Atoms, Molecules, and Ions

Chapter 2

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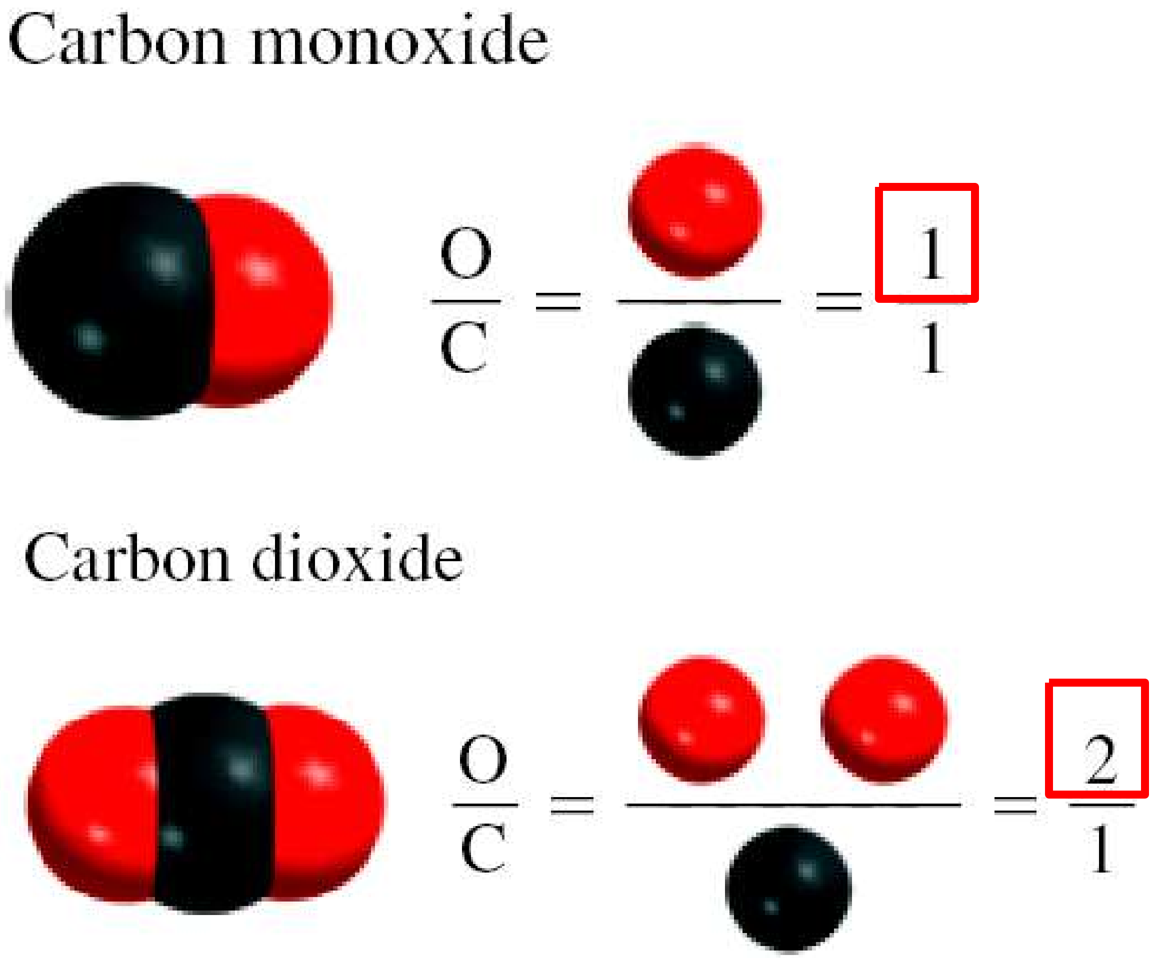
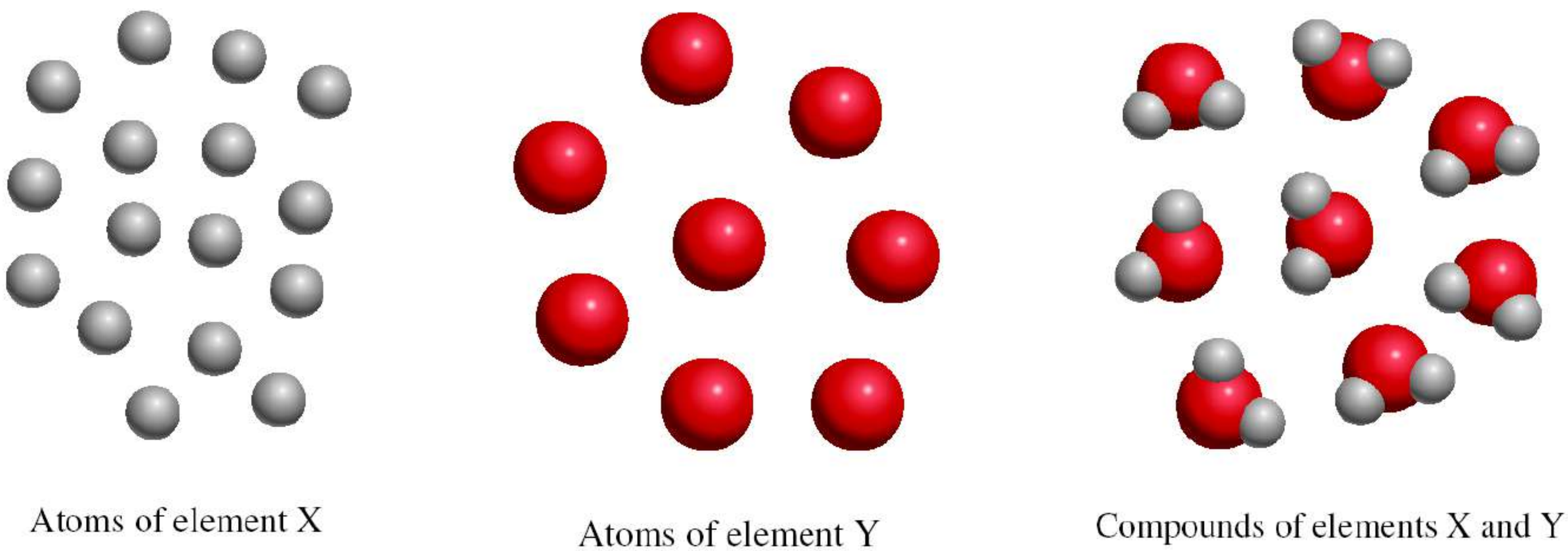
Dalton's Atomic Theory (1808)

1. Elements are composed of extremely small particles called ***atoms***.
2. All ***atoms*** of a given element are identical, having the same size, mass and chemical properties. The atoms of one element are different from the atoms of all other elements.
3. ***Compounds*** are composed of atoms of more than one element. In any compound, the ratio of the numbers of atoms of any two of the elements present is either an integer or a simple fraction.
4. A ***chemical reaction*** involves only the separation, combination, or rearrangement of atoms; it does not result in their creation or destruction.

Dalton's Atomic Theory



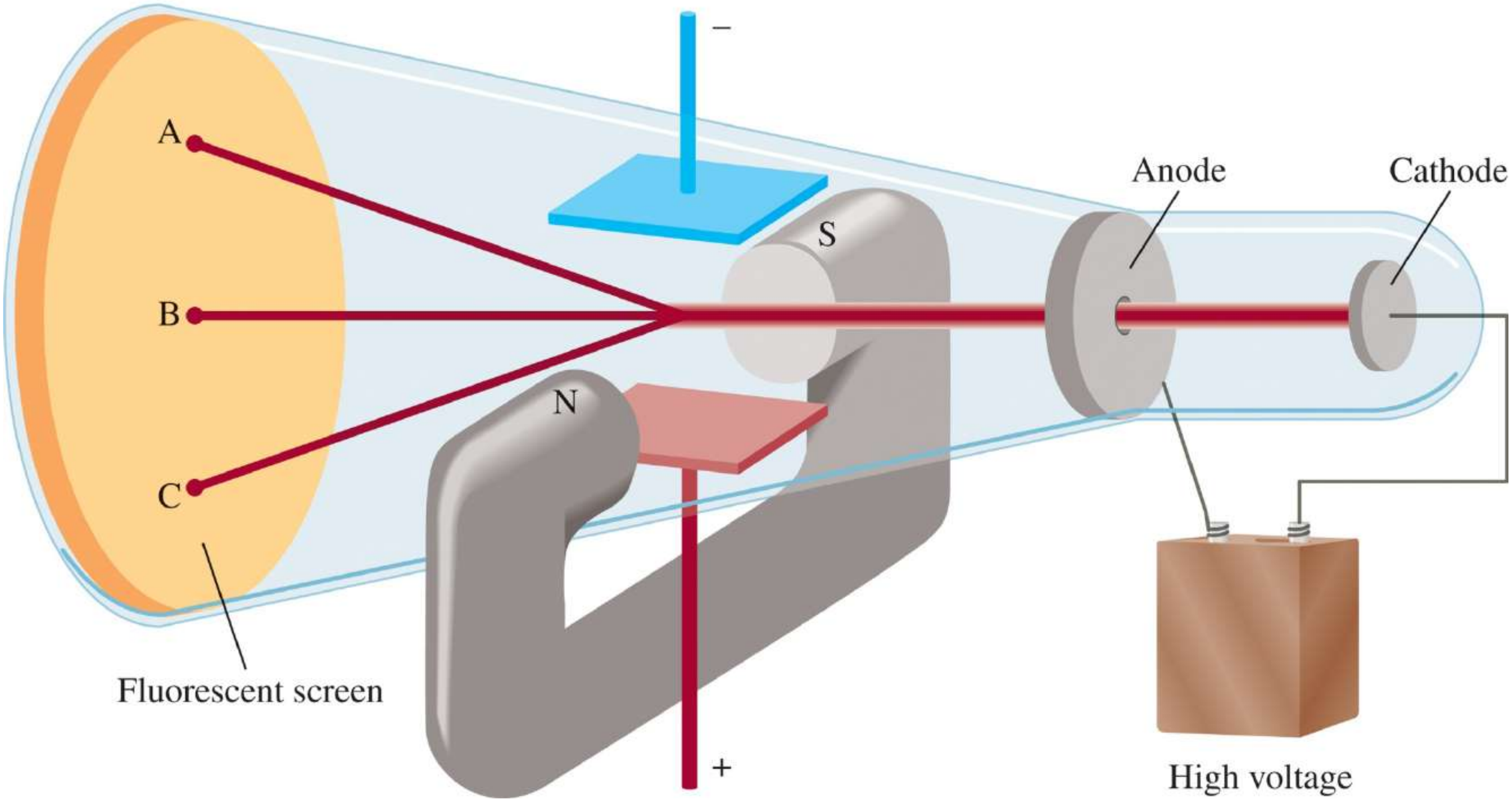
Law of Multiple Proportions



$$16\,X + 8\,Y \longrightarrow 8\,X_2Y$$

Law of Conservation of Mass

Cathode Ray Tube



J.J. Thomson, measured mass/charge of e^-

(1906 Nobel Prize in Physics)

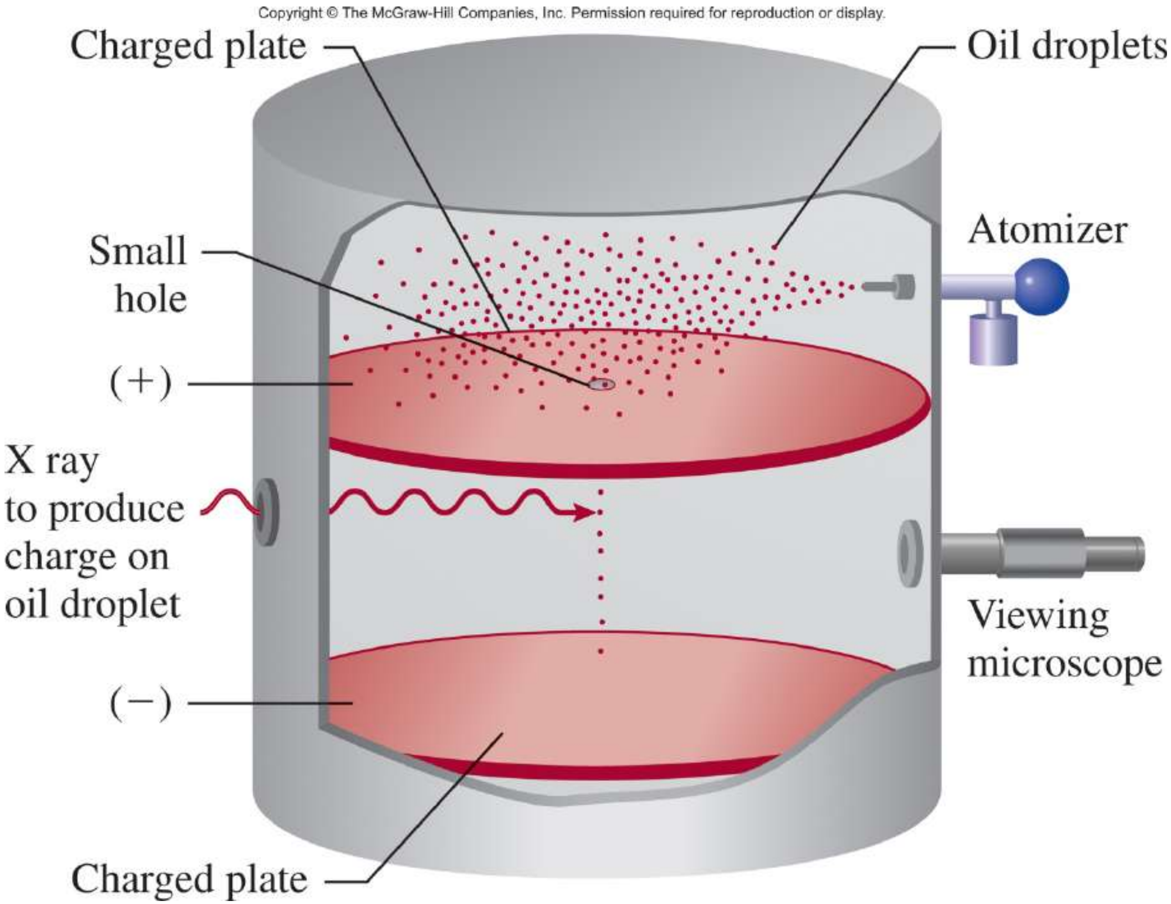
Cathode Ray Tube

(a)

(b)

(c)

Millikan's Experiment



Measured mass of e^-

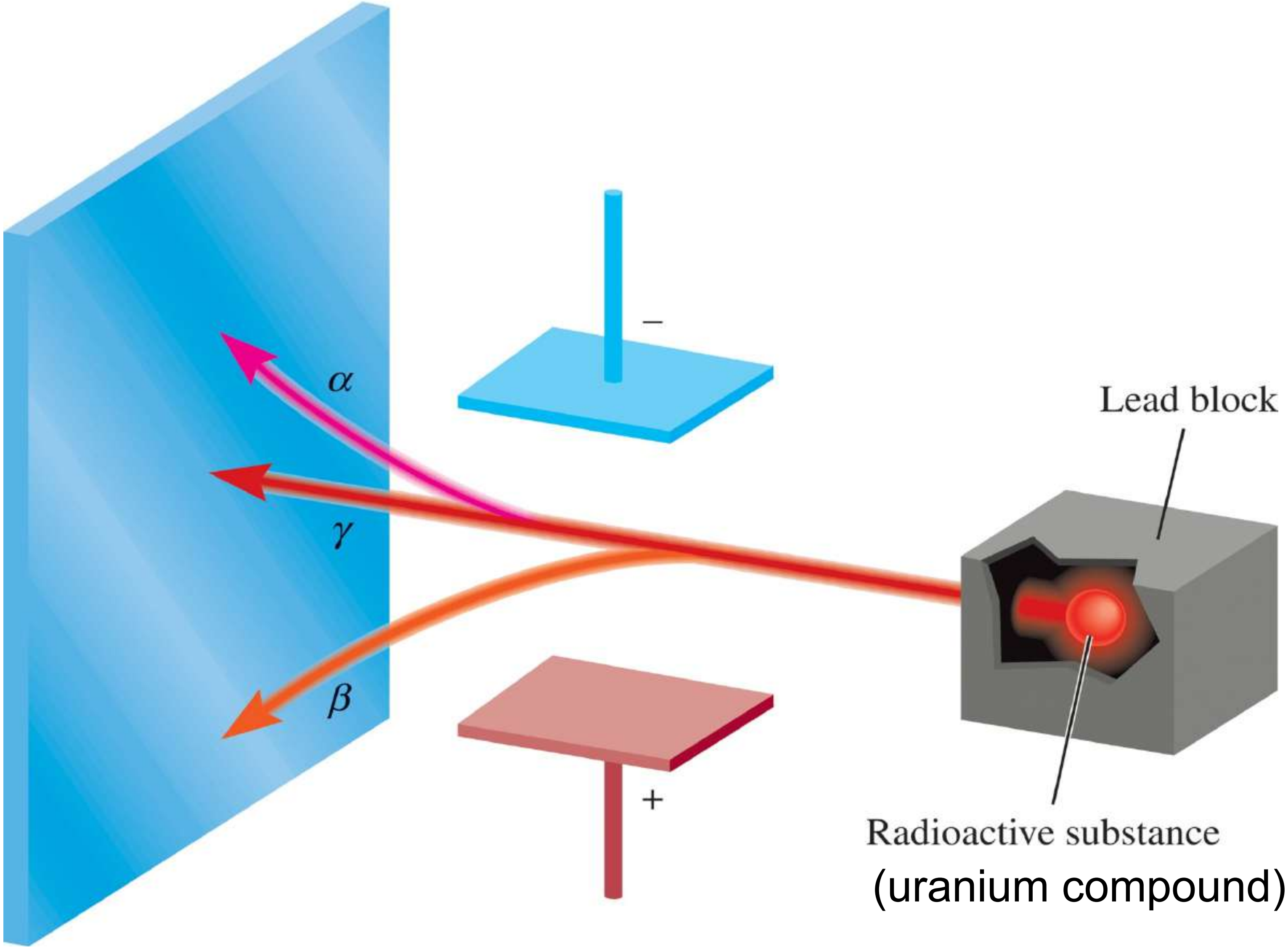
(1923 Nobel Prize in Physics)

e^- charge = -1.60×10^{-19} C

Thomson's charge/mass of e^- = -1.76×10^{8} C/g

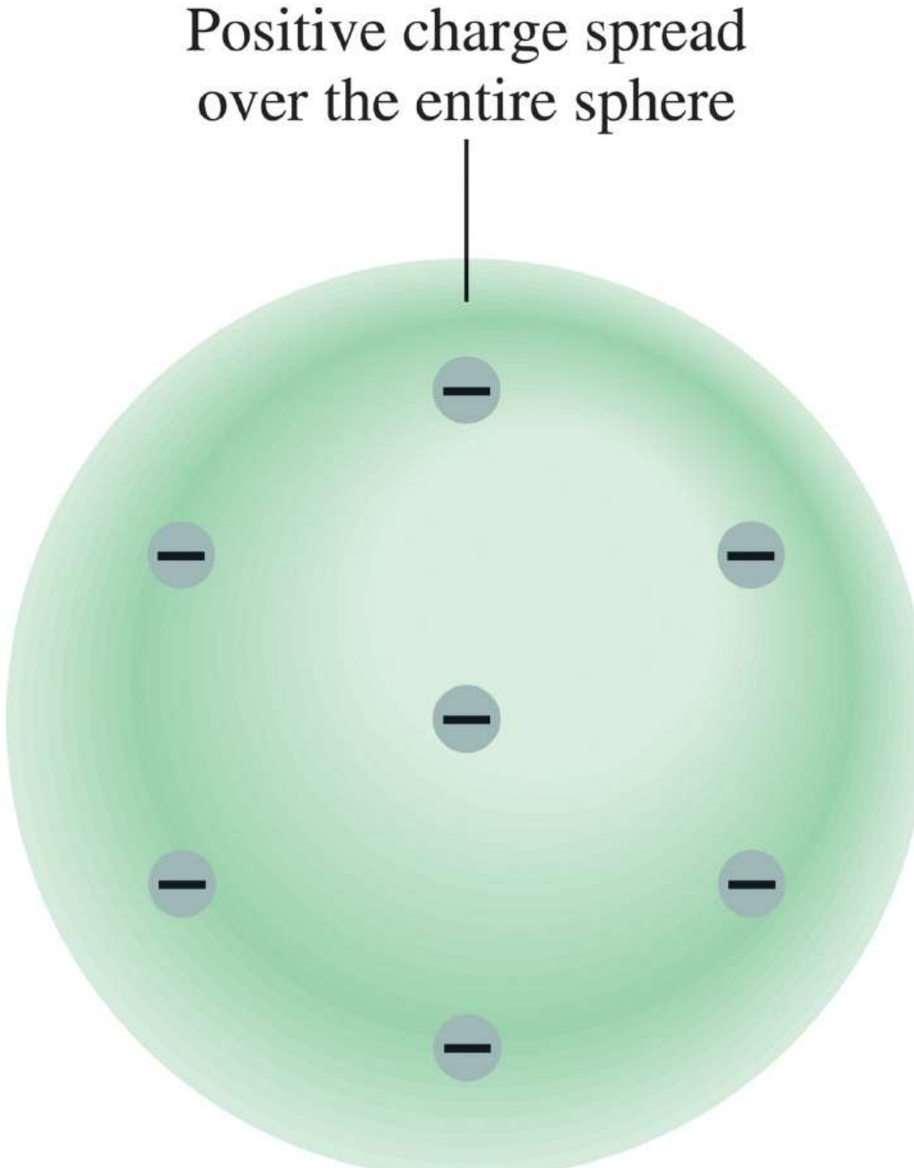
e^- mass = 9.10×10^{-28} g

Types of Radioactivity



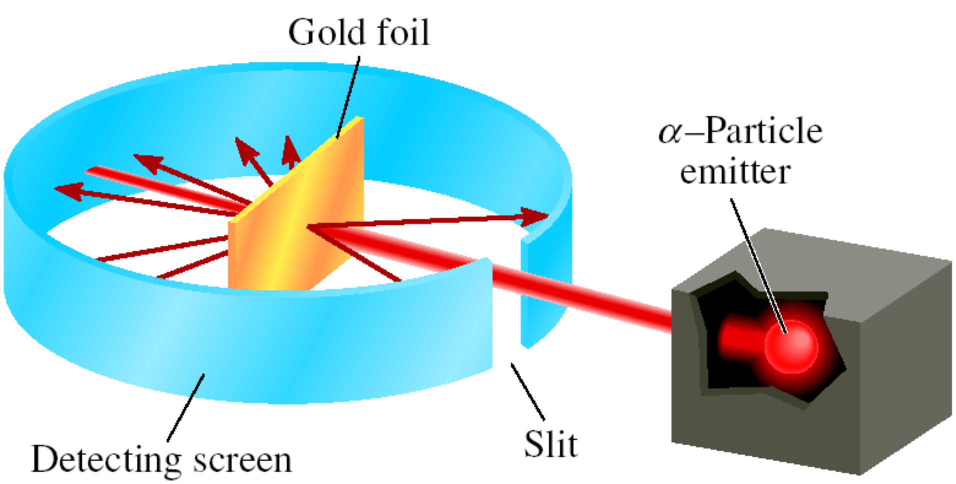
(uranium compound)

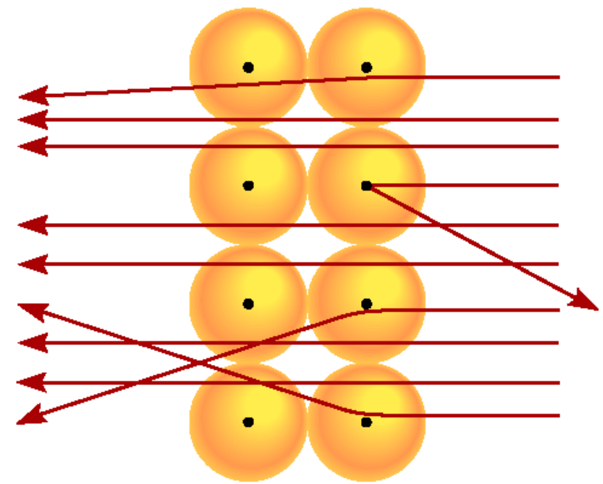
Thomson’s Model



Rutherford's Experiment

(1908 Nobel Prize in Chemistry)

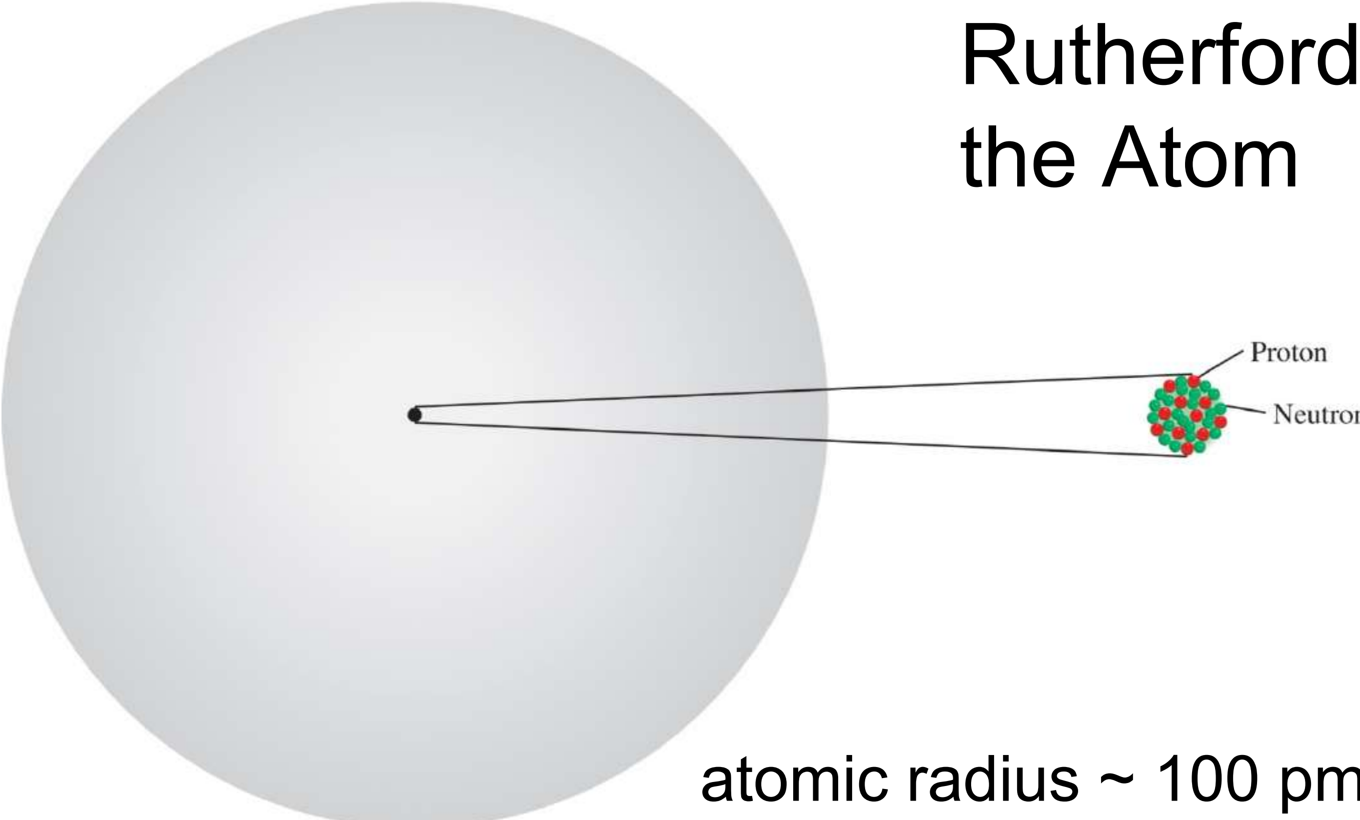




α particle velocity ~ 1.4 x 10^7 m/s
(~5% speed of light)

atoms positive charge is concentrated in the nucleus
proton (p) has opposite (+) charge of electron (-)
mass of p is 1840 x mass of e^- (1.67 x 10^{-24} g)

Rutherford's Model of the Atom



atomic radius ~ 100 pm = 1×10^{-10} m

nuclear radius ~ 5×10^{-3} pm = 5×10^{-15} m

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"If the atom is the Houston Astrodome, then the nucleus is a marble on the 50-yard line."

Chadwick's Experiment (1932)
(1935 Noble Prize in Physics)

H atoms: 1 p; He atoms: 2 p

mass He/mass H should = 2

measured mass He/mass H = 4

$$\alpha + {}^{9}Be \longrightarrow {}^{1}n + {}^{12}C + \text{energy}$$

neutron (n) is neutral (charge = 0)

n mass ~ p mass = 1.67×10^{-24} g

Table 2.1 Mass and Charge of Subatomic Particles

Particle	Mass (g)	Charge	
		Coulomb	Charge Unit
Electron*	9.10938×10^{-28}	-1.6022×10^{-19}	-1
Proton	1.67262×10^{-24}	$+1.6022 \times 10^{-19}$	$+1$
Neutron	1.67493×10^{-24}	0	0

*More refined measurements have given us a more accurate value of an electron's mass than Millikan's.

mass p ≈ mass n ≈ 1840 x mass e^-

Atomic Number, Mass Number, and 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

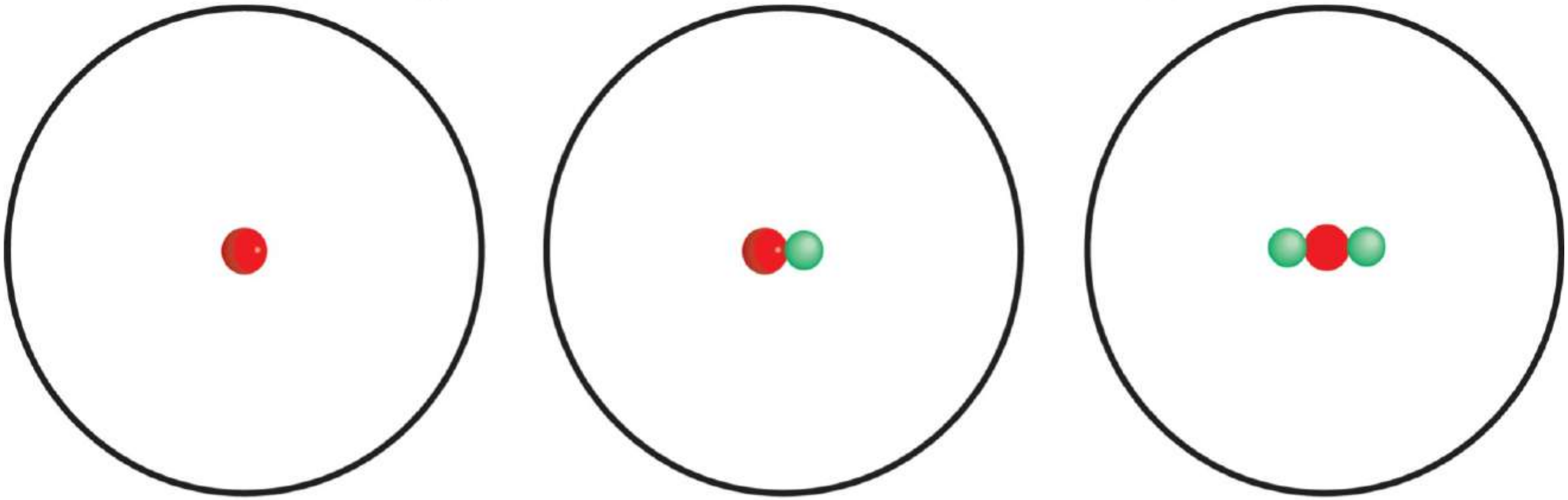
Mass Number → $^{A}_{Z}X$ ← Element Symbol

Atomic Number →

$^{1}_{1}H$ $\quad$ $^{2}_{1}H$ (D) $\quad$ $^{3}_{1}H$ (T)

$^{235}_{92}U$ $\quad$ $^{238}_{92}U$

The Isotopes of Hydrogen



$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

Example 2.1

Give the number of protons, neutrons, and electrons in each of the following species:

(a) $^{20}_{11}Na$

(b) $^{22}_{11}Na$

(c) ^{17}O

(d) carbon-14

Example 2.1

Strategy Recall that the superscript denotes the mass number (A) and the subscript denotes the atomic number (Z).

Mass number is always greater than atomic number. (The only exception is $^{1}_{1}H$, where the mass number is equal to the atomic number.)

In a case where no subscript is shown, as in parts (c) and (d), the atomic number can be deduced from the element symbol or name.

To determine the number of electrons, remember that because atoms are electrically neutral, the number of electrons is equal to the number of protons.

Example 2.1

Solution

(a) $^{20}_{11}Na$ The atomic number is 11, so there are 11 protons. The mass number is 20, so the number of neutrons is 20 − 11 = 9. The number of electrons is the same as the number of protons; that is, 11.

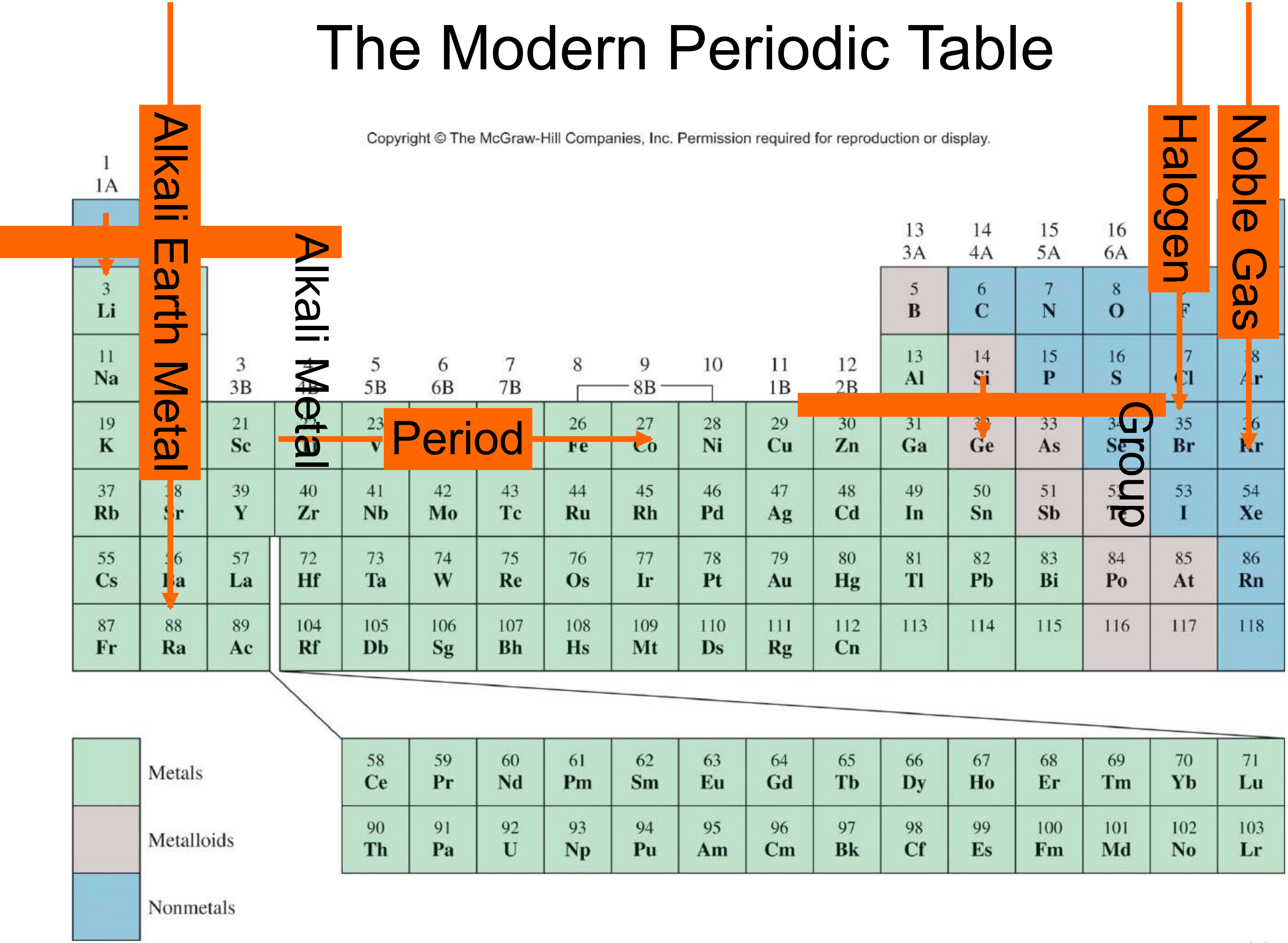
(b) $^{22}_{11}Na$ The atomic number is the same as that in (a), or 11. The mass number is 22, so the number of neutrons is 22 − 11 = 11. The number of electrons is 11. Note that the species in (a) and (b) are chemically similar isotopes of sodium.

Example 2.1

(c) ^{17}O The atomic number of O (oxygen) is 8, so there are 8 protons. The mass number is 17, so there are 17 − 8 = 9 neutrons. There are 8 electrons.

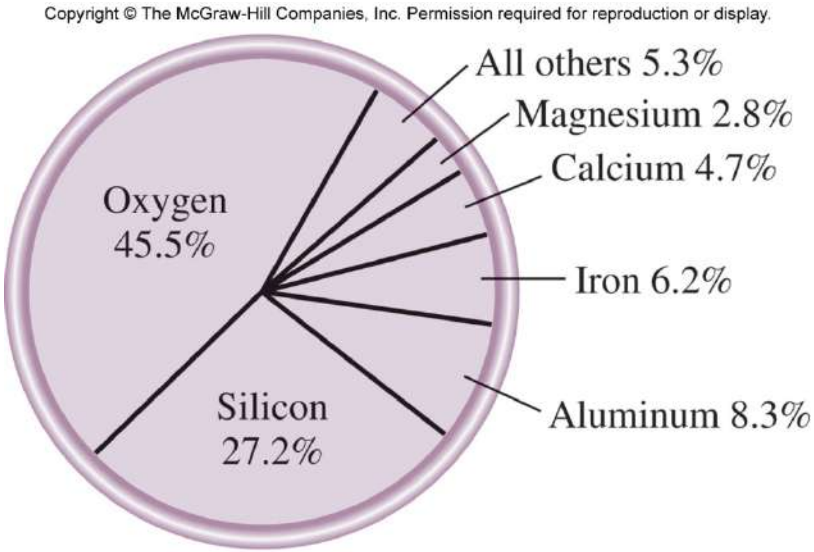
(d) Carbon-14 can also be represented as ^{14}C. The atomic number of carbon is 6, so there are 14 − 6 = 8 neutrons. The number of electrons is 6.

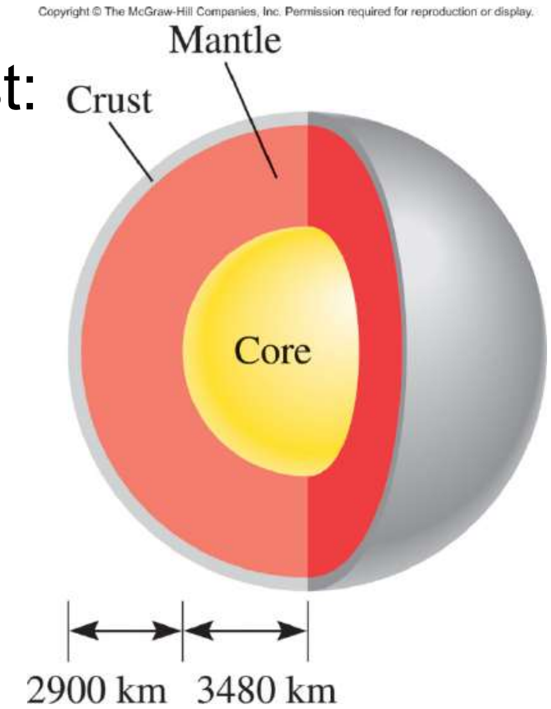
The Modern Periodic Table



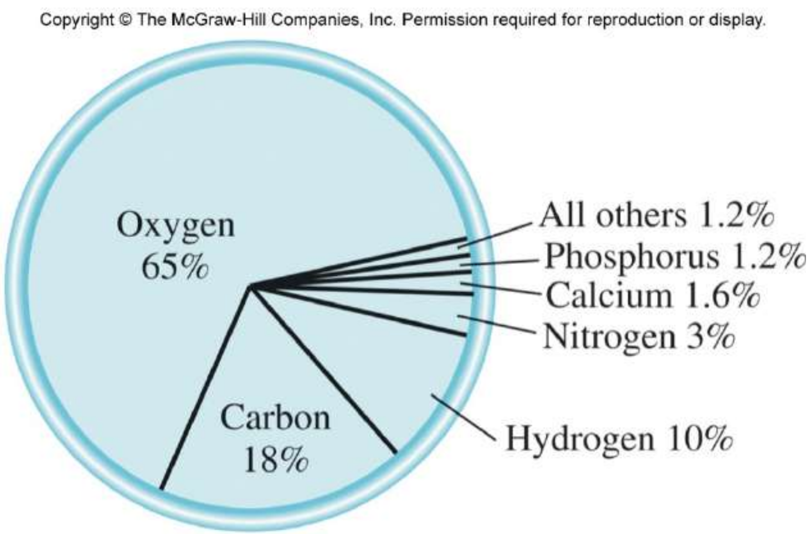
Chemistry In Action

Natural abundance of elements in Earth's crust:

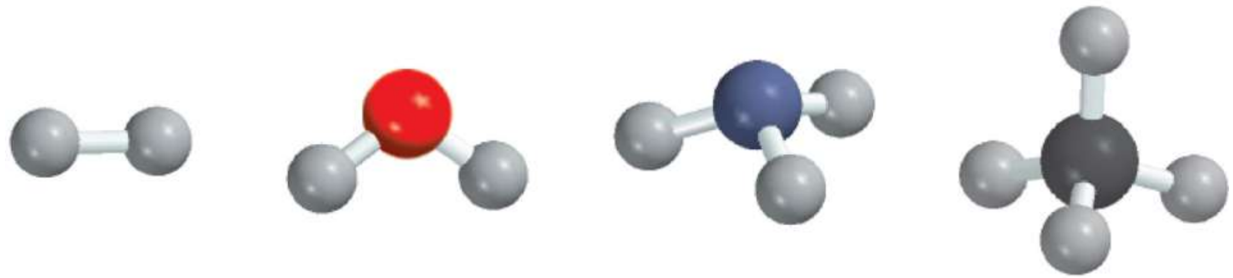




Natural abundance of elements in human body:



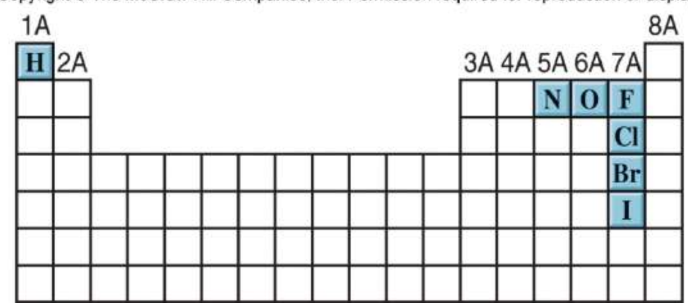
A ***molecule*** is an aggregate of two or more atoms in a definite arrangement held together by chemical forces.



H_2 H_2O NH_3 CH_4

A ***diatomic molecule*** contains only two atoms:

H_2, N_2, O_2, Br_2, HCl, CO



diatomic elements

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

O_3, H_2O, NH_3, CH_4

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.

Na

11 protons
11 electrons

Na^+

11 protons
10 electrons

anion – ion with a negative charge

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

Cl

17 protons
17 electrons

Cl^-

17 protons
18 electrons

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

Na^+, Cl^-, Ca^{2+}, O^{2-}, Al^{3+}, N^{3-}

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

OH^-, CN^-, NH_4^+, NO_3^-

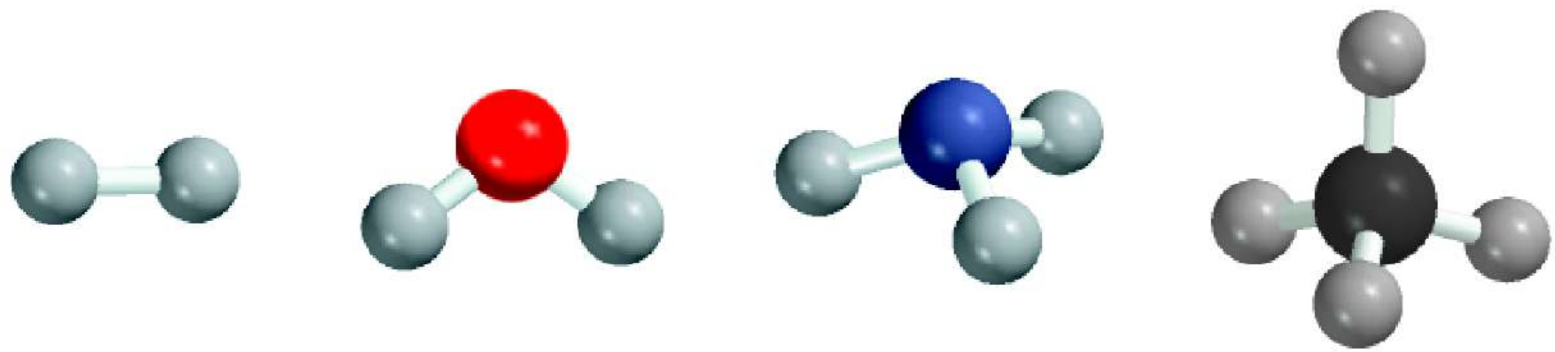
Common Ions Shown on the Periodic Table

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
Li^+													C^{4-}	N^{3-}	O^{2-}	F^-	
Na^+	Mg^{2+}											Al^{3+}		P^{3-}	S^{2-}	Cl^-	
K^+	Ca^{2+}				Cr^{2+} Cr^{3+}	Mn^{2+} Mn^{3+}	Fe^{2+} Fe^{3+}	Co^{2+} Co^{3+}	Ni^{2+} Ni^{3+}	Cu^+ Cu^{2+}	Zn^{2+}				Se^{2-}	Br^-	
Rb^+	Sr^{2+}									Ag^+	Cd^{2+}		Sn^{2+} Sn^{4+}		Te^{2-}	I^-	
Cs^+	Ba^{2+}									Au^+ Au^{3+}	Hg_2^{2+} Hg^{2+}		Pb^{2+} Pb^{4+}				

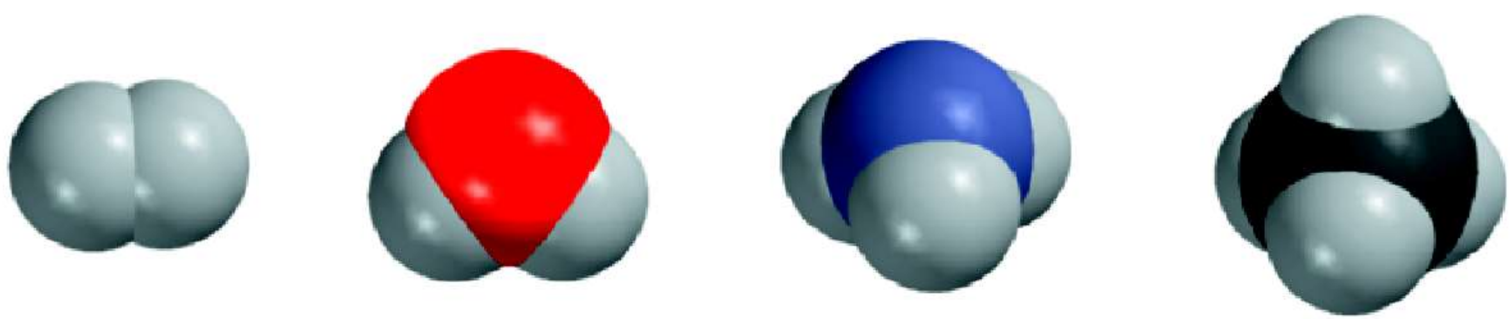
Formulas and Models

<table>
<tr><th></th><th>Hydrogen</th><th>Water</th><th>Ammonia</th><th>Methane</th></tr>
<tr><td>Molecular formula</td><td>H_2</td><td>H_2O</td><td>NH_3</td><td>CH_4</td></tr>
<tr><td>Structural formula</td><td>H—H</td><td>H—O—H</td><td>H—N—H
|
H</td><td>H
|
H—C—H
|
H</td></tr>
</table>

Ball-and-stick model



Space-filling model



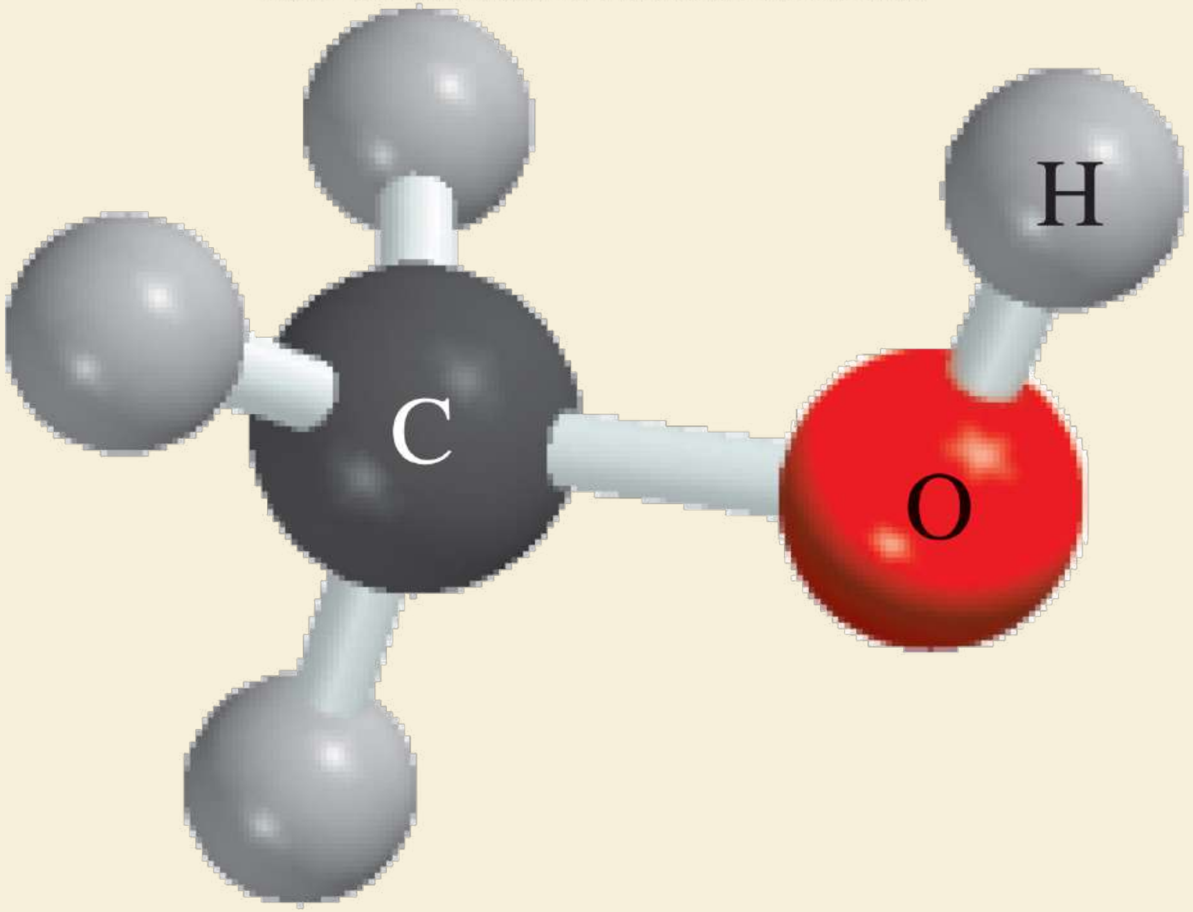
A ***molecular formula*** shows the exact number of atoms of each element in the smallest unit of a substance.

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

molecular	**empirical**
H_2O	H_2O
$C_6H_{12}O_6$	CH_2O
O_3	O
N_2H_4	NH_2

Example 2.2

Write the molecular formula of methanol, an organic solvent and antifreeze, from its ball-and-stick model, shown below.



Example 2.2

Solution

Refer to the labels (also see back endpapers).

There are four H atoms, one C atom, and one O atom. Therefore, the molecular formula is CH_4O.

However, the standard way of writing the molecular formula for methanol is CH_3OH because it shows how the atoms are joined in the molecule.

Example 2.3

Write the empirical formulas for the following molecules:

(a)acetylene (C_2H_2), which is used in welding torches

(b)glucose ($C_6H_{12}O_6$), a substance known as blood sugar

(c)nitrous oxide (N_2O), a gas that is used as an anesthetic gas ("laughing gas") and as an aerosol propellant for whipped creams.

Example 2.3

Strategy

Recall that to write the empirical formula, the subscripts in the molecular formula must be converted to the smallest possible whole numbers.

Example 2.3

Solution

(a)There are two carbon atoms and two hydrogen atoms in acetylene. Dividing the subscripts by 2, we obtain the empirical formula CH.

(b) In glucose there are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms. Dividing the subscripts by 6, we obtain the empirical formula CH_2O. Note that if we had divided the subscripts by 3, we would have obtained the formula $C_2H_4O_2$. Although the ratio of carbon to hydrogen to oxygen atoms in $C_2H_4O_2$ is the same as that in $C_6H_{12}O_6$ (1:2:1), $C_2H_4O_2$ is not the simplest formula because its subscripts are not in the smallest whole-number ratio.

Example 2.3

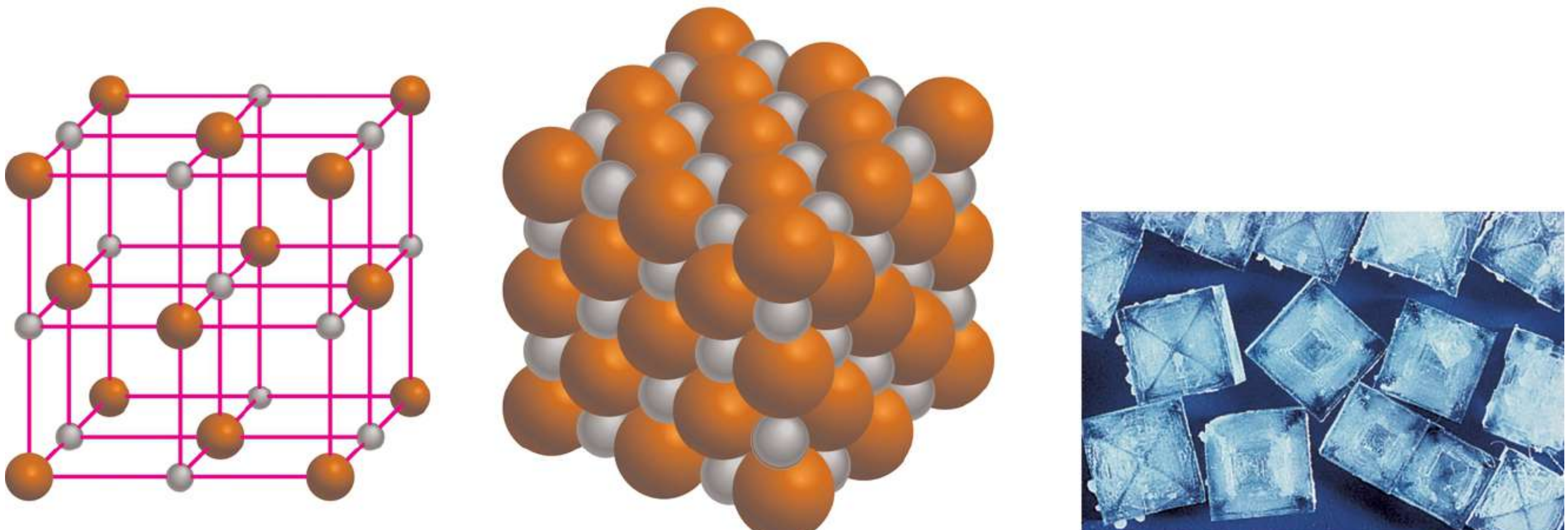
(c) Because the subscripts in N_2O are already the smallest possible whole numbers, the empirical formula for nitrous oxide is the same as its molecular formula.

Ionic compounds consist of a combination of cations and anions.

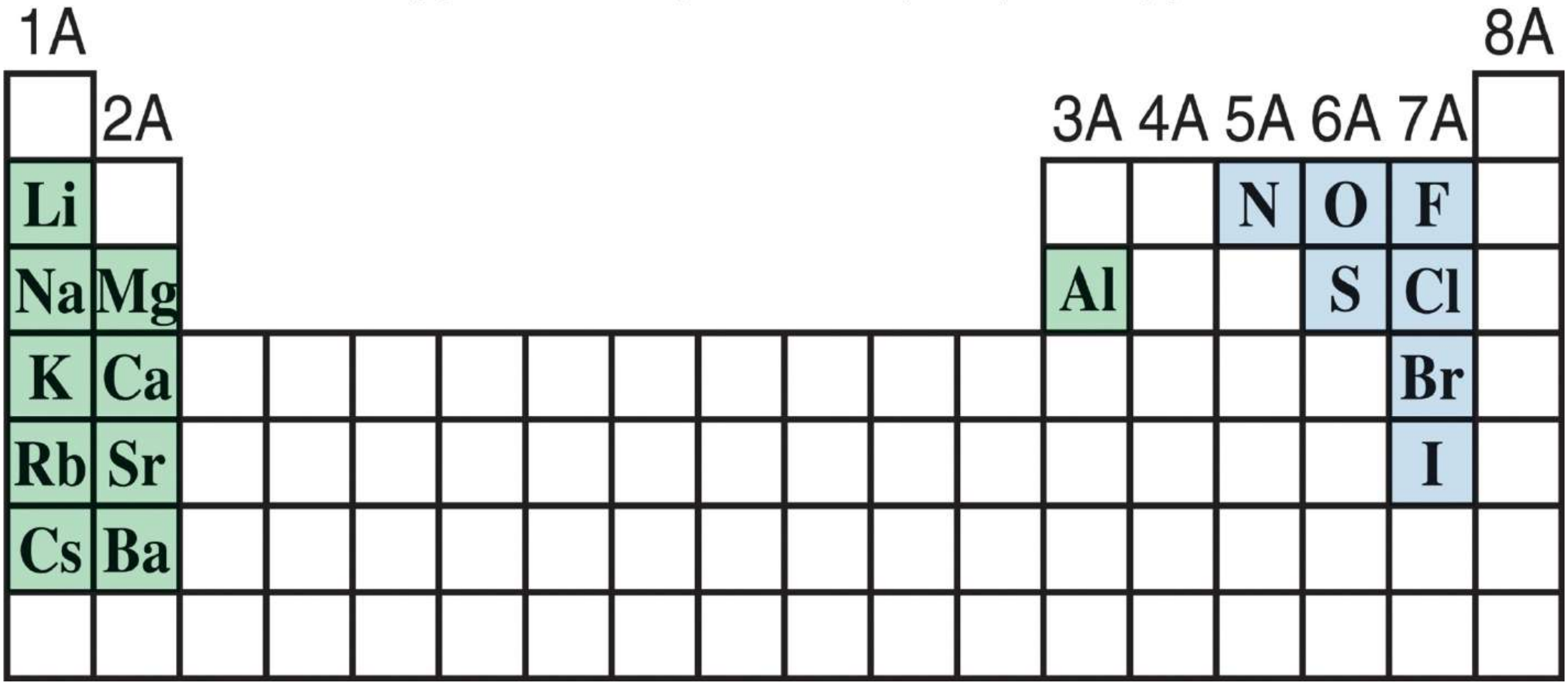
The formula is usually the same as the empirical formula.

The sum of the charges on the cation(s) and anion(s) in each formula unit must equal zero.

The ionic compound NaCl



(a) (b) (c)



The most reactive **metals** (green) and the most reactive **nonmetals** (blue) combine to form ionic compounds.

Formulas of Ionic Compounds

$2 \times +3 = +6$ $3 \times -2 = -6$

Al_2O_3

Al^{3+} O^{2-}

$1 \times +2 = +2$ $2 \times -1 = -2$

$CaBr_2$

Ca^{2+} Br^{-}

$2 \times +1 = +2$ $1 \times -2 = -2$

Na_2CO_3

Na^{+} CO_3^{2-}

Example 2.4

Write the formula of magnesium nitride, containing the Mg^{2+} and N^{3-} ions.

When magnesium burns in air, it forms both magnesium oxide and magnesium nitride.

Example 2.4

Strategy Our guide for writing formulas for ionic compounds is electrical neutrality; that is, the total charge on the cation(s) must be equal to the total charge on the anion(s).

Because the charges on the Mg^{2+} and N^{3-} ions are not equal, we know the formula cannot be MgN.

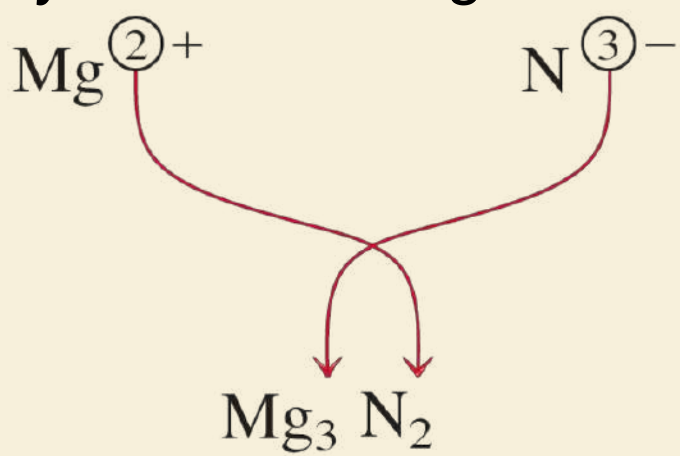
Instead, we write the formula as Mg_xN_y, where x and y are subscripts to be determined.

Example 2.4

Solution To satisfy electrical neutrality, the following relationship must hold:

$$(+2)x + (-3)y = 0$$

Solving, we obtain $x/y = 3/2$. Setting $x = 3$ and $y = 2$, we write



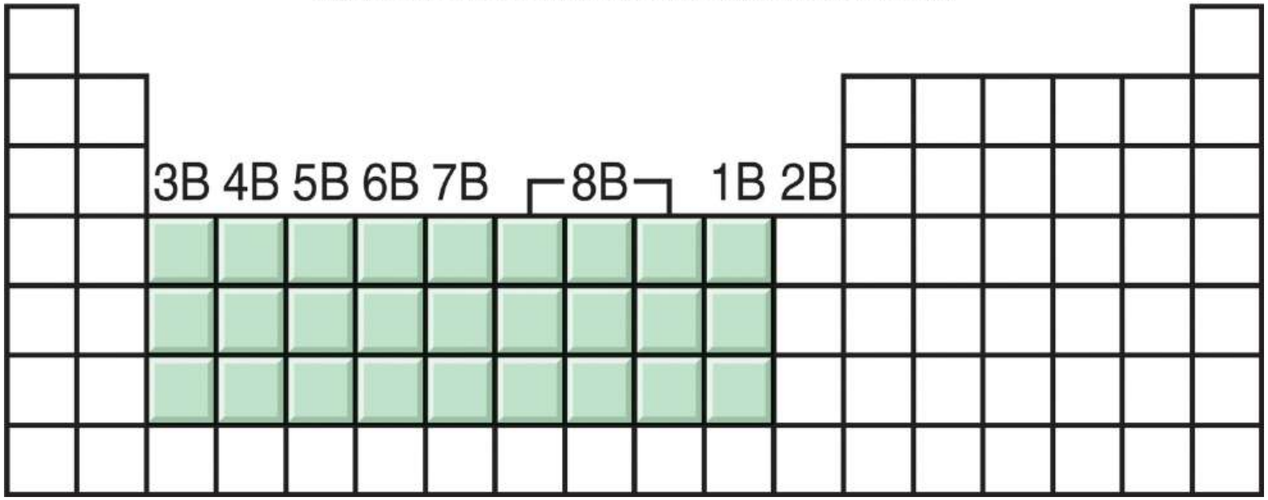
Check The subscripts are reduced to the smallest whole-number ratio of the atoms because the chemical formula of an ionic compound is usually its empirical formula.

Chemical Nomenclature

- **Ionic Compounds**
  - Often a metal + nonmetal
  - Anion (nonmetal), add “-ide” to element name

$BaCl_2$	barium chloride
K_2O	potassium oxide
$Mg(OH)_2$	magnesium hydroxide
KNO_3	potassium nitrate

- Transition metal ionic compounds
  - indicate charge on metal with Roman numerals



$FeCl_2$	2 Cl^- -2 so Fe is +2	iron(II) chloride
$FeCl_3$	3 Cl^- -3 so Fe is +3	iron(III) chloride
Cr_2S_3	3 S^{-2} -6 so Cr is +3 (6/2)	chromium(III) sulfide

Table 2.2 **The "-ide" Nomenclature of Some Common Monatomic Anions According to Their Positions in the Periodic Table**

Group 4A	Group 5A	Group 6A	Group 7A
C carbide (C^{4-})*	N nitride (N^{3-})	O oxide (O^{2-})	F fluoride (F^{-})
Si silicide (Si^{4-})	P phosphide (P^{3-})	S sulfide (S^{2-})	Cl chloride (Cl^{-})
		Se selenide (Se^{2-})	Br bromide (Br^{-})
		Te telluride (Te^{2-})	I iodide (I^{-})

*The word "carbide" is also used for the anion C_2^{2-}.

Table 2.3 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 ($Cr_2O_7^{2-}$)
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^-)
rubidium (Rb^+)	peroxide (O_2^{2-})
silver (Ag^+)	phosphate (PO_4^{3-})
sodium (Na^+)	sulfate (SO_4^{2-})
strontium (Sr^{2+})	sulfide (S^{2-})
tin(II) or stannous (Sn^{2+})	sulfite (SO_3^{2-})
zinc (Zn^{2+})	thiocyanate (SCN^-)

*Mercury(I) exists as a pair as shown.

Example 2.5

Name the following compounds:

(a) $Cu(NO_3)_2$

(b) KH_2PO_4

(c) NH_4ClO_3

Example 2.5

Strategy Note that the compounds in (a) and (b) contain both metal and nonmetal atoms, so we expect them to be ionic compounds.

There are no metal atoms in (c) but there is an ammonium group, which bears a positive charge. So NH_4ClO_3 is also an ionic compound.

Our reference for the names of cations and anions is Table 2.3.

Keep in mind that if a metal atom can form cations of different charges (see Figure 2.11), we need to use the Stock system.

Example 2.5

Solution

(a)The nitrate ion (NO_3^-) bears one negative charge, so the copper ion must have two positive charges. Because copper forms both Cu^+ and Cu^{2+} ions, we need to use the Stock system and call the compound copper(II) nitrate.

•The cation is K^+ and the anion is $H_2PO_4^-$ (dihydrogen phosphate). Because potassium only forms one type of ion (K^+), there is no need to use potassium(I) in the name. The compound is potassium dihydrogen phosphate.

(c) The cation is NH_4^+ (ammonium ion) and the anion is ClO_3^-. The compound is ammonium chlorate.

Example 2.6

Write chemical formulas for the following compounds:

(a)mercury(I) nitrite

(b)cesium sulfide

(c)calcium phosphate

Example 2.6

Strategy

We refer to Table 2.3 for the formulas of cations and anions.

Recall that the Roman numerals in the Stock system provide useful information about the charges of the cation.

Example 2.6

Solution

(a)The Roman numeral shows that the mercury ion bears a +1 charge. According to Table 2.3, however, the mercury(I) ion is diatomic (that is, Hg_2^{2+}) and the nitrite ion is NO_2^-. Therefore, the formula is $Hg_2(NO_2)_2$.

(b)Each sulfide ion bears two negative charges, and each cesium ion bears one positive charge (cesium is in Group 1A, as is sodium). Therefore, the formula is Cs_2S.

Example 2.6

(c) Each calcium ion (Ca^{2+}) bears two positive charges, and each phosphate ion (PO_4^{3-}) bears three negative charges.

To make the sum of the charges equal zero, we must adjust the numbers of cations and anions:

$$3(+2) + 2(-3) = 0$$

Thus, the formula is $Ca_3(PO_4)_2$.

- **Molecular compounds**
  - Nonmetals or nonmetals + metalloids
  - Common names
    - H_2O, NH_3, CH_4
  - Element furthest to the left in a period and closest to the bottom of a group on periodic table is placed first in formula
  - If more than one compound can be formed from the same elements, use prefixes to indicate number of each kind of atom
  - Last element name ends in *-ide*

Table 2.4

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

HI	hydrogen iodide
NF_3	nitrogen trifluoride
SO_2	sulfur dioxide
N_2Cl_4	dinitrogen tetrachloride
NO_2	nitrogen dioxide
N_2O	dinitrogen monoxide

Example 2.7

Name the following molecular compounds:

(a) $SiCl_4$

(b) P_4O_{10}

Example 2.7

Strategy

We refer to Table 2.4 for prefixes.

In (a) there is only one Si atom so we do not use the prefix "mono."

Solution

(a)Because there are four chlorine atoms present, the compound is silicon tetrachloride.

•There are four phosphorus atoms and ten oxygen atoms present, so the compound is tetraphosphorus decoxide. Note that the "a" is omitted in "deca."

Example 2.8

Write chemical formulas for the following molecular compounds:

(a)carbon disulfide

(b) disilicon hexabromide

Example 2.8

Strategy

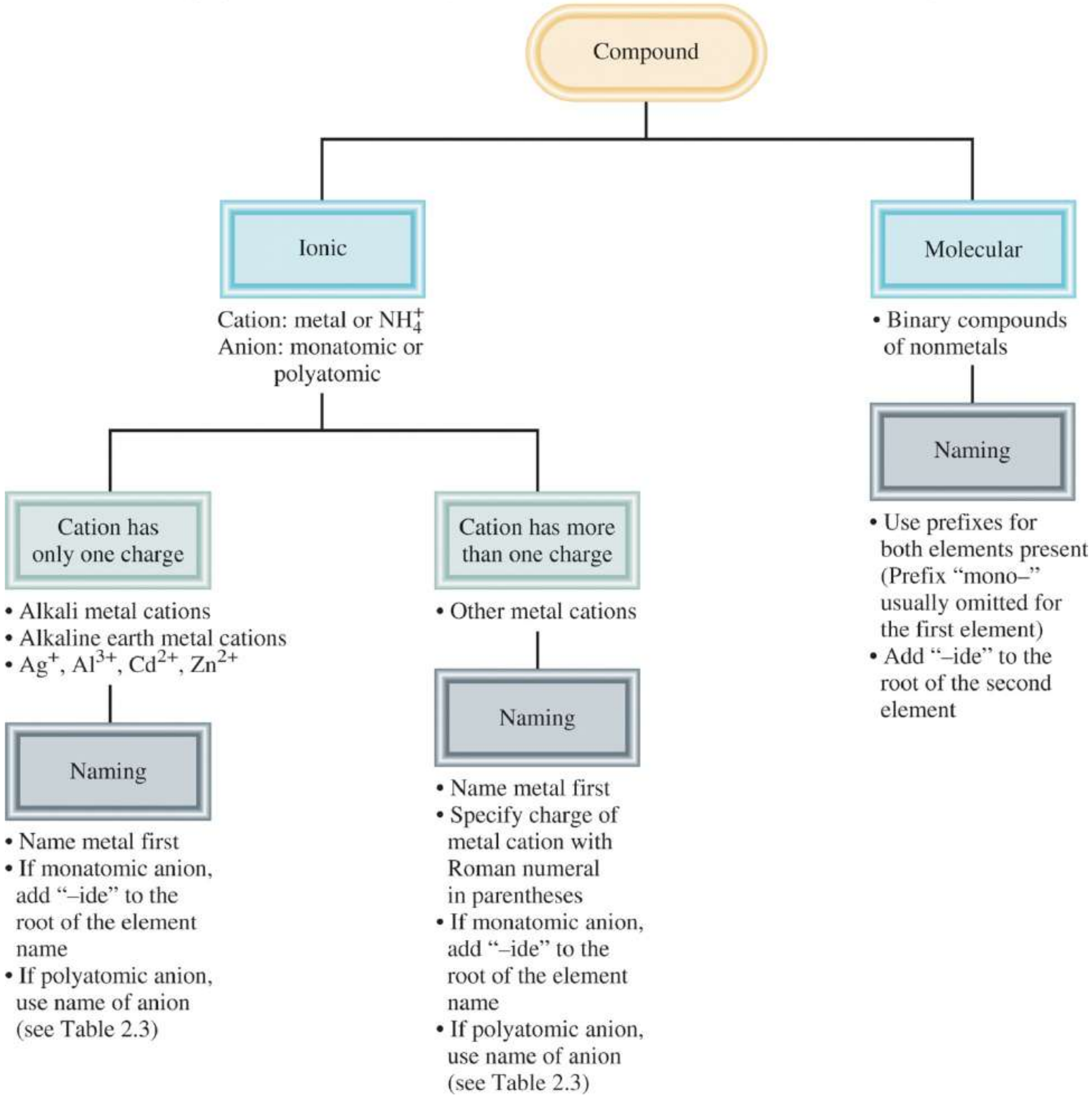
Here we need to convert prefixes to numbers of atoms (see Table 2.4).

Because there is no prefix for carbon in (a), it means that there is only one carbon atom present.

Solution

(a)Because there are two sulfur atoms and one carbon atom present, the formula is CS_2.

(b) There are two silicon atoms and six bromine atoms present, so the formula is Si_2Br_6.


Compound
Ionic
Cation: metal or NH_4^+
Anion: monatomic or polyatomic
Cation has only one charge
• Alkali metal cations
• Alkaline earth metal cations
• Ag^+, Al^{3+}, Cd^{2+}, Zn^{2+}
Naming
• Name metal first
• If monatomic anion, add "–ide" to the root of the element name
• If polyatomic anion, use name of anion (see Table 2.3)
Cation has more than one charge
• Other metal cations
Naming
• Name metal first
• Specify charge of metal cation with Roman numeral in parentheses
• If monatomic anion, add "–ide" to the root of the element name
• If polyatomic anion, use name of anion (see Table 2.3)
Molecular
• Binary compounds of nonmetals
Naming
• Use prefixes for both elements present (Prefix "mono–" usually omitted for the first element)
• Add "–ide" to the root of the second element

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

For example: HCl gas and HCl in water

Pure substance, hydrogen chloride

Dissolved in water (H_3O^+ and Cl^-), hydrochloric acid

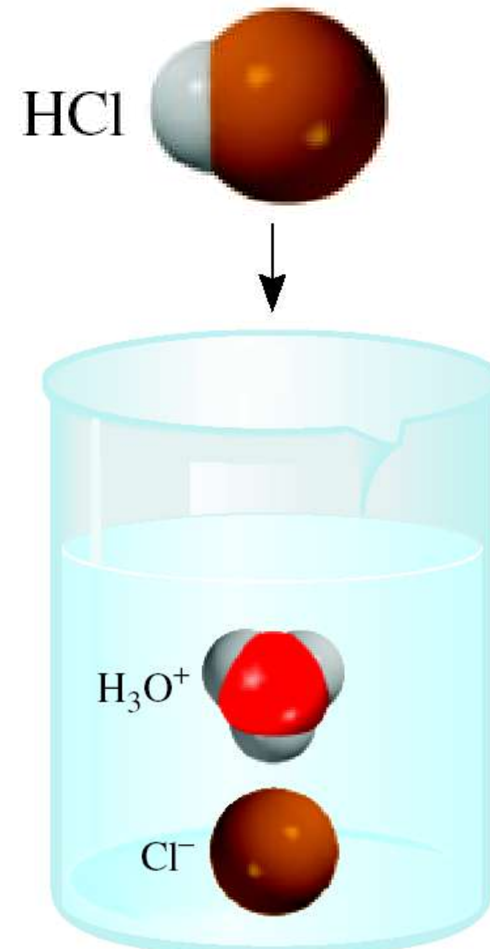
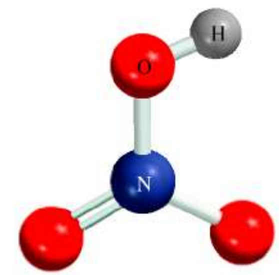


Table 2.5 Some Simple Acids

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

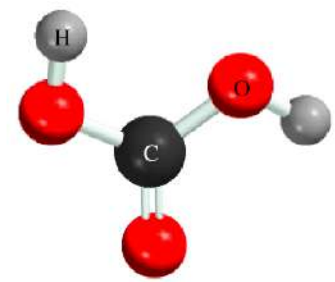
An ***oxoacid*** is an acid that contains hydrogen, oxygen, and another element.

HNO_3 nitric acid



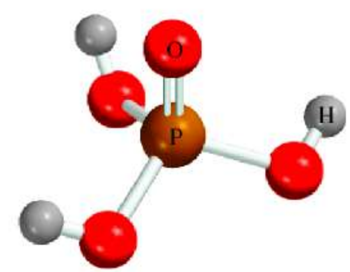
HNO_3

H_2CO_3 carbonic acid



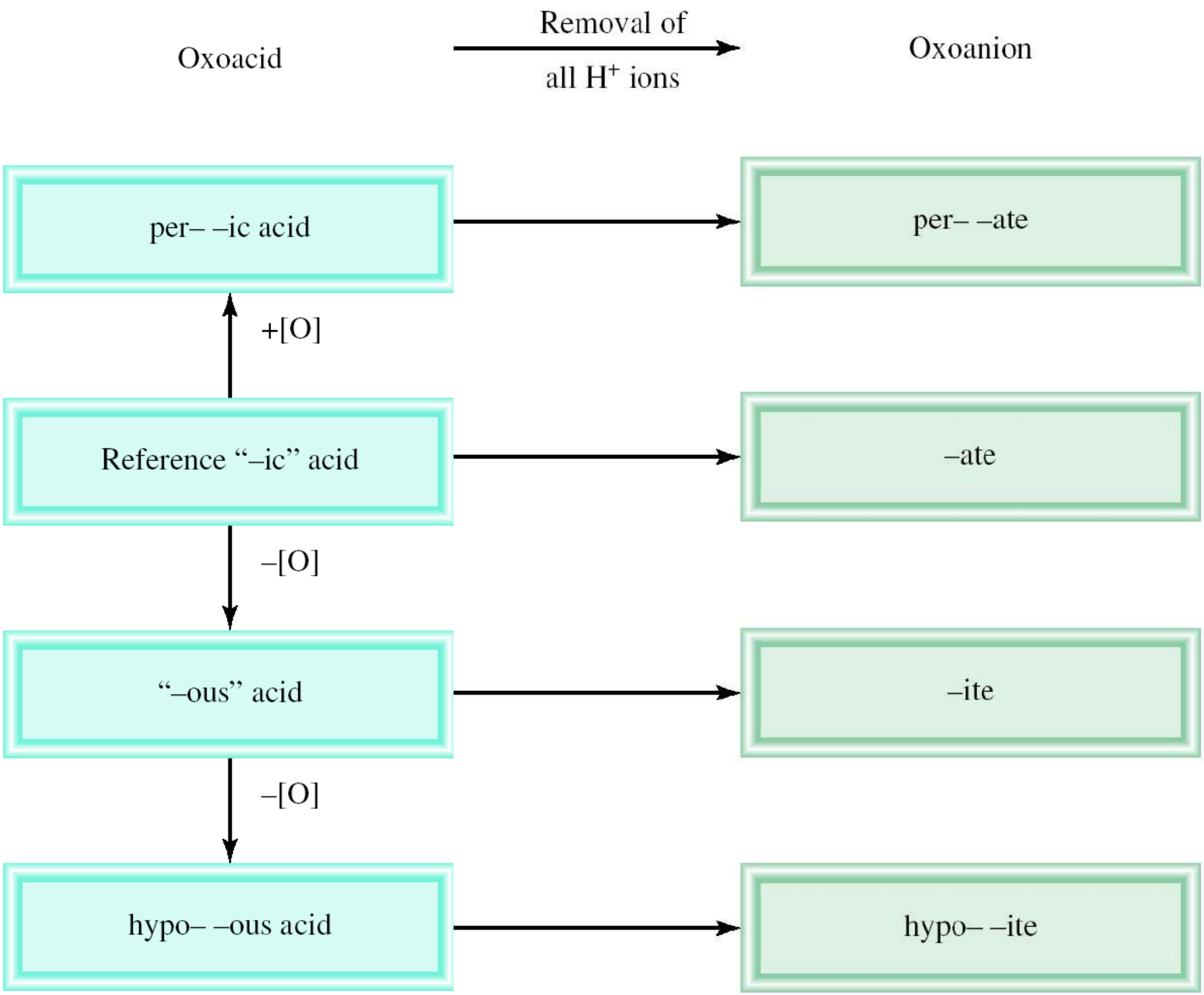
H_2CO_3

H_3PO_4 phosphoric acid



H_3PO_4

Naming Oxoacids and Oxoanions



The rules for naming ***oxoanions,*** *anions of oxoacids,* are as follows:

1. When all the H ions are removed from the "-ic" acid, the anion's name ends with "-ate."
2. When all the H ions are removed from the "-ous" acid, the anion's name ends with "-ite."
3. The names of anions in which one or more but not all the hydrogen ions have been removed must indicate the number of H ions present.

   For example:

   – $H_2PO_4^-$ dihydrogen phosphate

   – HPO_4^{2-} hydrogen phosphate

   – PO_4^{3-} phosphate

Table 2.6 Names of Oxoacids and Oxoanions That Contain Chlorine

Acid	Corresponding 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)

Example 2.9

Name the following oxoacid and oxoanion:

(a) H_3PO_3

(b) IO_4^-

Example 2.9

Strategy To name the acid in (a), we first identify the reference acid, whose name ends with "ic," as shown in Figure 2.15.

In (b), we need to convert the anion to its parent acid shown in Table 2.6.

Solution

•We start with our reference acid, phosphoric acid (H_3PO_4). Because H_3PO_3 has one fewer O atom, it is called phosphorous acid.

•The parent acid is HIO_4. Because the acid has one more O atom than our reference iodic acid (HIO_3), it is called periodic acid. Therefore, the anion derived from HIO_4 is called periodate.

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

$NaOH$	sodium hydroxide
KOH	potassium hydroxide
$Ba(OH)_2$	barium hydroxide

Hydrates are compounds that have a specific number of water molecules attached to them.

$BaCl_2 \cdot 2H_2O$ — barium chloride dihydrate

$LiCl \cdot H_2O$ — lithium chloride monohydrate

$MgSO_4 \cdot 7H_2O$ — magnesium sulfate heptahydrate

$Sr(NO_3)_2 \cdot 4H_2O$ — strontium nitrate tetrahydrate

$CuSO_4 \cdot 5H_2O$ →

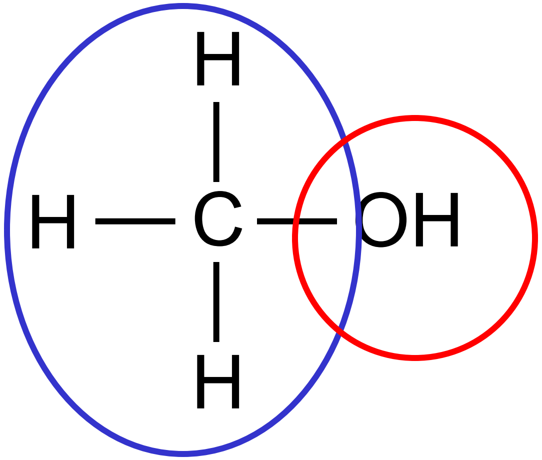
← $CuSO_4$

Table 2.7 Common and Systematic Names of Some Compounds

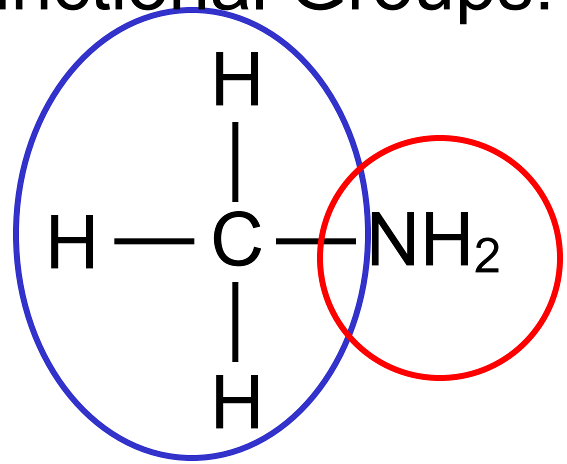
Formula	Common Name	Systematic Name
H_2O	Water	Dihydrogen monoxide
NH_3	Ammonia	Trihydrogen nitride
CO_2	Dry ice	Solid carbon dioxide
$NaCl$	Table salt	Sodium chloride
N_2O	Laughing gas	Dinitrogen monoxide
$CaCO_3$	Marble, chalk, limestone	Calcium carbonate
CaO	Quicklime	Calcium oxide
$Ca(OH)_2$	Slaked lime	Calcium hydroxide
$NaHCO_3$	Baking soda	Sodium hydrogen carbonate
$Na_2CO_3 \cdot 10H_2O$	Washing soda	Sodium carbonate decahydrate
$MgSO_4 \cdot 7H_2O$	Epsom salt	Magnesium sulfate heptahydrate
$Mg(OH)_2$	Milk of magnesia	Magnesium hydroxide
$CaSO_4 \cdot 2H_2O$	Gypsum	Calcium sulfate dihydrate

Organic chemistry is the branch of chemistry that deals with carbon compounds.

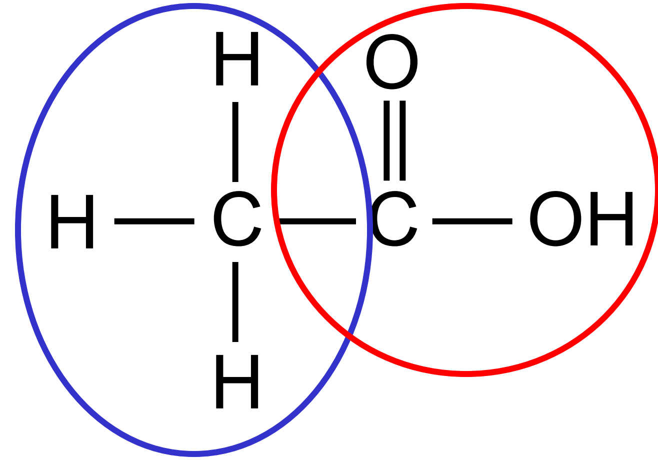
Functional Groups:



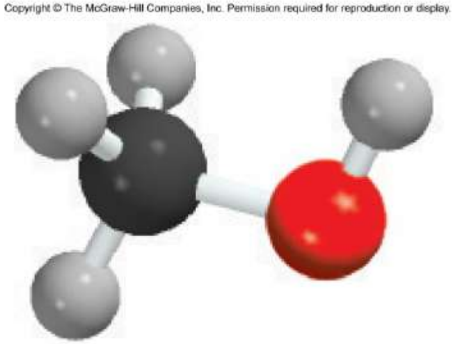
methanol



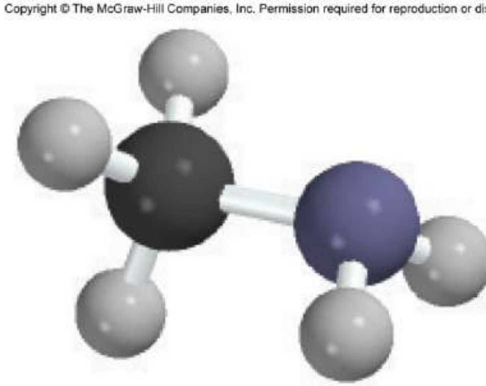
methylamine



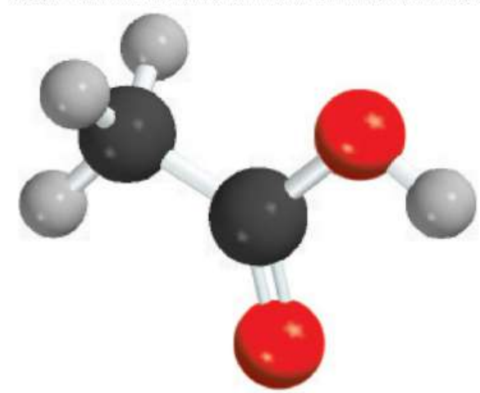
acetic acid



CH_3OH

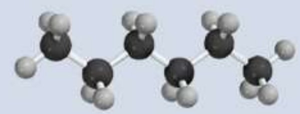


CH_3NH_2



CH_3COOH

Table 2.8 **The First Ten Straight-Chain Alkanes**

Name	Formula	Molecular Model
Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	
Pentane	C_5H_{12}	
Hexane	C_6H_{14}	
Heptane	C_7H_{16}	
Octane	C_8H_{18}	
Nonane	C_9H_{20}	
Decane	$C_{10}H_{22}$