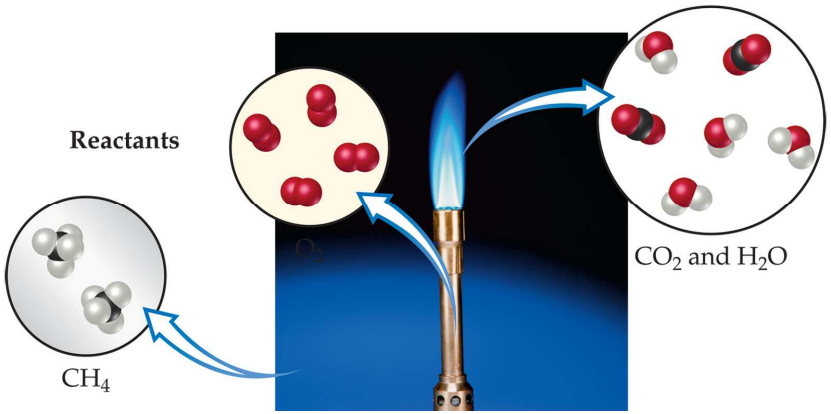
Atomic Theory of Matter

The theory that atoms are the fundamental building blocks of matter

John Dalton (1766-1844)



<u>Postulates of Dalton's Theory</u>

1) Each element is composed of extremely small particles called atoms

2) All atoms of a given element are identical to one another in mass and other properties, but the atoms of one element are different from the atoms of all other elements

3) Atoms of an element are not changed into atoms of a different element by chemical reactions; atoms are neither created nor destroyed in chemical reactions

4) Compounds are formed when atoms of more than one element combine; a given compound always has the same relative number and kind of atoms

Joseph Proust (1754-1826)

Law of Constant Proportion

The elemental composition of pure substances is never varies

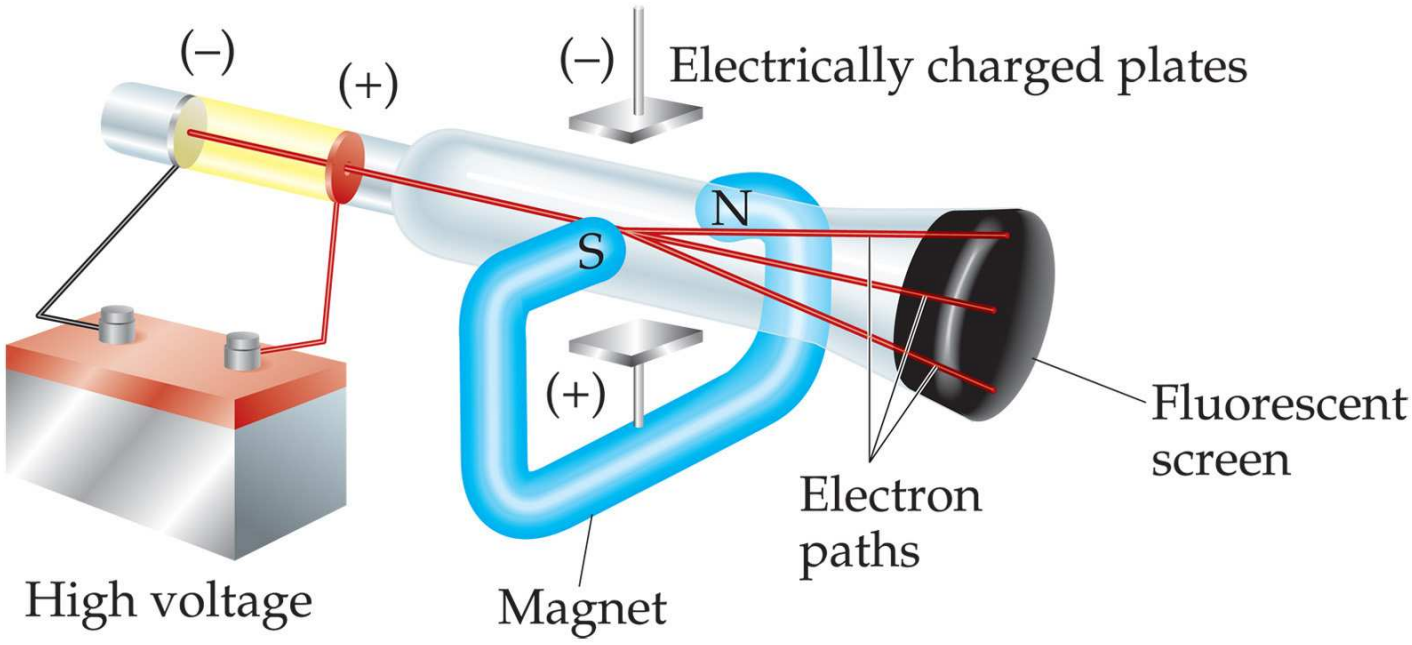
Lavoisier (1743-1794)

Law of Conservation of Mass

The total mass of substances present at the end of a chemical process is the same as the mass of substances present before the process took place.

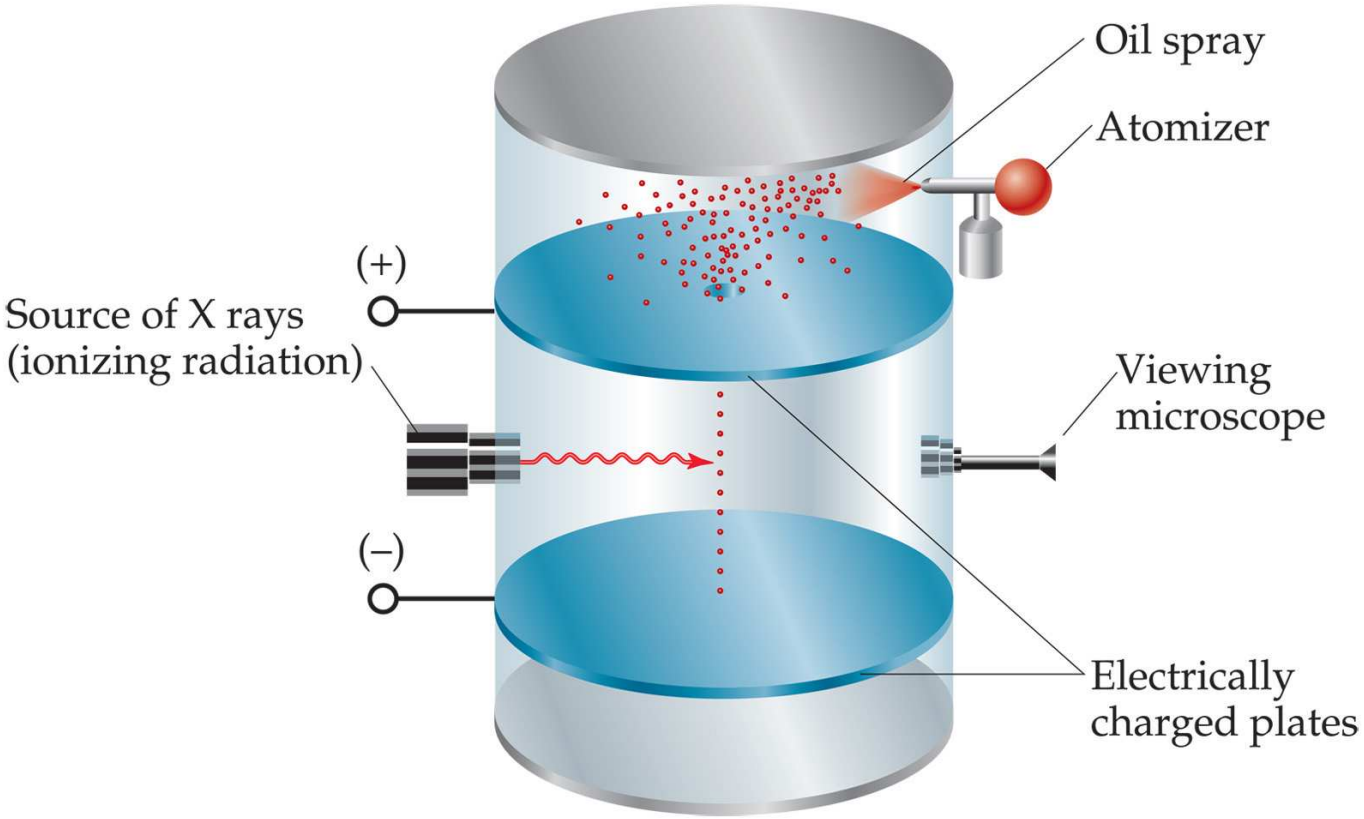
Discovery of the electron (e-)

J. J. Thompson 1897



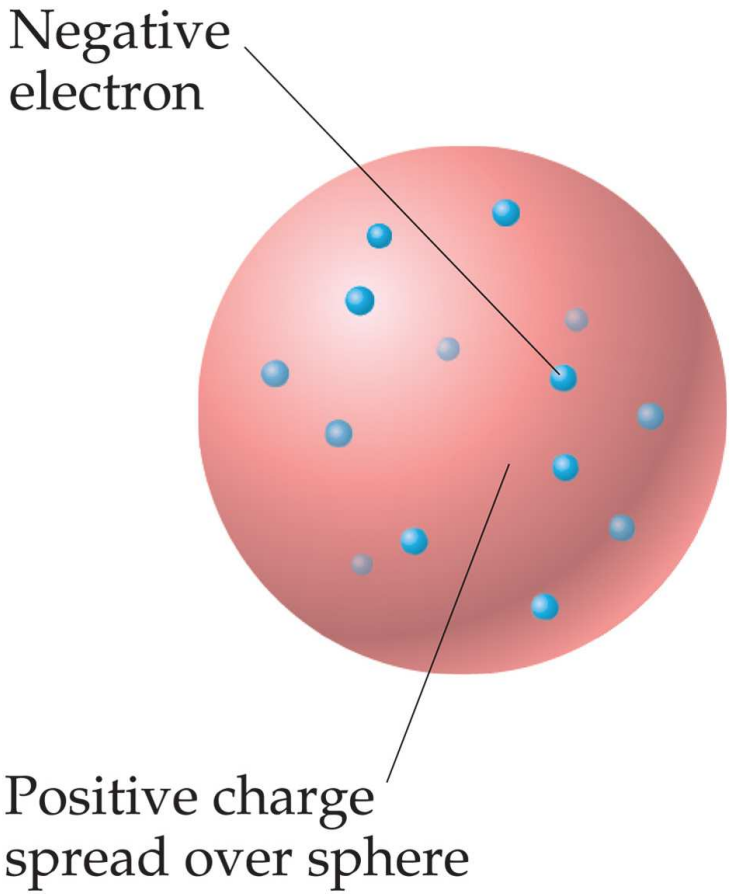
Determined: e- charge/mass ratio

Millikan Oil Drop Experiment 1909



Determined charge of an e- (1.6×10^{-19}C)

Plum Pudding Model of the Atom

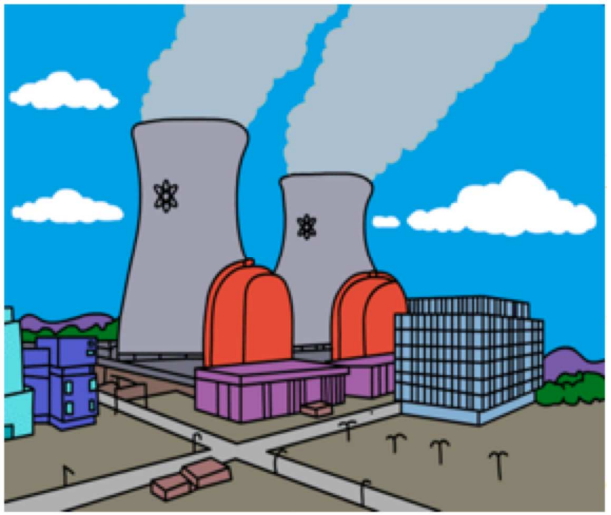


J. J. Thomson Plum Pudding Model
~1900

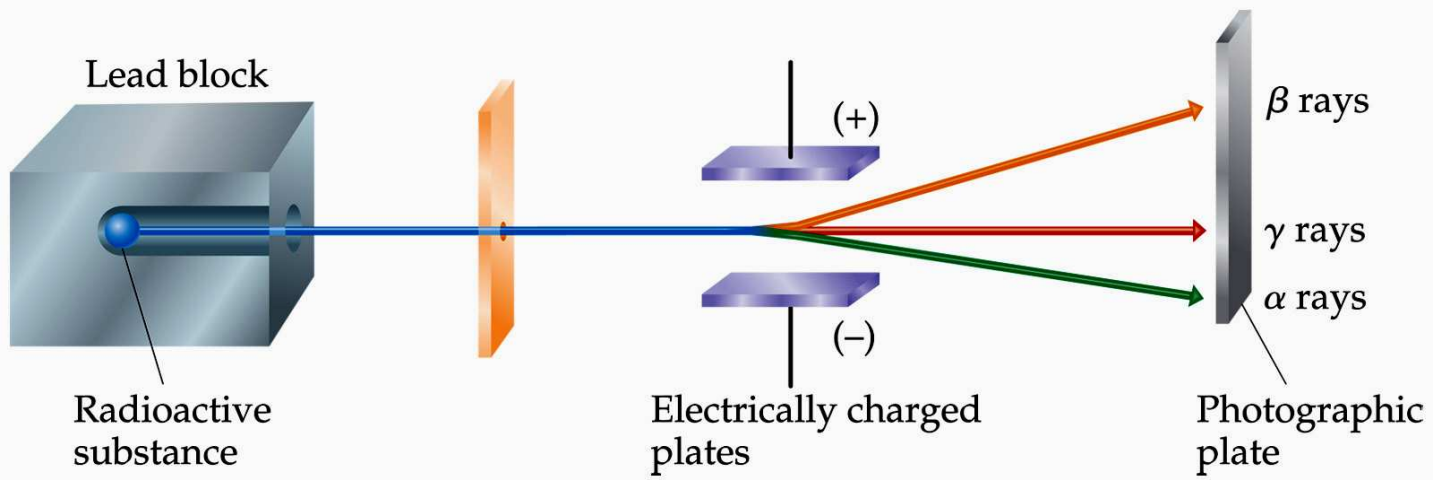
Negative charges spread (like raisins) in uniform clump of positive matter (pudding)

Radioactivity

Spontaneous emission of radiation
Studied by Becquerel, and the Curies



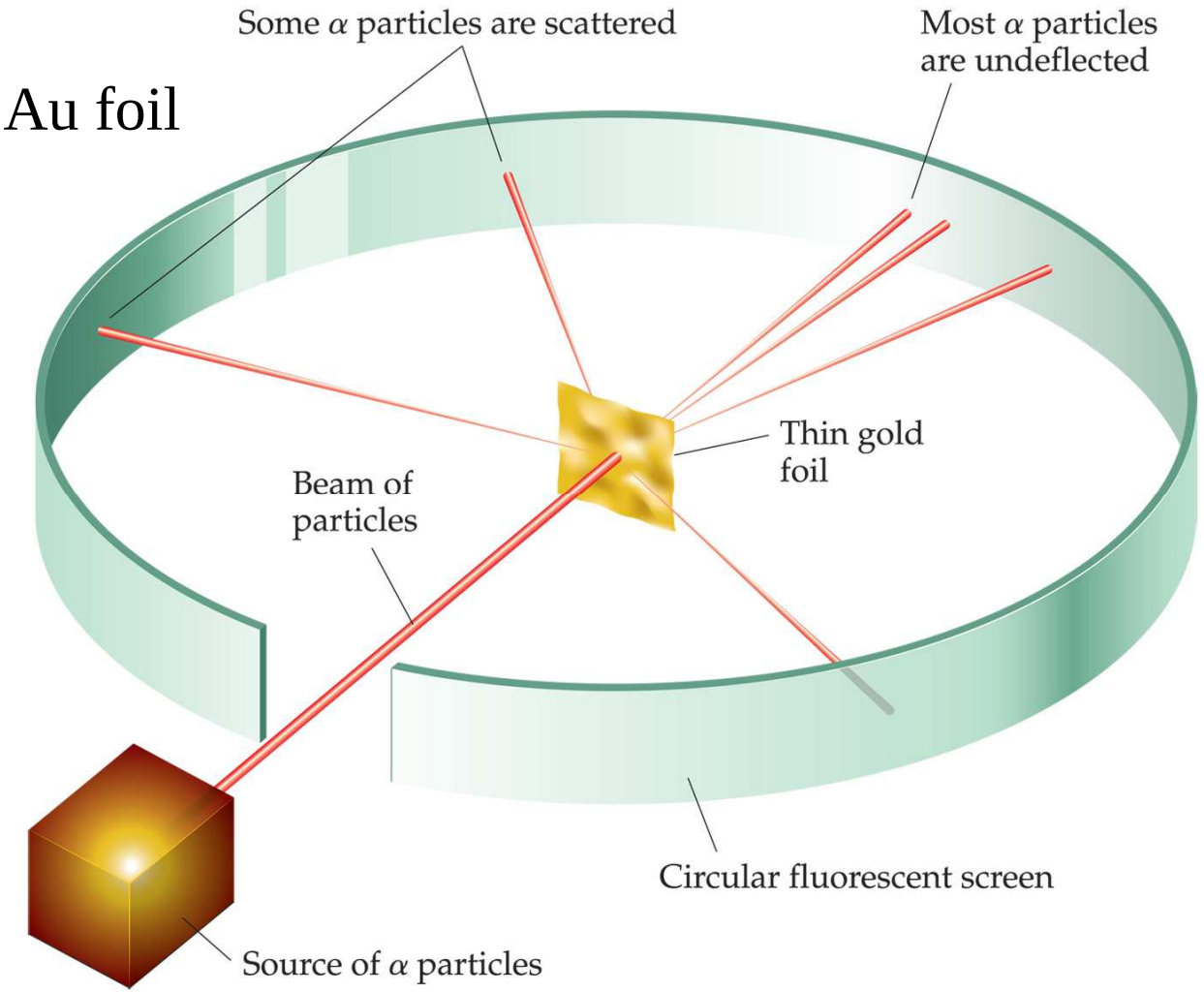
Ernest Rutherford discovered three types of radiation



Ernest Rutherford Discovery the Atomic Nucleus

Aimed a radiation at Au foil

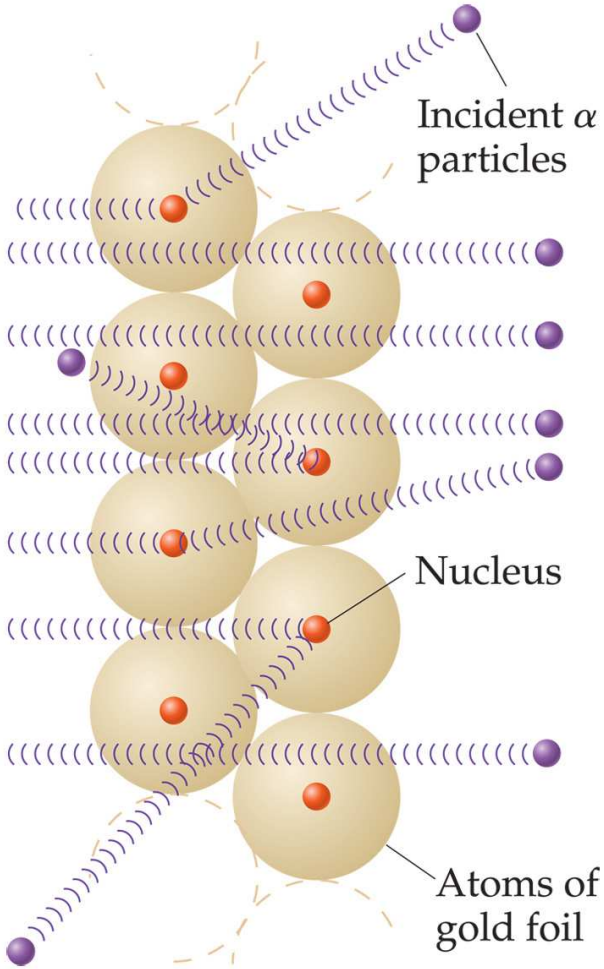
Monitored the scattered particles



Ernest Rutherford Discovered the Atomic Nucleus

Since most particles went through:

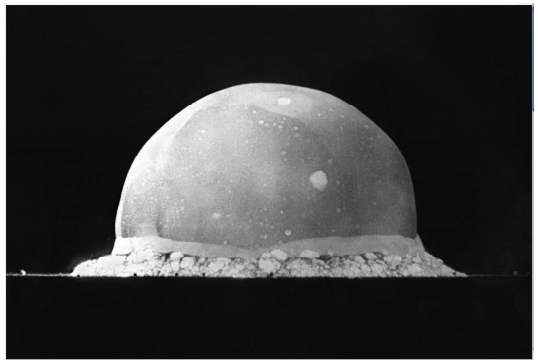
- Plum pudding model incorrect
- Most of the atom is EMPTY
- The + portion is small and dense



Nucleus Contains Protons (+) and Neutrons (neutral)

Rutherford discovers the proton in 1919

James Chadwick discovers neutron in 1932

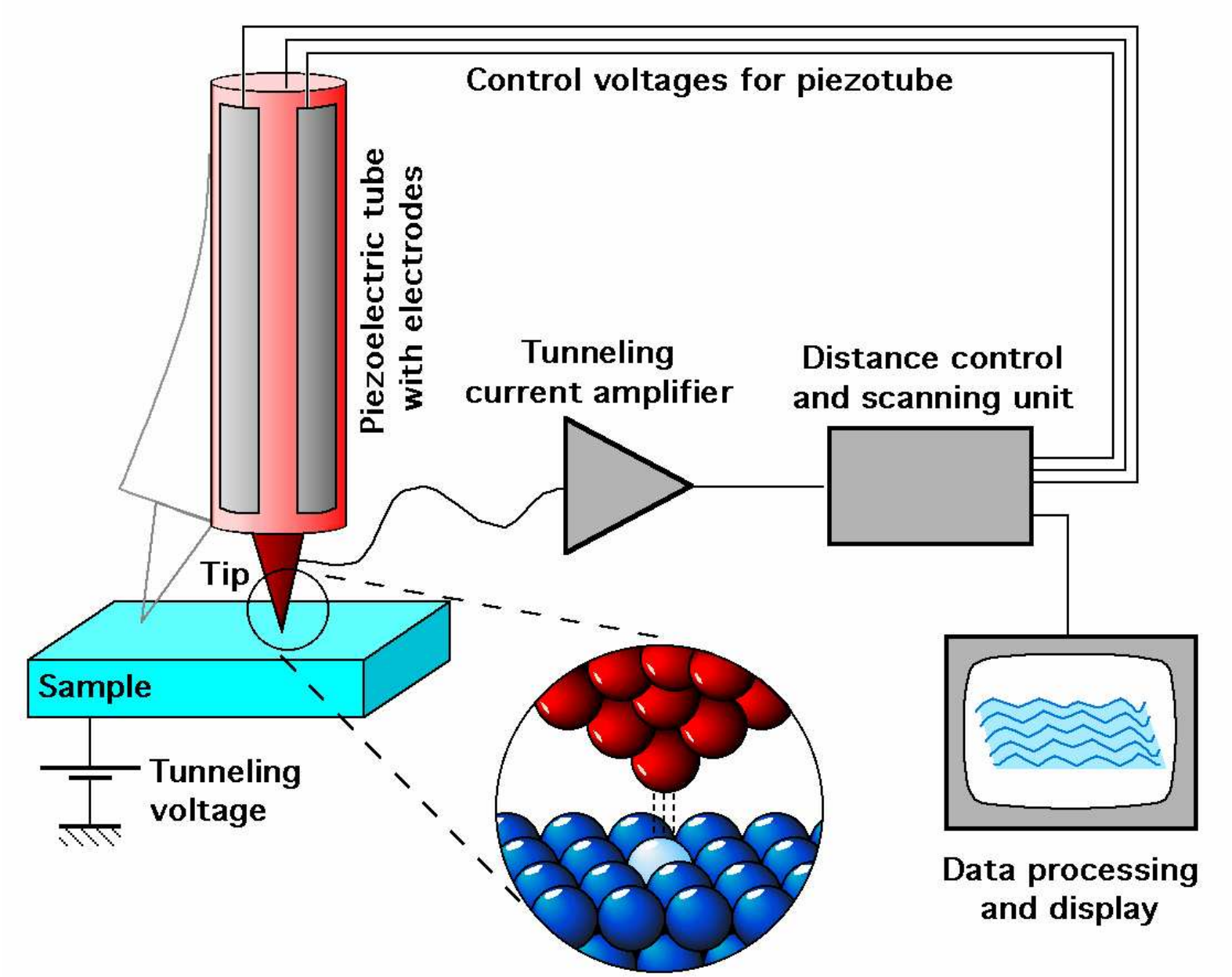


Trinity Bomb 1945

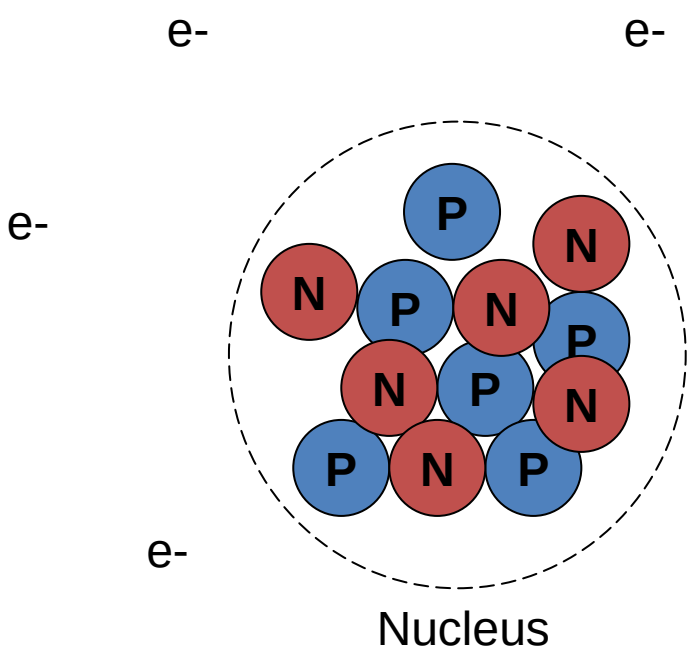
Particle	Charge	Mass (amu)
Proton	Positive (1+)	1.0073
Neutron	None (neutral)	1.0087
Electron	Negative (1−)	5.486×10^{-4}

1 atomic mass unit (amu) = 1.66054×10^{-24} g

Scanning Tunneling Microscope (STM)



Modern View of Atom



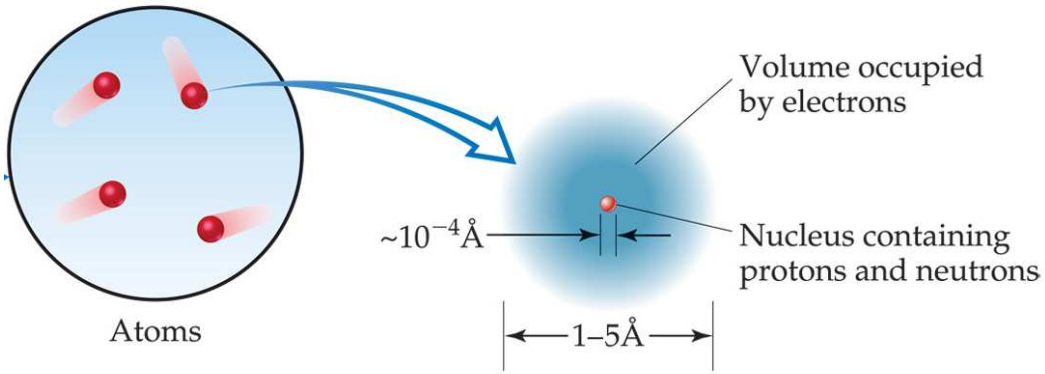
- Small positively charged, massive nucleus surrounded by light electrons in large orbits

- Nucleus contains protons and neutrons

- The number of protons determines which element it is

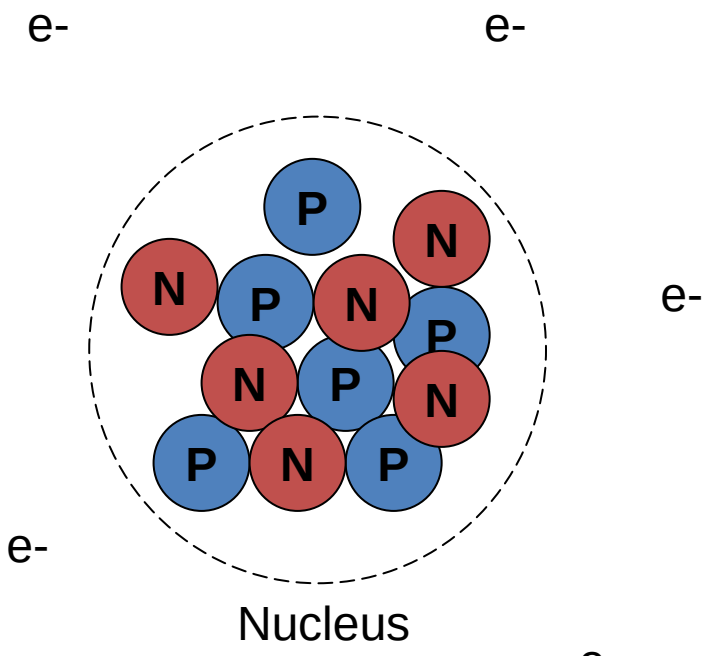
- The number of e- equals the number of protons for nuetral atoms

- Different isotopes of an element have different number of nuetrons.



Atomic Symbols

The mass of an atom in atomic mass units (amu) is the total number of protons and neutrons in the atom.



Atomic Mass
(Protons + Neutrons)

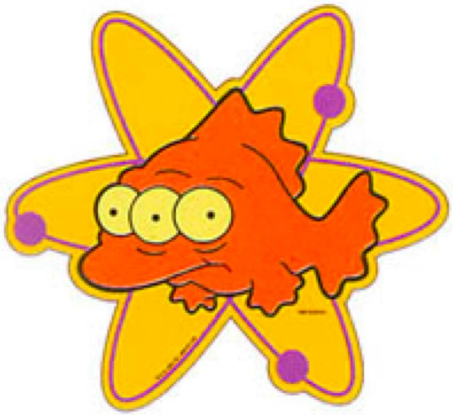
$^{12}_{6}C$

Atomic Symbol

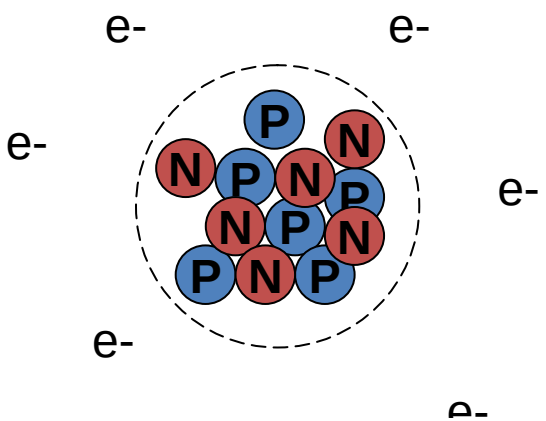
Atomic Number (Z)
(# Protons, same elements – same Z)

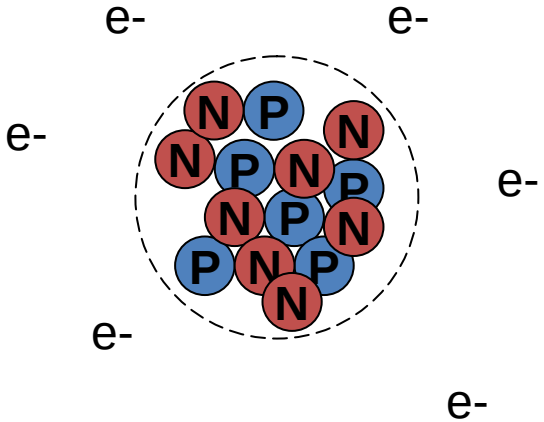
Isotopes

- Atoms of the same element with different masses.
- Isotopes have different numbers of neutrons.

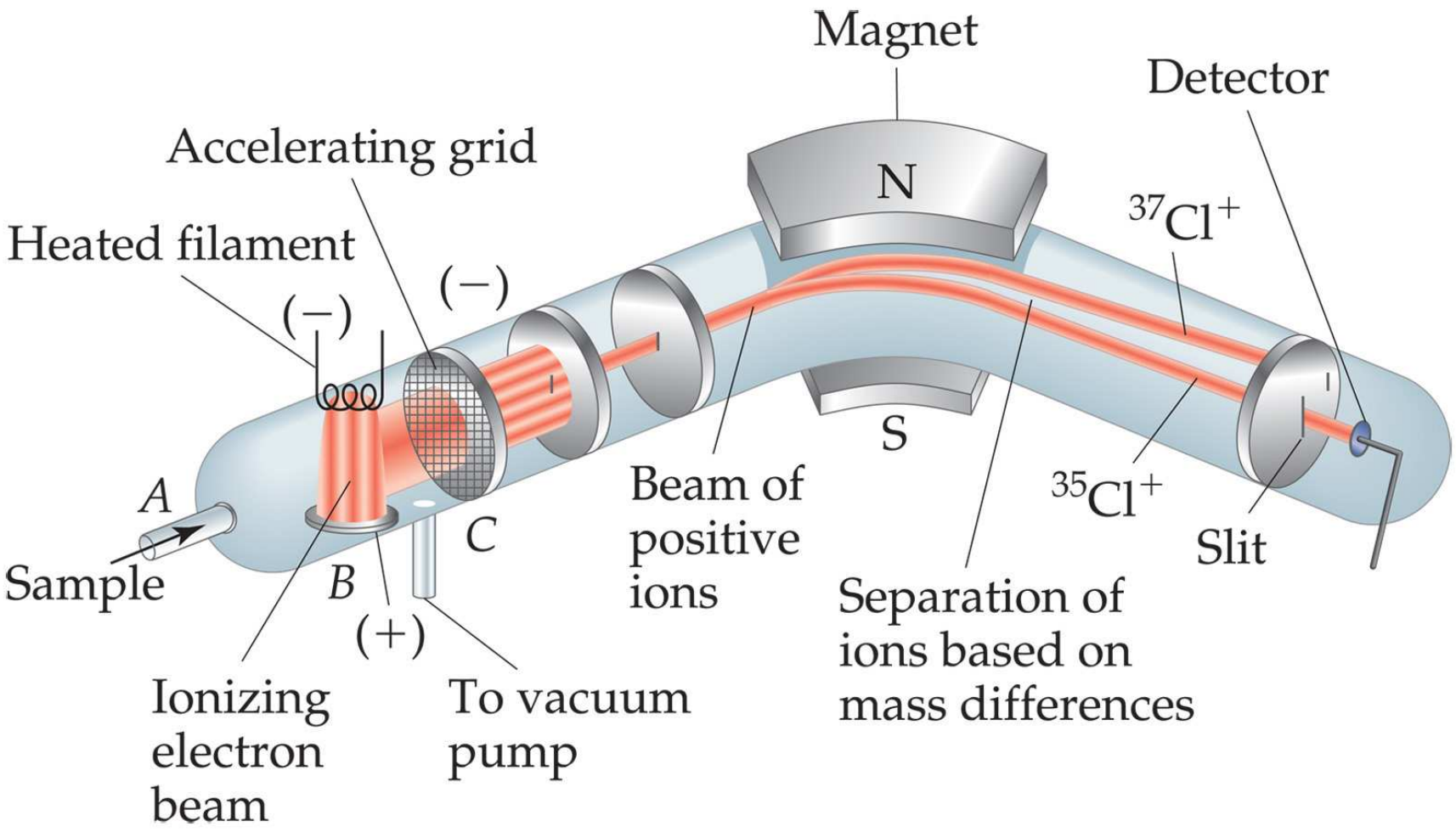


$^{11}_{6}C$ $^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$





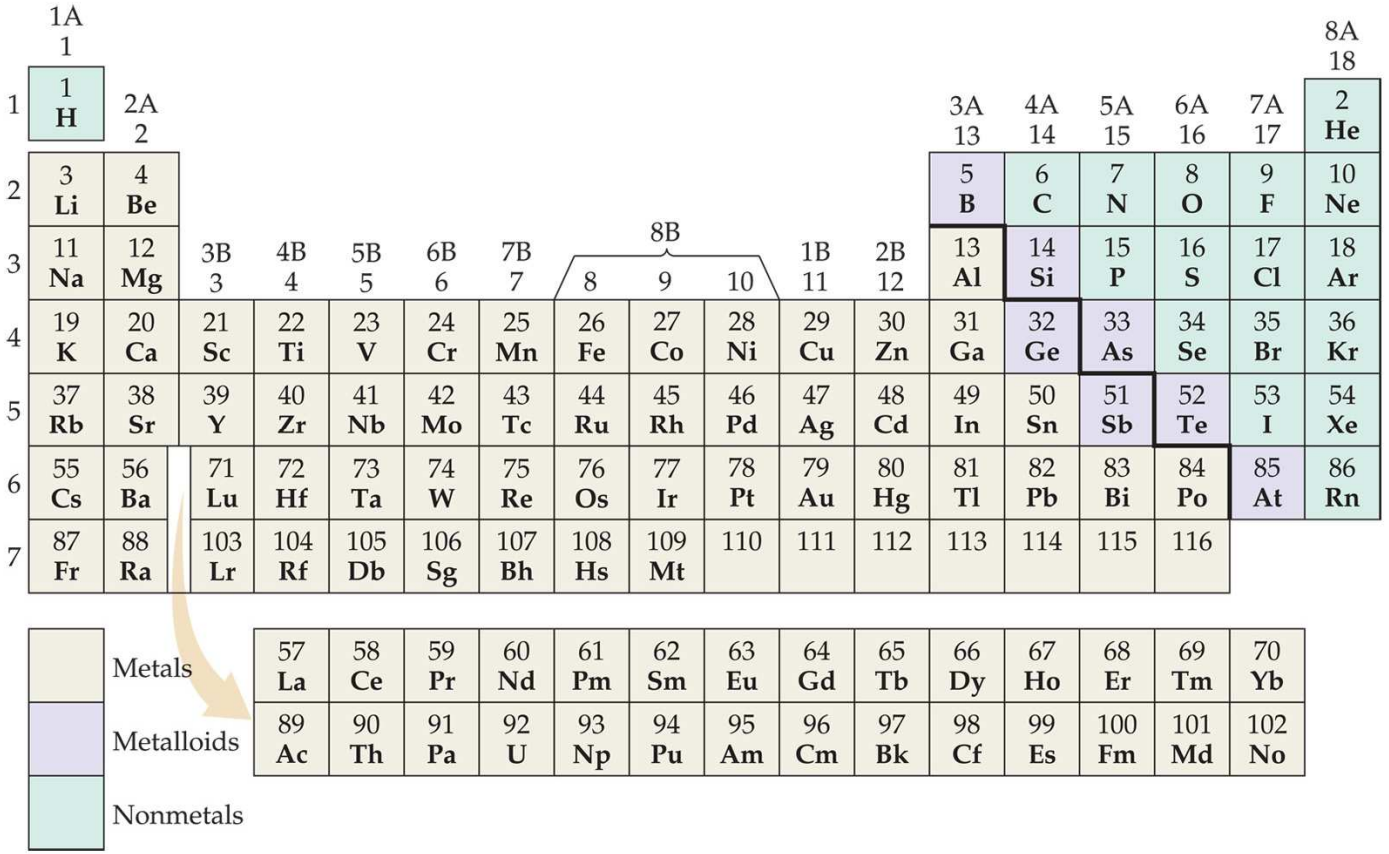
Mass Spectroscopy



Periodic Table

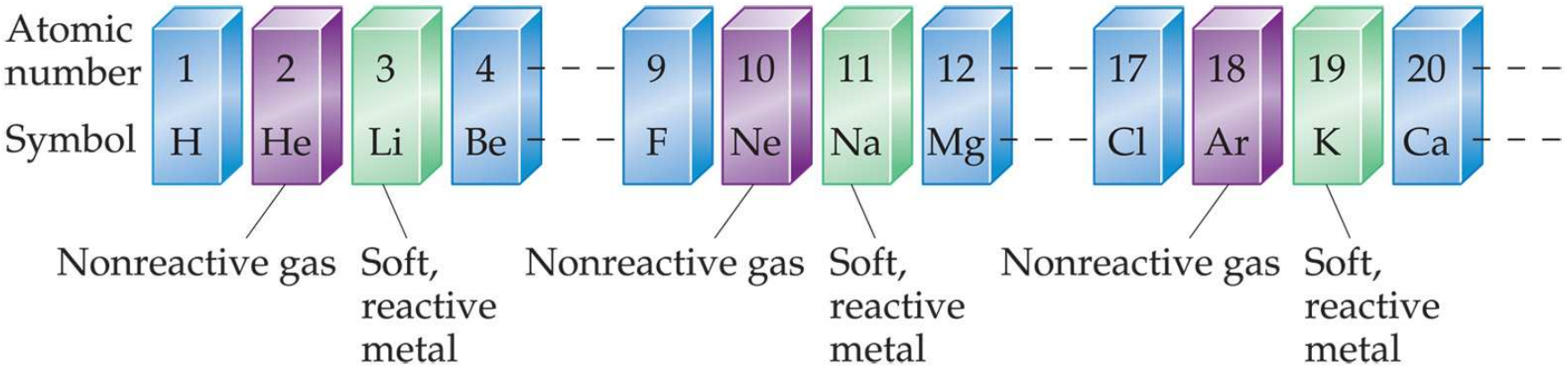
- Table of elements arranged by atomic number
- The rows on the periodic chart are periods.
- Columns are groups.
- Elements in the same group have similar chemical properties.

Metals



Non-Metals

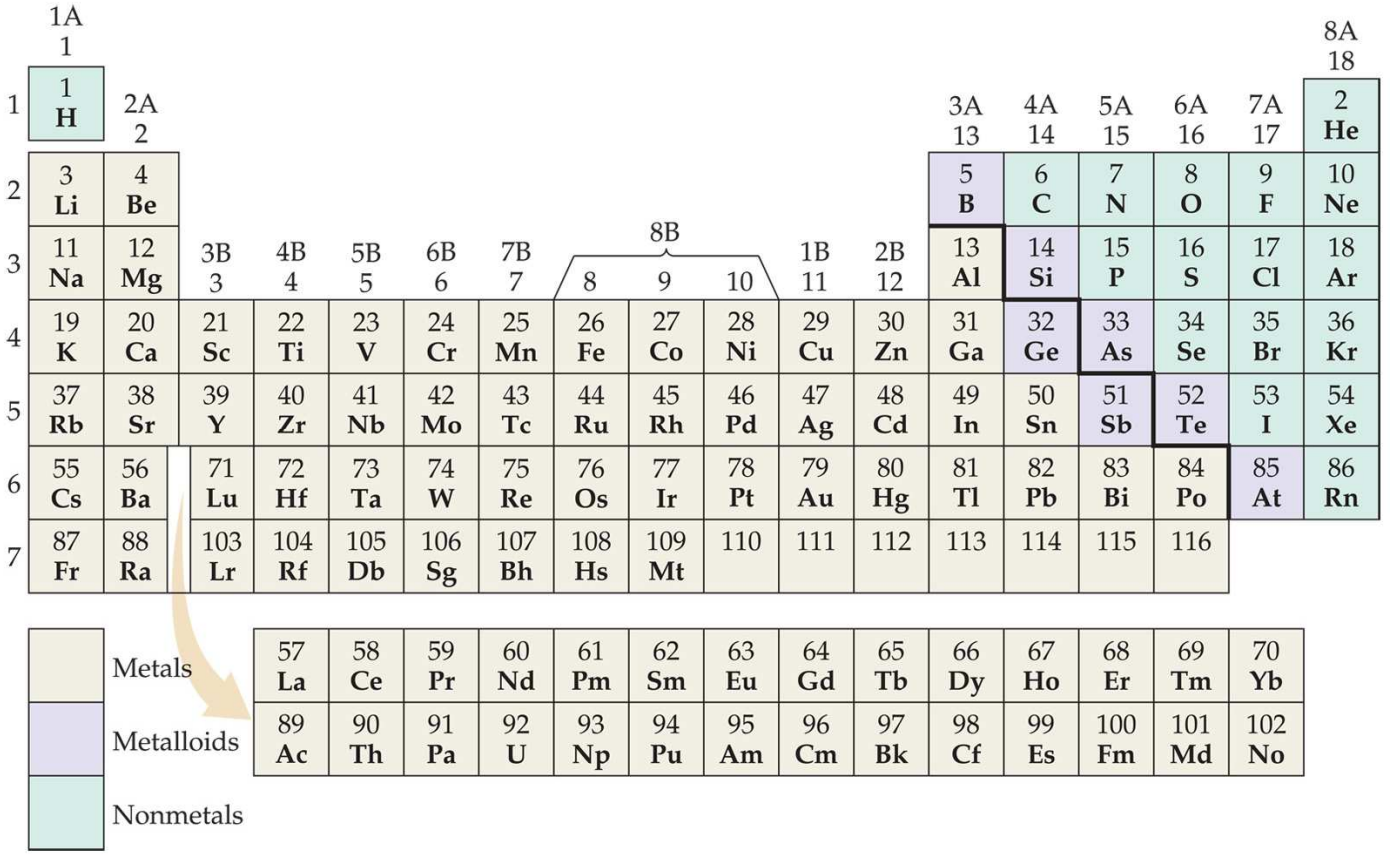
Periodicity



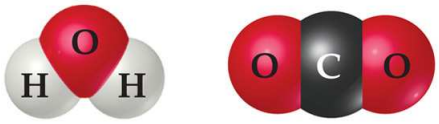
When one looks at the chemical properties of elements, one notices a repeating pattern of reactivities.

Groups

Group	Name	Elements
1A	Alkali metals	Li, Na, K, Rb, Cs, Fr
2A	Alkaline earth metals	Be, Mg, Ca, Sr, Ba, Ra
7A	Halogens	F, Cl, Br, I, At
8A	Noble gases (or rare gases)	He, Ne, Ar, Kr, Xe, Rn



Chemical Formulas



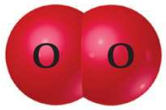
Water, H_2O

Carbon dioxide, CO_2

Carbon monoxide, CO

Methane, CH_4

Hydrogen peroxide, H_2O_2



Oxygen, O_2

CH_4

Number of atoms in the molecule

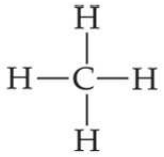
Empirical formulas give the lowest whole-number ratio of atoms of each element in a compound.

$$C_nH_{2n}O_n = C_n(H_2O)_n$$

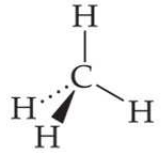
Molecular formulas give the exact number of atoms of each element in a compound.

$$C_6H_{12}O_6$$

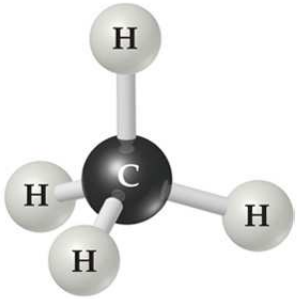
Chemical Formulas



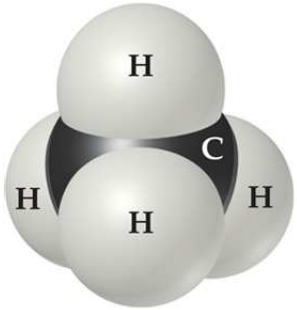
Structural formula



Perspective drawing



Ball-and-stick model

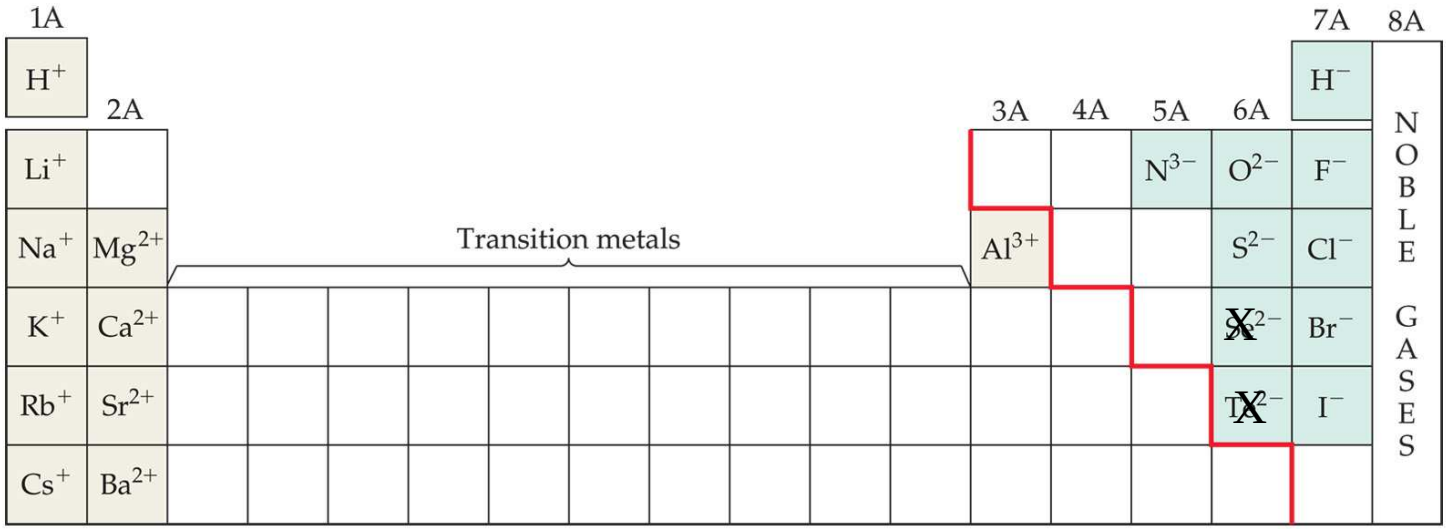


Space-filling model

Structural formulas show the order in which atoms are bonded.

Perspective drawings also show the three-dimensional array of atoms in a compound.

Ions



Ion = an atom or molecule that has a charge (neg. or pos.)

Positive ions are called cations

Negative ions are call anions

TABLE 2.4 Common Cations*

Charge	Formula	Name	Formula	Name
1+	**H^+**	**Hydrogen ion**	**NH_4^+**	**Ammonium ion**
	Li^+	Lithium ion	Cu^+	Copper(I) or cuprous ion
	Na^+	**Sodium ion**		
	K^+	**Potassium ion**		
	Cs^+	Cesium ion		
	Ag^+	**Silver ion**		
2+	**Mg^{2+}**	**Magnesium ion**	~~Co^{2+}~~	~~Cobalt(II) or cobaltous ion~~
	Ca^{2+}	**Calcium ion**	**Cu^{2+}**	**Copper(II)** or cupric ion
	Sr^{2+}	Strontium ion	**Fe^{2+}**	**Iron(II)** or ferrous ion
	Ba^{2+}	Barium ion	~~Mn^{2+}~~	~~Manganese(II) or manganous ion~~
	Zn^{2+}	**Zinc ion**	~~Hg_2^{2+}~~	~~Mercury(I) or mercurous ion~~
	~~Cd^{2+}~~	~~Cadmium ion~~	**Hg^{2+}**	**Mercury(II)** or mercuric ion
			Ni^{2+}	Nickel(II) or nickelous ion
			Pb^{2+}	**Lead(II)** or plumbous ion
			Sn^{2+}	Tin(II) or stannous ion
3+	**Al^{3+}**	**Aluminum ion**	Cr^{3+}	Chromium(III) or chromic ion
			Fe^{3+}	**Iron(III)** or ferric ion

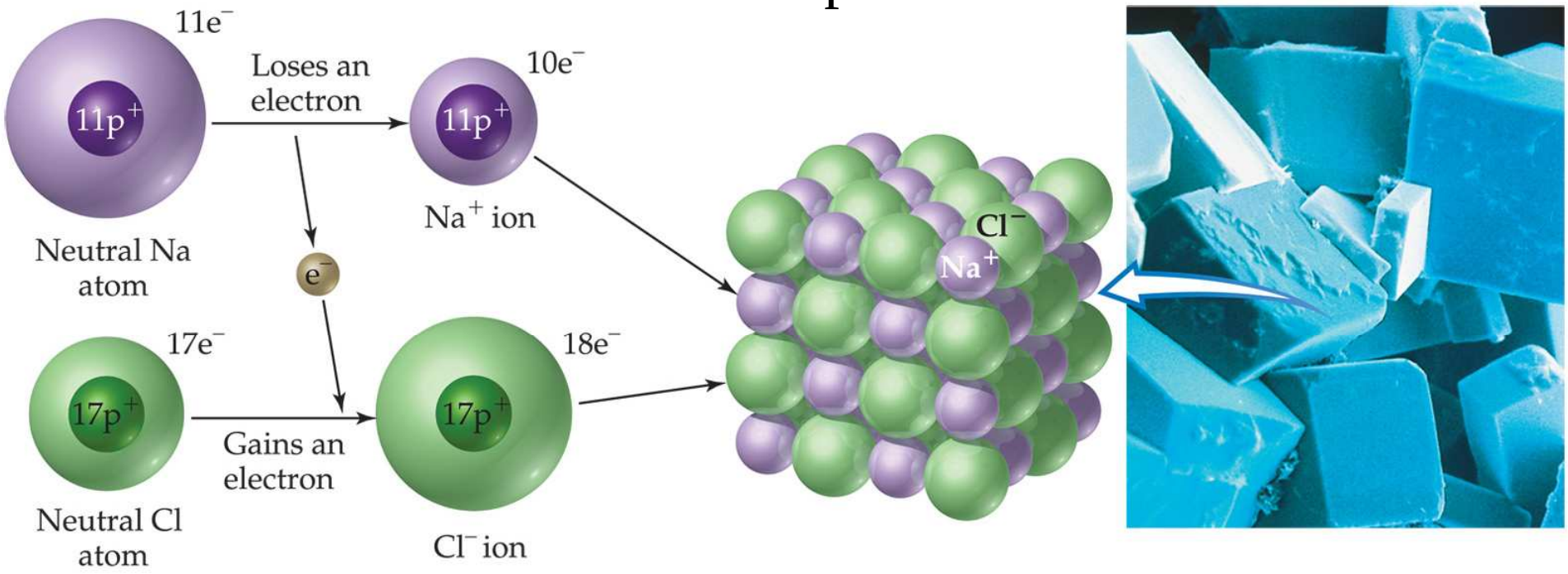
*The most common ions are in boldface.

TABLE 2.5 Common Anions*

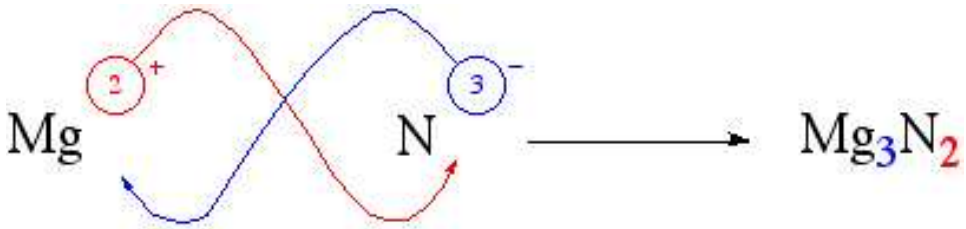
Charge	Formula	Name	Formula	Name
1−	H^-	Hydride ion	~~$C_2H_3O_2^-$~~	~~Acetate ion~~
	F^-	**Fluoride ion**	ClO_3^-	Chlorate ion
	Cl^-	**Chloride ion**	~~ClO_4^-~~	~~Perchlorate ion~~
	Br^-	**Bromide ion**	**NO_3^-**	**Nitrate ion**
	I^-	**Iodide ion**	~~MnO_4^-~~	~~Permanganate ion~~
	CN^-	Cyanide ion		
	OH^-	**Hydroxide ion**		
2−	**O^{2-}**	**Oxide ion**	**CO_3^{2-}**	**Carbonate ion**
	O_2^{2-}	Peroxide ion	~~CrO_4^{2-}~~	~~Chromate ion~~
	S^{2-}	**Sulfide ion**	~~$Cr_2O_7^{2-}$~~	~~Dichromate ion~~
			SO_4^{2-}	**Sulfate ion**
3−	N^{3-}	Nitride ion	**PO_4^{3-}**	**Phosphate ion**

*The most common ions are in boldface.

Ionic Compounds



Writing Ionic Formulas:



Nomenclature for Inorganic Compounds

-Write the name of the cation.

-If the anion is an element, change its ending to -*ide*; if the anion is a polyatomic ion, simply write the name of the polyatomic ion.

- If the cation can have more than one possible charge, write the charge as a Roman numeral in parentheses

NaCl = sodium chloride
$CuCl_2$ = copper (II) chloride

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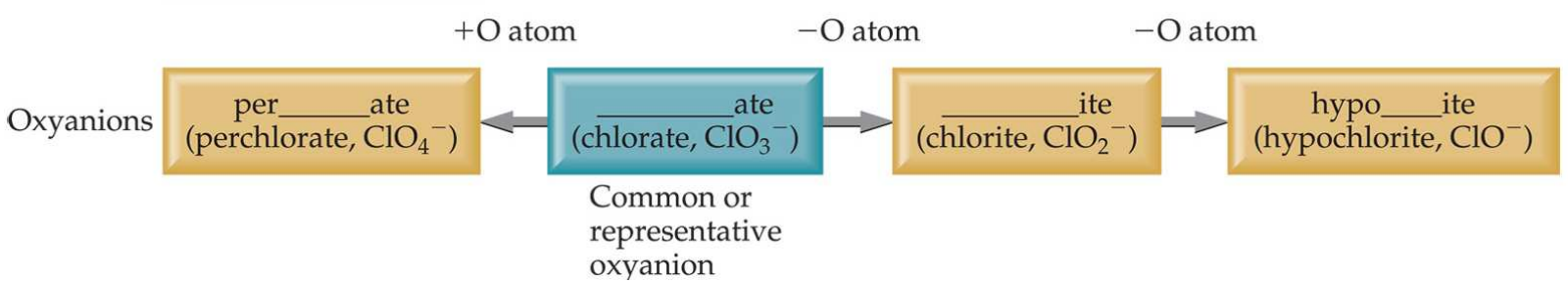
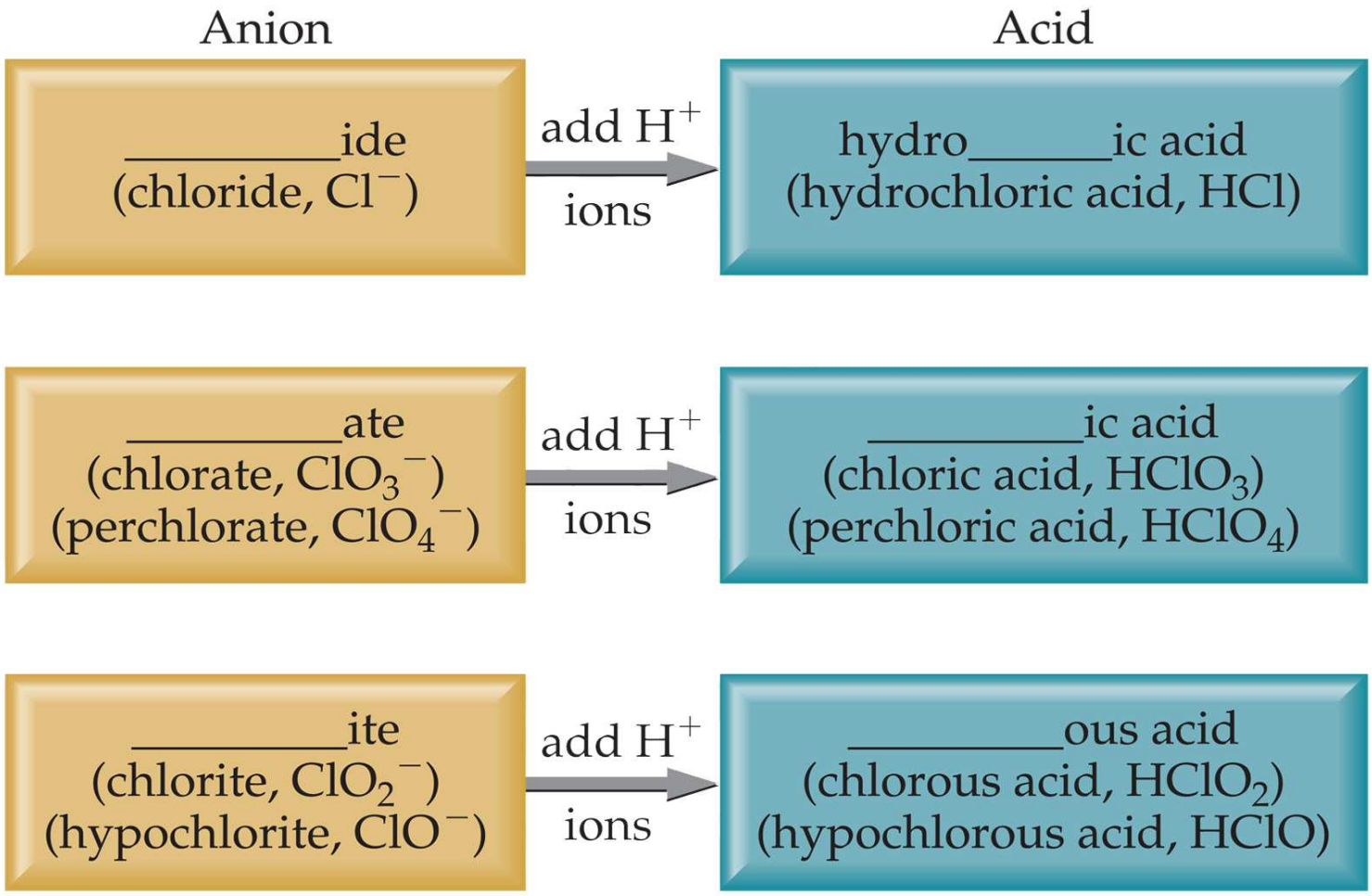
Pattern in Oxyanion Nomenclature



ClO_4^- perchlorate	ClO_3^- chlorate	ClO_2^- chlorite	ClO^- hypochlorite
	NO_3^- nitrate	NO_2^- nitrite	
	PO_4^{-3} phosphate	PO_3^{-3} phosphite	PO_2^{-3} hypophosphite
	SO_4^{-2} sulfate	SO_3^{-2} sulfite	

Acid Nomenclature



Nomenclature of Binary Compounds

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

The less electronegative atom is usually listed first.

A prefix is used to denote the number of atoms of each element in the compound (*mono*- is not used on the first element listed, however.)
H_2O = dihydrogen monoxide

Ending on the more second atom ends with –ide: CCl_4carbon tetrachloride

If the prefix ends with '*a*' or '*o*' and the name of the element begins with a vowel, the two successive vowels are often elided into one:
N_2O_5 = dinitrogen pentoxide