water,
dangerous / deadly to drink

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*One extra atom affects the reactivity!
Nomenclature very important!*

Nomenclature

Nomenclature: a set of rules used to generate names for chemical compounds - or, being able to "talk the talk" of chemistry

Important to describe H₂O (essential to life) versus H₂O₂ (deadly oxidizing agent) - one atom (more or less) makes a huge difference



This is arguably the most important chapter of CH 151!

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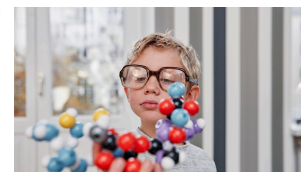
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Compounds and Molecules

COMPOUNDS are a combination of 2 or more elements in definite ratios by mass.

The character of each element is lost when forming a compound.

MOLECULES are the smallest unit of a compound that retains the characteristics of the compound.



Chemical Bond

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Bonding, the way **atoms** are attracted to each other to form **molecules**, determines nearly all of the chemical properties. We shall see later that the number "8" is very important to chemical bonding.

Bonding can be **ionic** or **covalent**.

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Ions

Atoms are **electrically neutral** because

number of protons = number of electrons

By **gaining** or **losing electrons** an atom can be converted into a **charged particle** called an **ion**.

Loss of one or more electrons gives **positively charged ion** called a **cation**.

Gaining one or more electrons gives **negatively charged ion** called a **anion**.



IONS AND IONIC COMPOUNDS



CATIONS have protons > electrons

ANIONS have electrons > protons

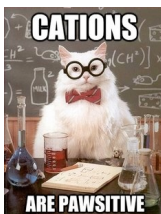
Remember:

CATS have **PAWS**

CATIONS are **PAWSitive**



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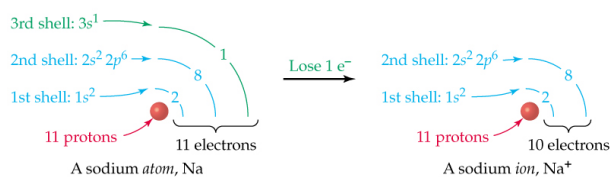


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Cations

The symbol for a **cation** is written by adding a **positive charge** as a **superscript** to the symbol for the element.

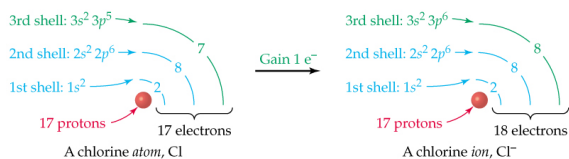
For example, Na loses an electron to make the **sodium cation** (Na^+).



Anions

The symbol for a **anion** is written by adding a **negative charge** as a **superscript** to the symbol for the element.

For example, Cl gains an electron to make the **chloride anion** (Cl^-).



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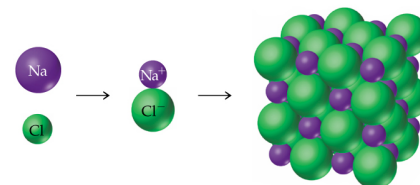
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Ionic Bonds

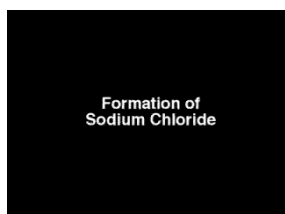
Opposite electrical charges **attract**

When sodium combines with chlorine, sodium transfers electron to chlorine forming Na^+ and Cl^- ions.

The oppositely charged Na^+ and Cl^- ions are held together by a **ionic bond**, making an **ionic compound**.



Formation of NaCl



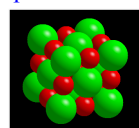
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Ionic Compounds

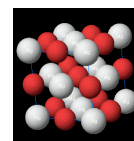
Ionic compounds *usually* form crystalline solids

Ions vary in size and charge.

Ionic compounds have **high melting and boiling points**.



NaCl , Na^+ and Cl^- ,
m.p. 804 °C



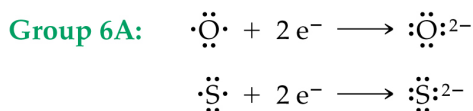
MgO , Mg^{2+} and O^{2-} ,
m.p. 2800 °C

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Ions of Some Common Elements

Metals of group 1A and 2A form *only* +1 and +2 ions. Ions of these elements all have a **noble gas configuration** through *electron loss* from their outermost shell.

Group 6A and 7A elements attain **noble gas configuration** by *gaining* 1 or 2 electrons.



"noble gas configuration" means 8 electrons

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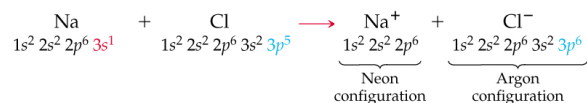
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Ions and the Octet Rule

Octet Rule: Main group elements undergo reactions that leave them with **8 valence electrons** or a **noble gas configuration - isoelectronic** (same number of electrons) **with noble gases**.

All noble gases (except helium) have 8 electrons in their valence shell.

For example, in NaCl, Na⁺ and Cl⁻ have the following electron configurations:



Common ions formed by elements in the first four periods

1A 1 H ⁺	2A 4 Be ²⁺	Transition metals										3A 5 Al ³⁺	4A 6 C ⁴⁻	5A 7 N ³⁻	6A 8 O ²⁻	7A 9 F ⁻	8A 2 He			
3 Li ⁺	11 Na ⁺	12 Mg ²⁺	19 K ⁺	20 Ca ²⁺	21 Sc ³⁺	22 Ti ⁴⁺	23 V ²⁺	24 Cr ²⁺	25 Mn ²⁺	26 Fe ²⁺	27 Co ²⁺	28 Ni ²⁺	29 Cu ²⁺	30 Zn ²⁺	31 Ga ³⁺	32 Ge ⁴⁺	33 As ³⁻	34 Se ²⁻	35 Br ⁻	36 Kr

Groups IA - IIIA: ion usually gets a **positive charge equal to the group number**

Groups VA - VIIA: ion usually gets a **negative charge equal to the group number minus eight**

Ex: Aluminum makes the Al³⁺ ion

Ex: Nitrogen makes the N³⁻ ion

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Naming Fixed Charge Cations

Main group metal cations (Groups 1A, 2A, and "the stairs") named by identifying the metal, followed by the word "ion":

K⁺ Potassium ion

Mg²⁺ Magnesium ion

Al³⁺ Aluminum ion

These metals are called "fixed charge metals"

the stairs:

		Al ³⁺ 13
	Zn ²⁺ 30	Ga ³⁺ 31
Ag ¹⁺ 47	Cd ²⁺ 48	In ³⁺ 49

Naming Anions

Main group nonmetal anions (Groups VA, VIA, and VIIA) named by identifying the nonmetal and *changing ending to "ide"* followed by the word "ion":

Cl⁻ Chloride ion

O²⁻ Oxide ion

P³⁻ Phosphide ion

C⁴⁻ Carbide ion

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Naming Variable Charge Cations

Many metals (transition, lanthanide, actinide, etc.) can often form more than one type of cation. Use Roman number to describe charge on metal:

Cr²⁺ Cr³⁺

Chromium(II) ion Chromium(III) ion

Roman numeral indicates **charge on cation**:

iron(III) would be Fe³⁺

A **Polyatomic ion** is an ion composed of more than one atom. Formula for polyatomic ions shown by **subscripts**. Example: SO_4^{2-} ion has **one** sulfur atom, **four** oxygen atoms and a **-2** charge

Many polyatomic ions known - *memorize!*

CATION: Positive Ion

NH_4^+ ammonium ion

ANIONS: Negative Ions

Based on a Group 4A element

CN^- cyanide ion
 CH_3CO_2^- acetate ion
 CO_3^{2-} carbonate ion
 HCO_3^- hydrogen carbonate ion (or bicarbonate ion)

Based on a Group 5A element

NO_2^- nitrite ion
 NO_3^- nitrate ion
 PO_4^{3-} phosphate ion
 HPO_4^{2-} hydrogen phosphate ion
 H_2PO_4^- dihydrogen phosphate ion

Based on a Group 6A element

OH^- hydroxide ion
 SO_3^{2-} sulfite ion
 SO_4^{2-} sulfate ion
 HSO_4^- hydrogen sulfate ion (or bisulfate ion)

Based on a Group 7A element

ClO^- hypochlorite ion
 ClO_2^- chlorite ion
 ClO_3^- chlorate ion
 ClO_4^- perchlorate ion

Based on a transition metal

CrO_4^{2-} chromate ion
 $\text{Cr}_2\text{O}_7^{2-}$ dichromate ion
 MnO_4^- permanganate ion

Polyatomic Ions

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Introducing: Nick the Camel!

Nick the Camel Brat ate Icky Clam for Supper in Phoenix



Nick the Camel

Nick the Camel Brat ate Icky Clam for Supper in Phoenix



Consonants = Oxygen Vowels = Charge Polyatomic Ion

Nick = Nitrate	3	-1	NO_3^-
Camel = Carbonate	3	-2	CO_3^{2-}
Brat = Bromate	3	-1	BrO_3^-
Icky = Iodate	3	-1	IO_3^-
Clam = Chlorate	3	-1	ClO_3^-
Supper = Sulfate	4	-2	SO_4^{2-}
Phoenix = Phosphate	4	-3	PO_4^{3-}
Did Nick have Crepes for dessert too? :			
Crepes = chromate	4	-2	CrO_4^{2-}

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Naming Ionic Compounds

Ionic compounds are named by citing first the cation and then the anion with a space between the words. For example:

NaBr – Sodium bromide

MgSO_4 – Magnesium sulfate

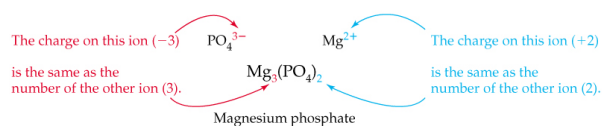
SnCl_2 – Tin(II) chloride

SnCl_4 – Tin(IV) chloride

Al_2O_3 – Aluminum oxide

Formulas of Ionic Compounds

Formula of an ionic compound shows the **lowest possible ratio** of atoms in the compound.

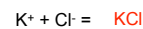
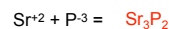
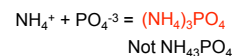
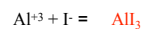
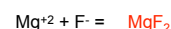
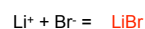
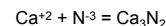
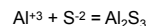
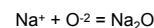
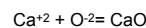
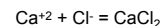
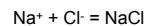


Practice, practice, practice!!!

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Formulas of Ionic Compounds



Make final compound neutral

Learning Check

Write the formulas and names for compounds of the following ions:

	Br ⁻	S ²⁻	N ³⁻
Na ⁺			
Al ³⁺			
Sn ²⁺			
Sn ⁴⁺			

Remember: To write formulas, cross the charge. To write the name, name the cation (Roman numeral if necessary) then the anion.

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Learning Check - Answers

Write the formulas and names for compounds of the following ions:

	Br ⁻	S ²⁻	N ³⁻
Na ⁺	NaBr sodium bromide	Na ₂ S sodium sulfide	Na ₃ N sodium nitride
Al ³⁺	AlBr ₃ aluminum bromide	Al ₂ S ₃ aluminum sulfide	AlN aluminum nitride
Sn ²⁺	SnBr ₂ tin(II) bromide	SnS tin(II) sulfide	Sn ₃ N ₂ tin(II) nitride
Sn ⁴⁺	SnBr ₄ tin(IV) bromide	SnS ₂ tin(IV) sulfide	Sn ₃ N ₄ tin(IV) nitride

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Learning Check

Write formulas and names for compounds of the following ions.

	OH ⁻	CO ₃ ²⁻	PO ₄ ³⁻
NH ₄ ⁺			
Ca ²⁺			

Remember: To write formulas, cross the charges. To name an ionic compound, name the cation (with Roman numeral if necessary), then the anion. If you need more than one polyatomic ion, use parentheses with the number of ions as a subscript.

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Learning Check - Answers

Write formulas and names for compounds of the following ions.

	OH ⁻	CO ₃ ²⁻	PO ₄ ³⁻
NH ₄ ⁺	NH ₄ OH ammonium hydroxide	(NH ₄) ₂ CO ₃ Ammonium carbonate	(NH ₄) ₃ PO ₄ ammonium phosphate
Ca ²⁺	Ca(OH) ₂ Calcium hydroxide	CaCO ₃ Calcium carbonate	Ca ₃ (PO ₄) ₂ calcium phosphate

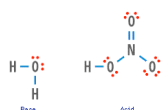
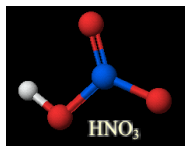
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H⁺ and Acids

The *Hydrogen cation* (H⁺) contains only a proton (no electrons or neutrons).

Acids are substances that provide H⁺ ions in water; for example, HCl, H₂SO₄, HNO₃.

HCl dissolved in water → H⁺ + Cl⁻



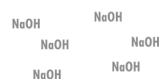
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OH⁻ Ions and Bases

The *Hydroxide anion* (OH⁻) is a polyatomic ion with a -1 charge.

Bases are substances that provide OH⁻ ions in water; for example, NaOH, KOH, Ba(OH)₂.

NaOH dissolved in water → Na⁺ + OH⁻



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Covalent Bonds

Test Yourself: Ionic Compounds

Give the names for the following formulas:

NaCl

CaBr₂

MnF₂

Ga₂(SO₄)₃

Cr(NO₃)₃

Give the formulas for the following names:

hydrochloric acid

iron(III) oxide

potassium hydroxide

chromium(III) iodide

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Practice, practice, practice!

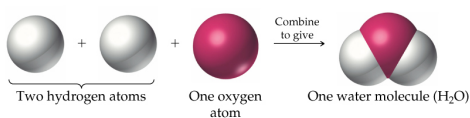
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A **covalent bond** is a bond formed by **sharing electrons** between atoms.

A **molecule** is a **group of atoms** held together by covalent bonds.

Nonmetals form covalent bonds with nonmetals. They reach the Noble Gas configuration by **sharing** an appropriate number of electrons.

A **water molecule** results when two hydrogen atoms and one oxygen atom are **covalently bonded**:



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Test Yourself

Are these compounds bonded through ionic or covalent bonding?

PCl₅

Na₂O

SO₃

CaSO₃

SbAs

Nomenclature of covalent compounds different from ionic compounds; important to know the difference

Naming Molecular Compounds

When **two or more nonmetal elements** combine they form **covalent compounds**.

The formulas of covalent compounds are written with the **less electronegative (i.e. more metal-like)** element first.

More electronegative element gets **-ide** suffix

Use **Greek Prefixes** to indicate number of atoms present.

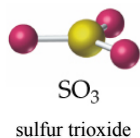
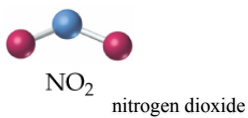
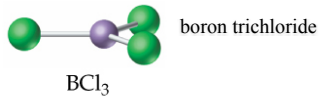
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Greek Prefixes

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

Covalent compounds and nomenclature:



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Test Yourself - Covalent Bonding

Give the names for the following formulas:



Give the formulas for the following names:

tetraphosphorus decaoxide

carbon dioxide

carbon monoxide

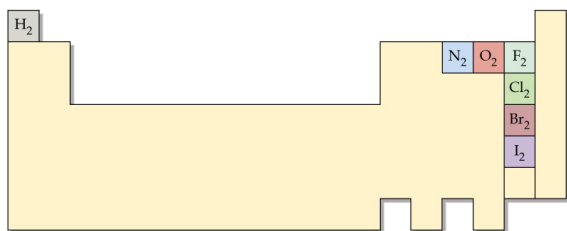
nitrogen dioxide

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Practice, practice, practice!

Most elements exist as individual atoms.

Seven elements *always* exist as diatomic molecule - the **seven diatomics**



HONCl BrIF

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Elements that Exist as Diatomic Molecules

Have
No
Fear
Of
Ice
Clear
Brew



Nitrogen, N₂

End of Chapter 3 Part I

