



TECHNICAL CHEMISTRY - BMMV 1013

Atom, Molecules & Ions

Chapter 2

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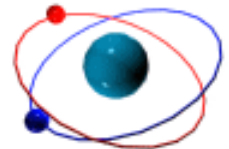
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The Atom

● Atom is the basic unit of an element, made up of even smaller particles called subatomic particles.

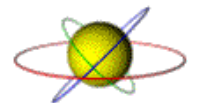


● There are three fundamental components (subatomic particles) that are important in chemistry: Electron, Proton and Neutron.



● The protons and neutrons of an atom are packed in an extremely small nucleus.

● Electrons are shown as 'clouds' around the nucleus.



The Structure of the Atom

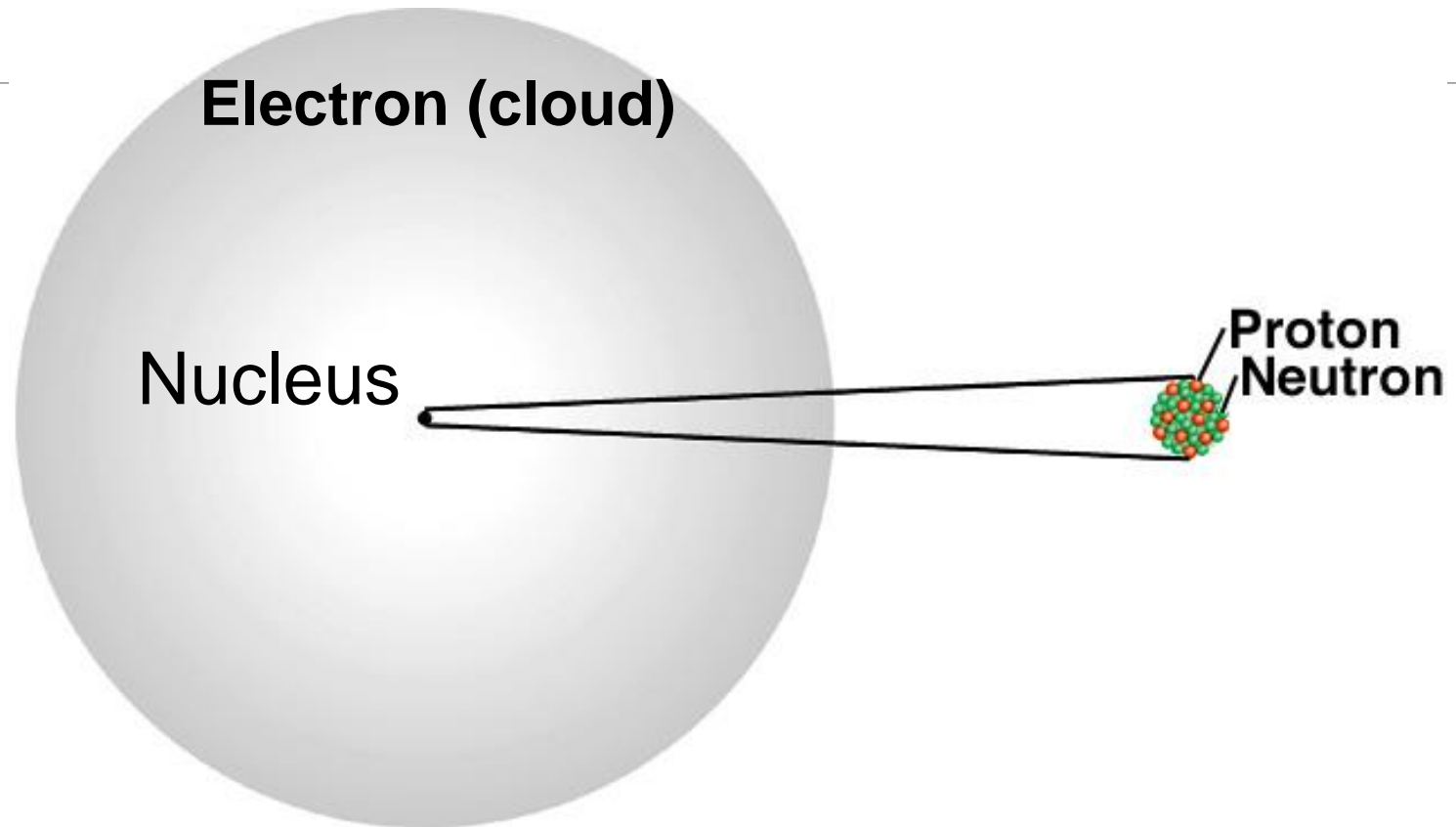
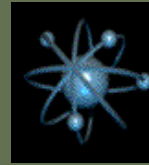
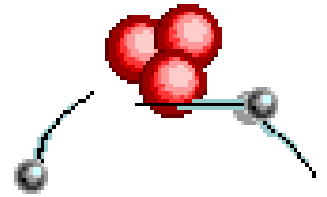


Figure above shows the location of the protons, Neutrons and electrons in an atom

Subatomic Particles



Particle	Mass (g)	Charge (Coulombs)	Charge (units)
Electron (e^-)	9.1×10^{-28}	-1.6×10^{-19}	-1
Proton (p^+)	1.67×10^{-24}	$+1.6 \times 10^{-19}$	+1
Neutron (n)	1.67×10^{-24}	0	0

$$\text{mass } p = \text{mass } n = 1840 \times \text{mass } e^-$$

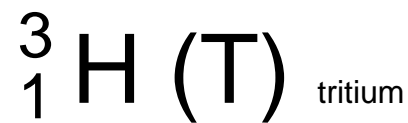
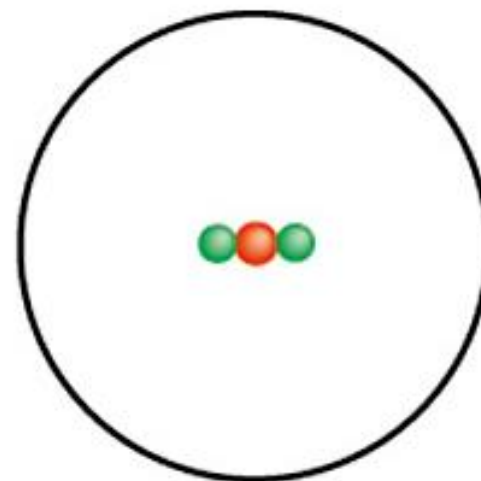
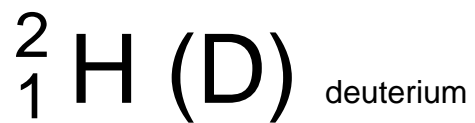
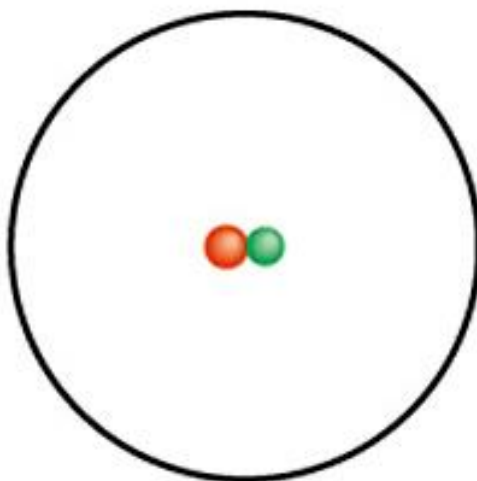
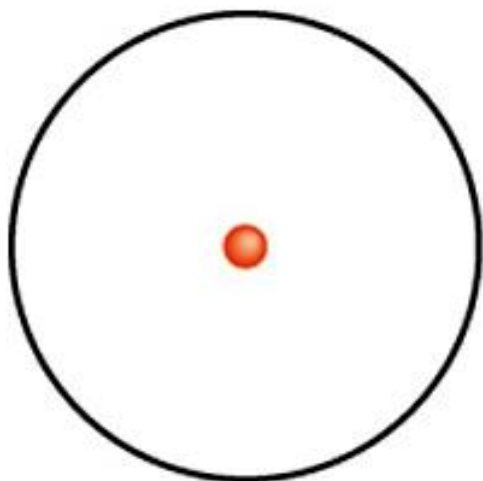
Atomic Number, Mass Number & Isotopes

Atomic number (Z) = number of protons in nucleus

Mass number (A) = number of protons + number of neutrons
= atomic number (Z) + number of neutrons

Isotopes are atoms of the same element (X) with different numbers of neutrons in their nuclei







Do You Understand Isotopes?

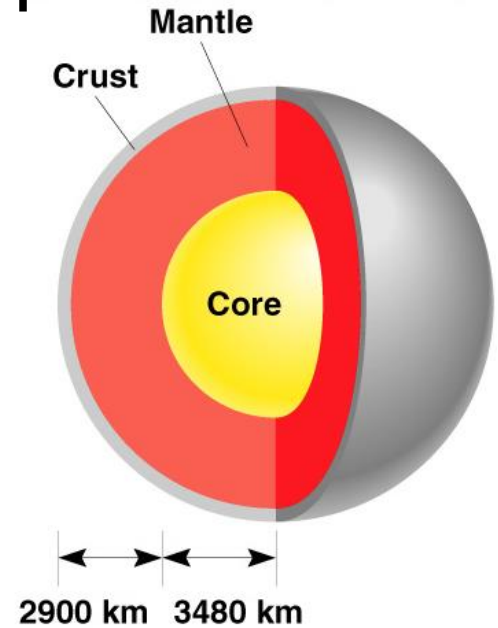
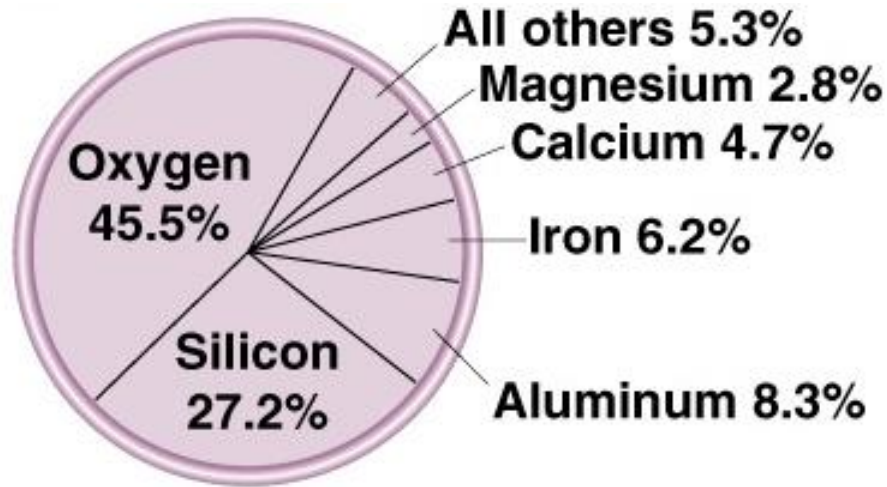
How many protons, neutrons, and electrons are in $^{14}_6\text{C}$?

How many protons, neutrons, and electrons are in $^{11}_6\text{C}$?

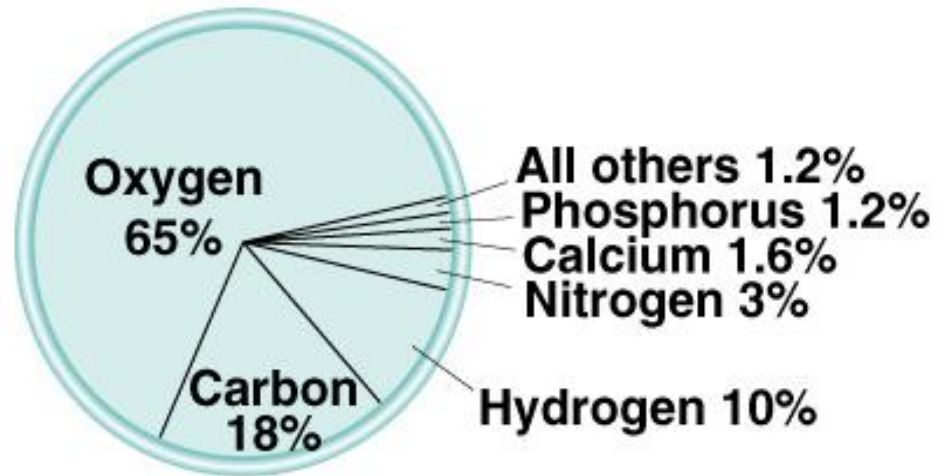
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Chemistry In Action

Natural abundance of elements in Earth's crust

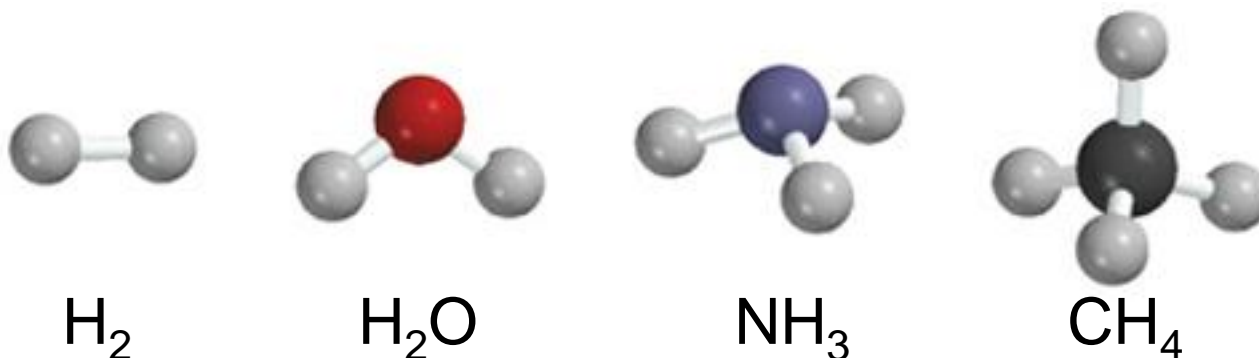


Natural abundance of elements in human body



Molecules & Ions

A **molecule** is an aggregate of two or more atoms in a definite arrangement held together by chemical bonds



A **diatomic molecule** contains only two atoms



A **polyatomic molecule** contains more than two atoms



An **ion** is an atom, or group of atoms, that has a net positive or negative charge.

cation – ion with a positive charge

If a neutral atom **loses** one or more electrons it becomes a cation.



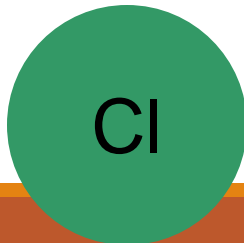
11 protons
11 electrons



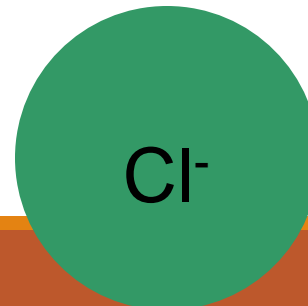
11 protons
10 electrons

anion – ion with a negative charge

If a neutral atom **gains** one or more electrons it becomes an anion.

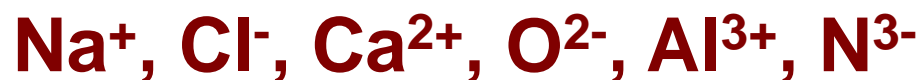


17 protons
17 electrons

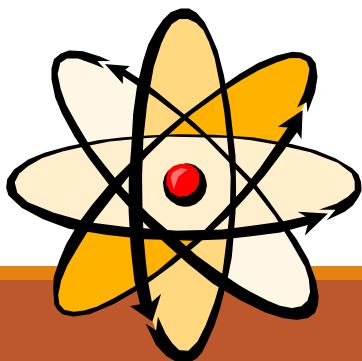


17 protons
18 electrons

A ***monatomic ion*** contains only one atom



A ***polyatomic ion*** contains more than one atom



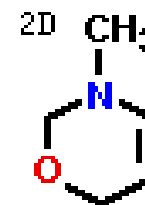


Do You Understand Ions?

How many protons and electrons are in ${}_{13}^{27}\text{Al}^{3+}$?

How many protons and electrons are in ${}_{34}^{78}\text{Se}^{2-}$?

Chemical Formulas



Standard Types of Formulas and Models

	Hydrogen	Water	Ammonia	Methane
Molecular formula	H_2	H_2O	NH_3	CH_4
Structural formula	$H-H$	$H-O-H$	$\begin{array}{c} H-N-H \\ \\ H \end{array}$	$\begin{array}{c} H \\ \\ H-C-H \\ \\ H \end{array}$
Ball-and-stick model				
Space-filling model				

A ***molecular formula*** shows the exact number of atoms of each element in the smallest unit of a substance

An ***empirical formula*** shows the simplest whole-number ratio of the atoms in a substance

molecular

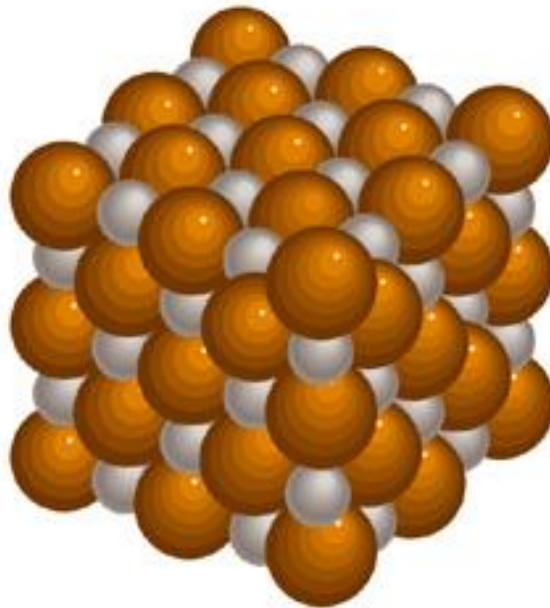
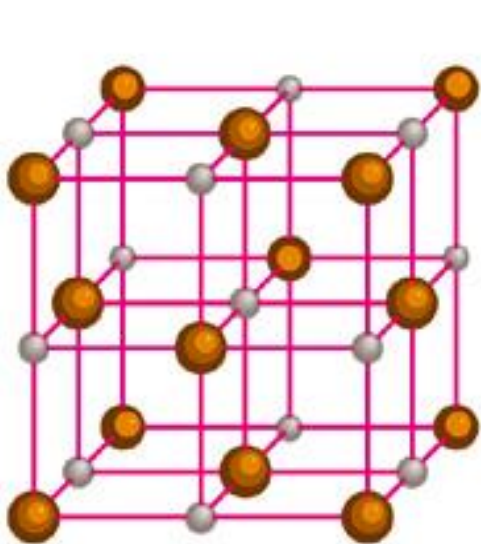
empirical



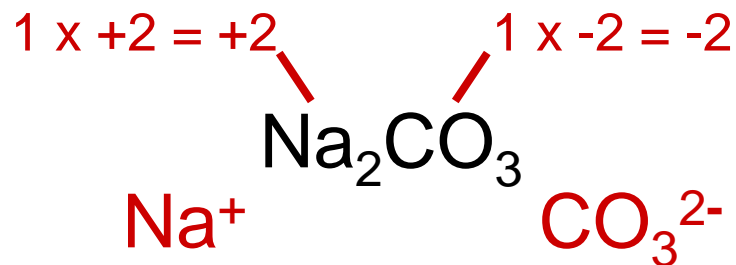
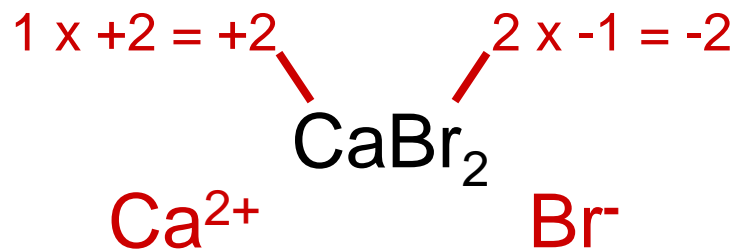
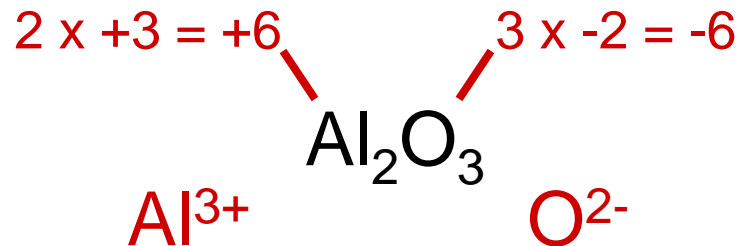
ionic compounds consist of a combination of cations and an anions

- the formula is always the same as the empirical formula
- the sum of the charges on the cation(s) and anion(s) in each formula unit must equal zero

The ionic compound NaCl



Formula of Ionic Compounds



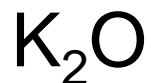
Names and Formulas of Some Common Inorganic Cations and Anions

Cation	Anion
Aluminum (Al^{3+})	Bromide (Br^-)
Ammonium (NH_4^+)	Carbonate (CO_3^{2-})
Barium (Ba^{2+})	Chlorate (ClO_3^-)
Cadmium (Cd^{2+})	Chloride (Cl^-)
Calcium (Ca^{2+})	Chromate (CrO_4^{2-})
Cesium (Cs^+)	Cyanide (CN^-)
Chromium(III) or chromic (Cr^{3+})	Dichromate ($\text{Cr}_2\text{O}_7^{2-}$)
Cobalt(II) or cobaltous (Co^{2+})	Dihydrogen phosphate (H_2PO_4^-)
Copper(I) or cuprous (Cu^+)	Fluoride (F^-)
Copper(II) or cupric (Cu^{2+})	Hydride (H^-)
Hydrogen (H^+)	Hydrogen carbonate or bicarbonate (HCO_3^-)
Iron(II) or ferrous (Fe^{2+})	Hydrogen phosphate (HPO_4^{2-})
Iron(III) or ferric (Fe^{3+})	Hydrogen sulfate or bisulfate (HSO_4^-)
Lead(II) or plumbous (Pb^{2+})	Hydroxide (OH^-)
Lithium (Li^+)	Iodide (I^-)
Magnesium (Mg^{2+})	Nitrate (NO_3^-)
Manganese(II) or manganous (Mn^{2+})	Nitride (N^{3-})
Mercury(I) or mercurous (Hg_2^{2+})*	Nitrite (NO_2^-)
Mercury(II) or mercuric (Hg^{2+})	Oxide (O^{2-})
Potassium (K^+)	Permanganate (MnO_4^-)
Silver (Ag^+)	Peroxide (O_2^{2-})

Naming Compound

Ionic Compounds

- often a metal + nonmetal
- anion (nonmetal), add “ide” to element name



Transition metal ionic compounds

- indicate charge on metal with Roman numerals



Molecular compounds

- nonmetals or nonmetals + metalloids
- common names
 - H_2O , NH_3 , CH_4 , C_{60}
- element further left in periodic table is 1st
 - NF_3 , NO_2
- element closest to bottom of group is 1st
 - SO_2
- if more than one compound can be formed from the same elements, use prefixes to indicate number of each kind of atom
- last element ends in ide

Greek Prefixes Used in Naming Molecular Compounds

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

Molecular Compounds



Acid & Bases

An **acid** can be defined as a substance that yields hydrogen ions (H^+) when dissolved in water.

HCl

- Pure substance, hydrogen chloride
- Dissolved in water ($\text{H}^+ \text{Cl}^-$), hydrochloric acid

An **oxoacid** is an acid that contains hydrogen, oxygen, and another element.



nitric acid



carbonic acid

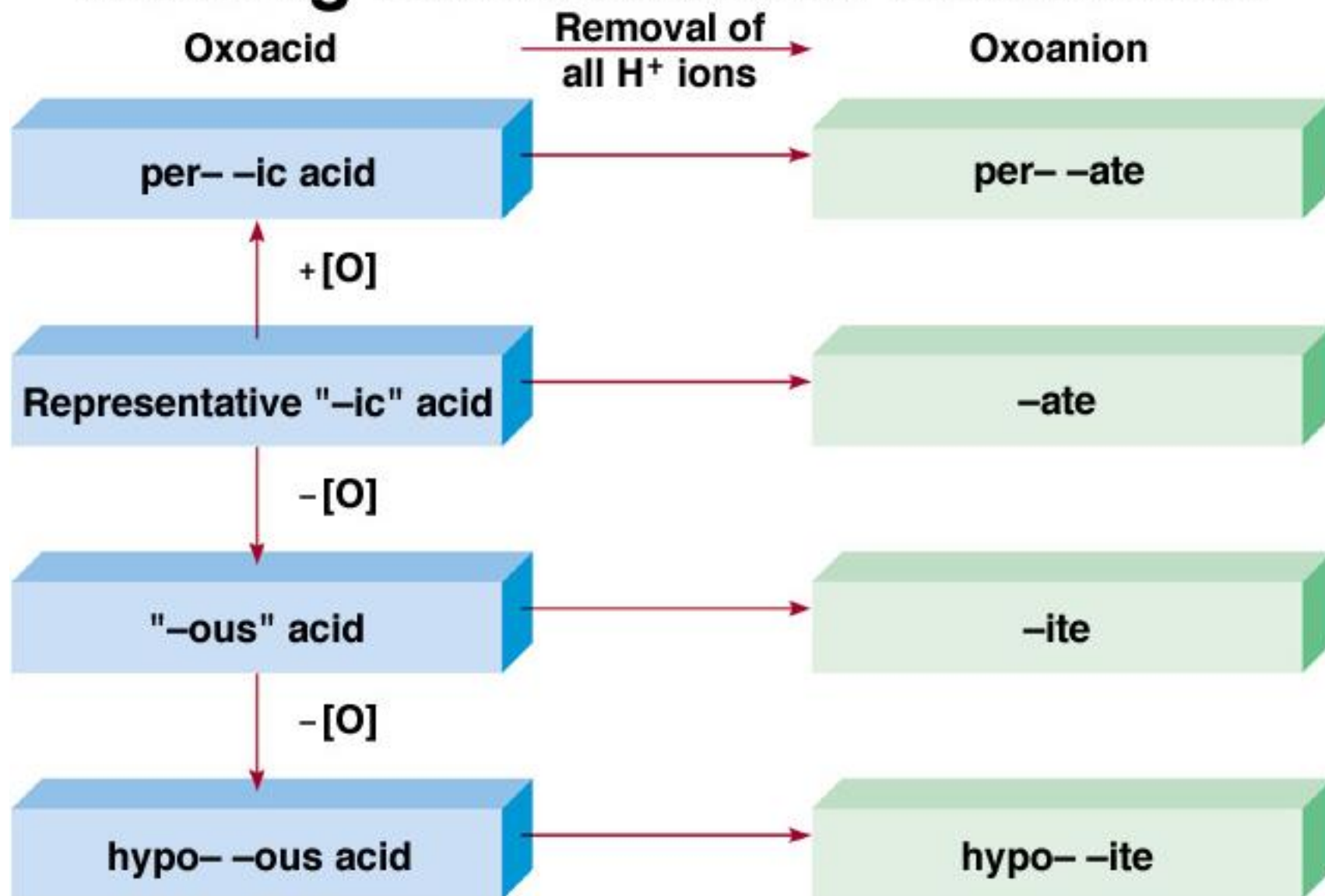


sulfuric acid

Some Simple Acids

Anion	Corresponding Acid
F^- (fluoride)	HF (hydrofluoric acid)
Cl^- (chloride)	HCl (hydrochloric acid)
Br^- (bromide)	HBr (hydrobromic acid)
I^- (iodide)	HI (hydroiodic acid)
CN^- (cyanide)	HCN (hydrocyanic acid)
S^{2-} (sulfide)	H_2S (hydrosulfuric acid)

Naming Oxoacids and Oxoanions



Names of Oxoacids and Oxoanions That Contain Chlorine

Acid

Anion

HClO_4 (perchloric acid)

ClO_4^- (perchlorate)

HClO_3 (chloric acid)

ClO_3^- (chlorate)

HClO_2 (chlorous acid)

ClO_2^- (chlorite)

HClO (hypochlorous acid)

ClO^- (hypochlorite)

A **base** can be defined as a substance that yields hydroxide ions (OH^-) when dissolved in water.



sodium hydroxide



potassium hydroxide



barium hydroxide

Common and Systematic Names of Some Compounds

Formula	Common Name	Systematic Name
H_2O	Water	Dihydrogen monoxide
NH_3	Ammonia	Trihydrogen nitride
CO_2	Dry ice	Solid carbon dioxide
NaCl	Table salt	Sodium chloride
N_2O	Laughing gas	Dinitrogen monoxide
CaCO_3	Marble, chalk, limestone	Calcium carbonate
CaO	Quicklime	Calcium oxide
Ca(OH)_2	Slaked lime	Calcium hydroxide
NaHCO_3	Baking soda	Sodium hydrogen carbonate
$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	Washing soda	Sodium carbonate decahydrate
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	Epsom salt	Magnesium sulfate heptahydrate
Mg(OH)_2	Milk of magnesia	Magnesium hydroxide
$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	Gypsum	Calcium sulfate dihydrate