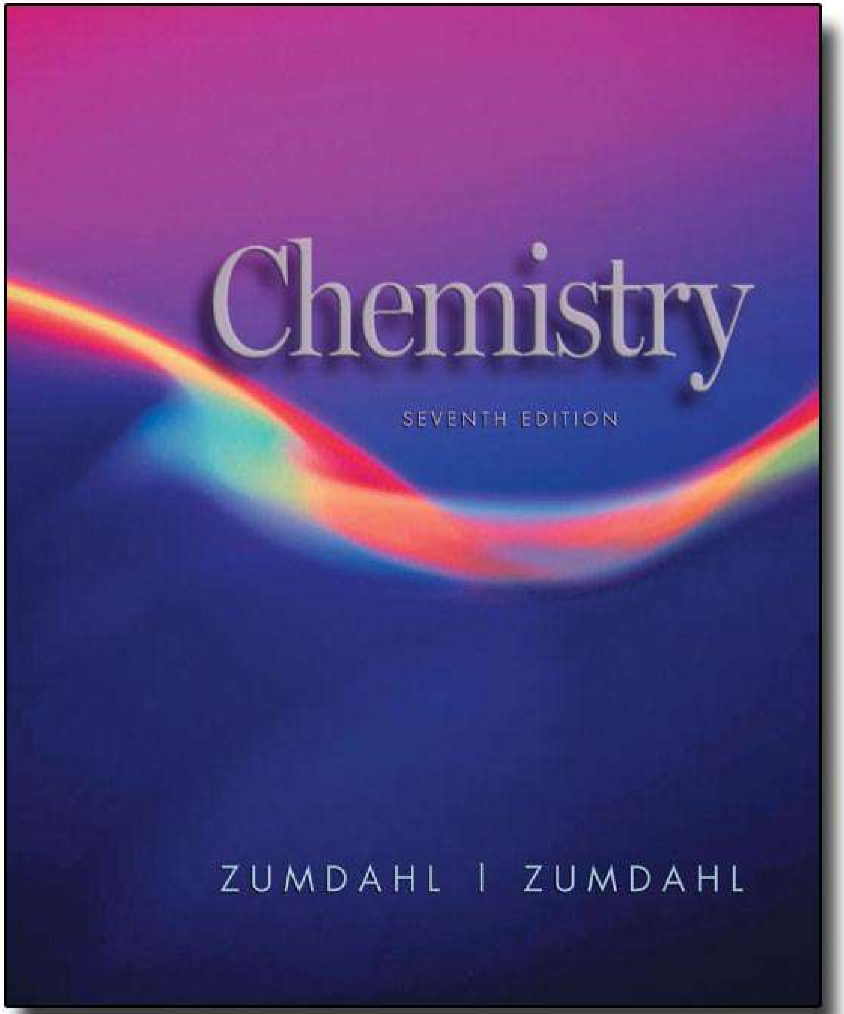
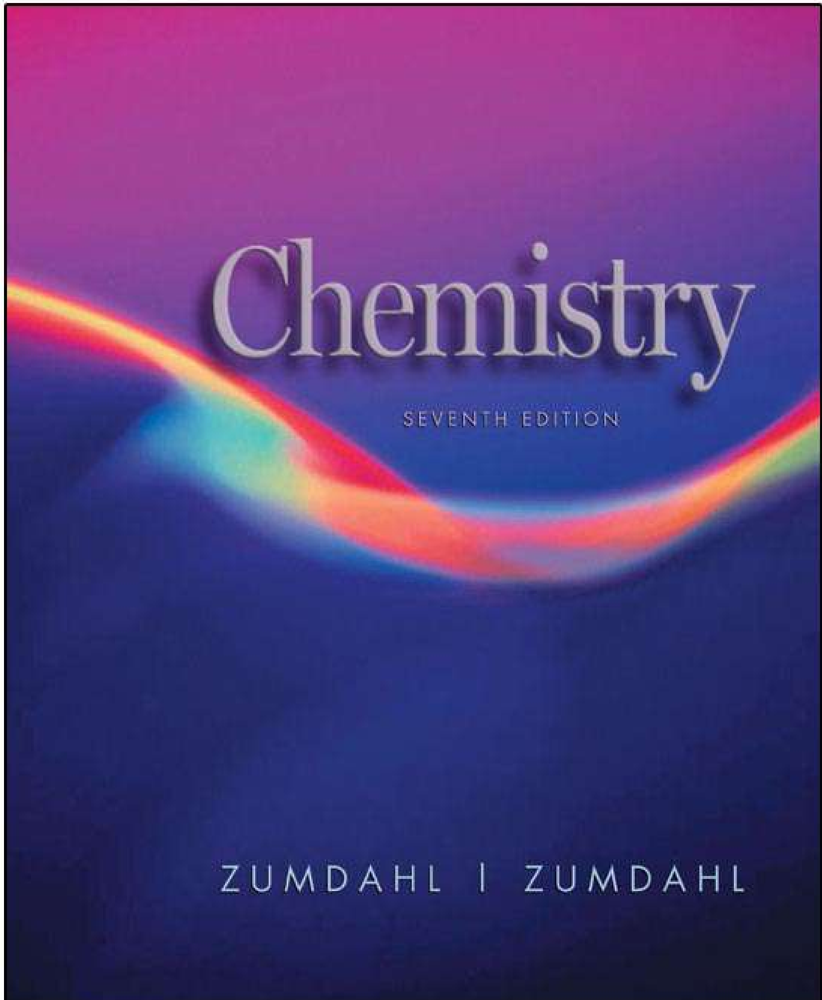


Chapter Two:

ATOMS, MOLECULES, AND IONS



Fundamental Chemical Laws

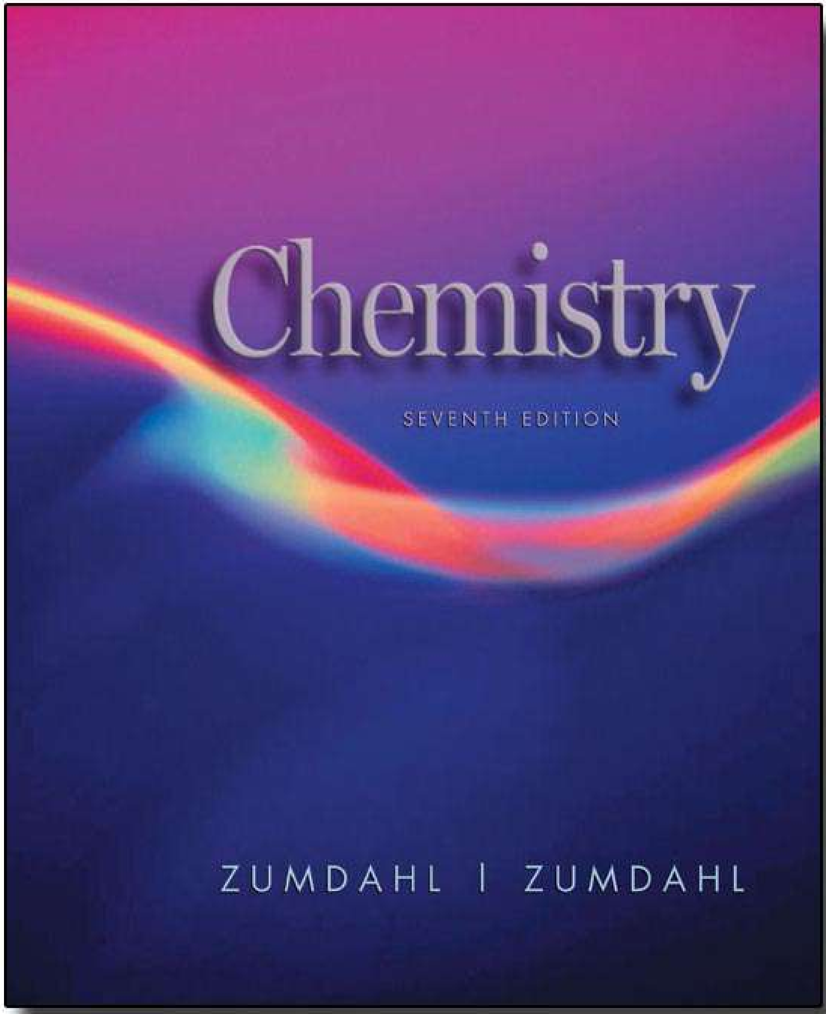
Figure 2.1 The Priestley Medal is the Highest Honor Given by the American Chemical Society

Three Important Laws

- Law of conservation of mass
  - Mass is neither created nor destroyed
- Law of definite proportion
  - A given compound always contains exactly the same proportion of elements by mass

Three Important Laws (continued)

- Law of multiple proportions
  - When two elements form a series of compounds, the ratios of the masses of the second element that combine with 1 gram of the first element can always be reduced to small whole numbers.



Dalton’s Atomic Theory

Dalton’s Atomic Theory (1808)

- Each element is made up of tiny particles called atoms.

Dalton's Atomic Theory (1808) (continued)

- *The atoms of a given element are identical;* the atoms of different elements are different in some fundamental way or ways.

Dalton's Atomic Theory (continued)

- *Chemical compounds are formed when atoms combine with each other.* A given compound always has the same relative numbers and types of atoms.

Dalton’s Atomic Theory (continued)

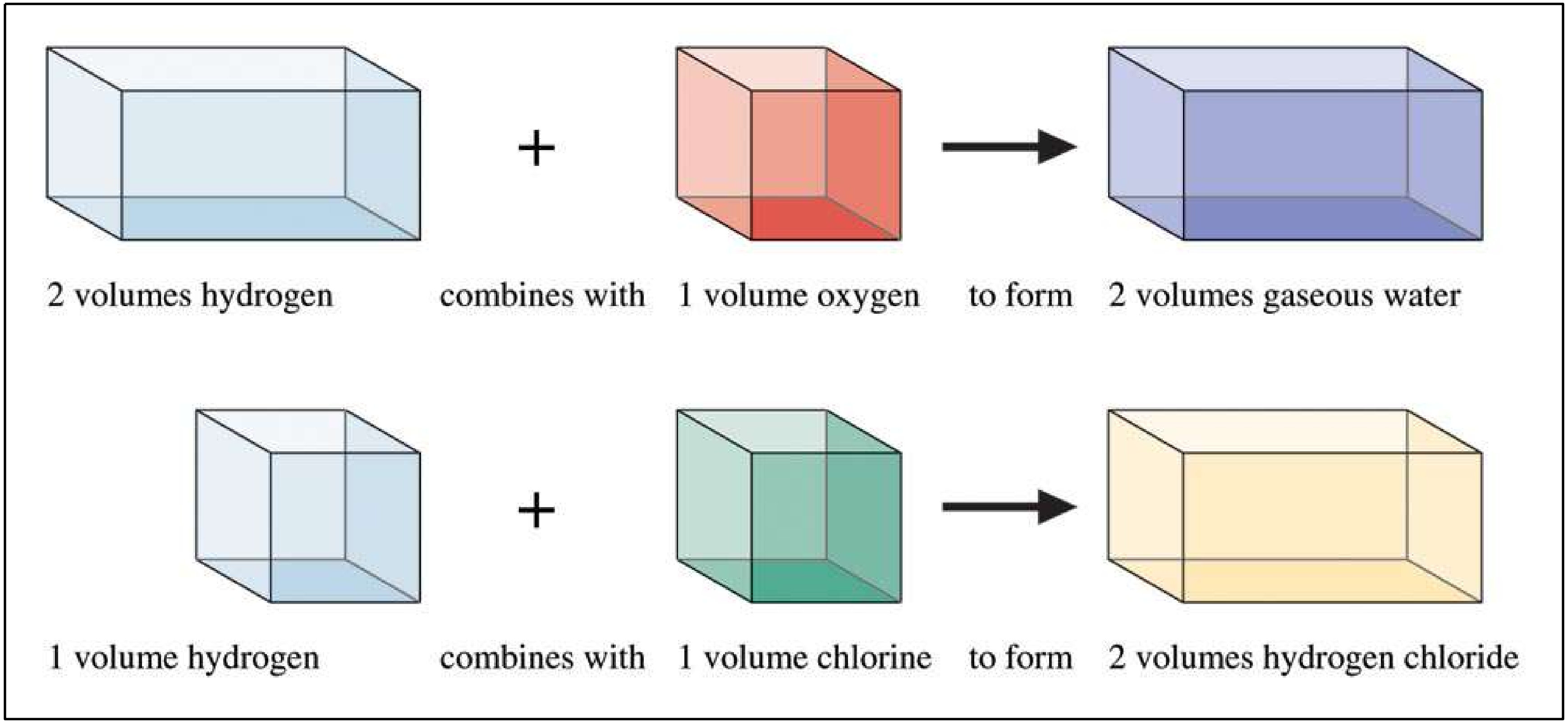
- *Chemical reactions involve reorganization of the atoms* - changes in the way they are bound together. The atoms themselves are not changed in a chemical reaction.

Plant is Newly Discovered Source of Gold

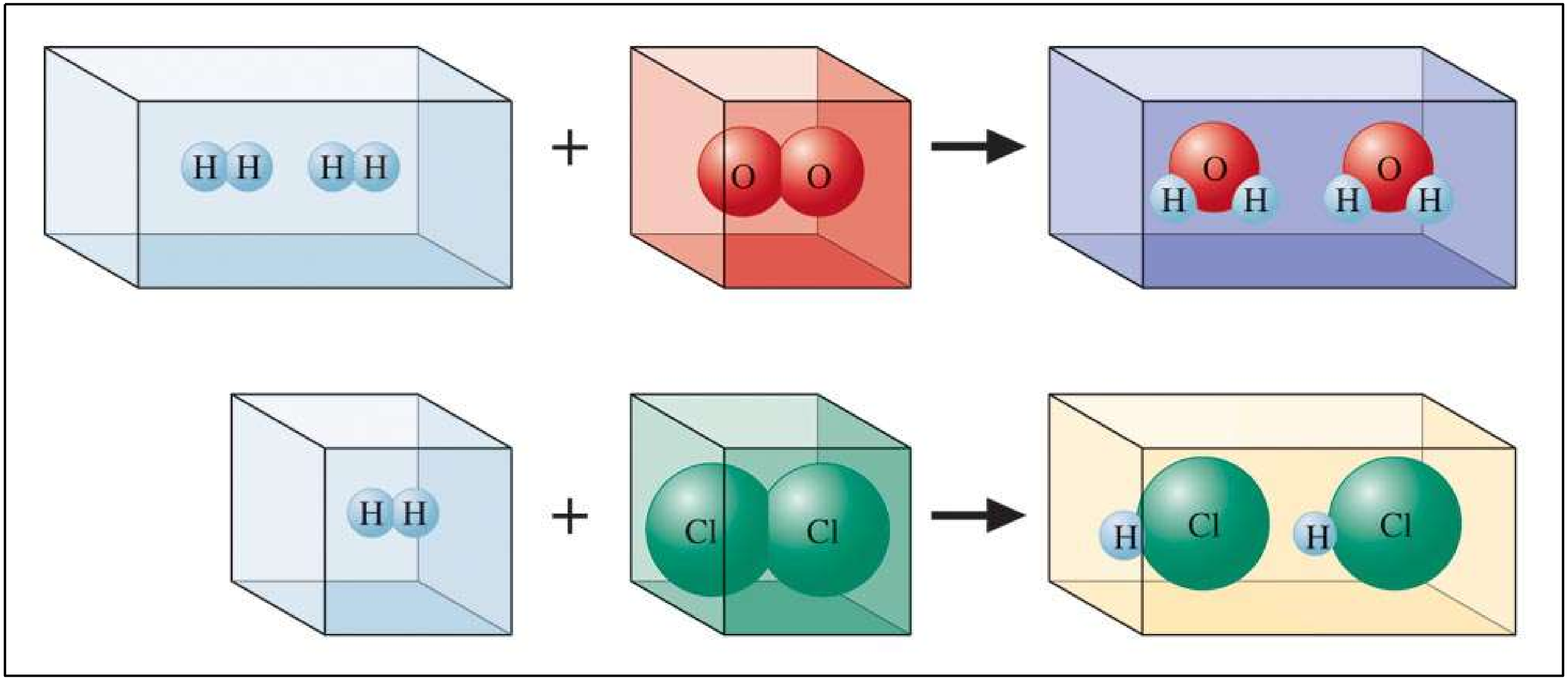
Avogadro's Hypothesis (1811)

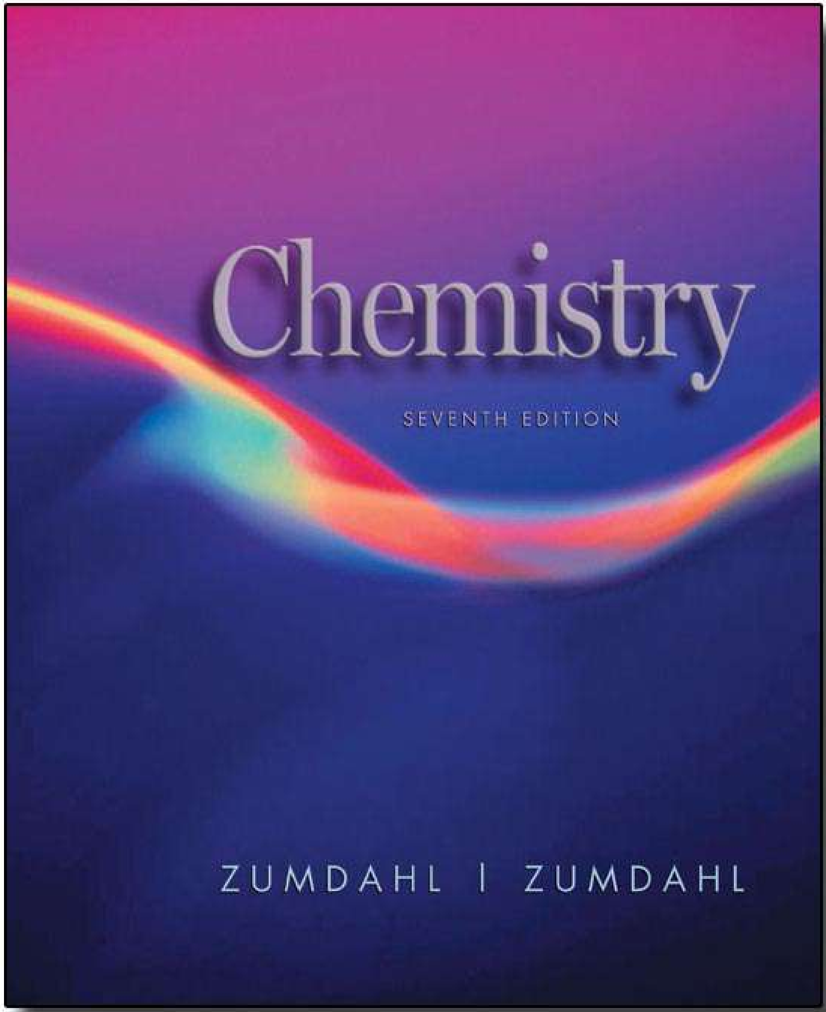
- At the same temperature and pressure, equal volumes of different gases contain the same number of particles.
  - 5 liters of oxygen
  - 5 liters of nitrogen
  - Same number of particles!

Representing Gay-Lussac's Results



Representing Gay-Lussac's Results





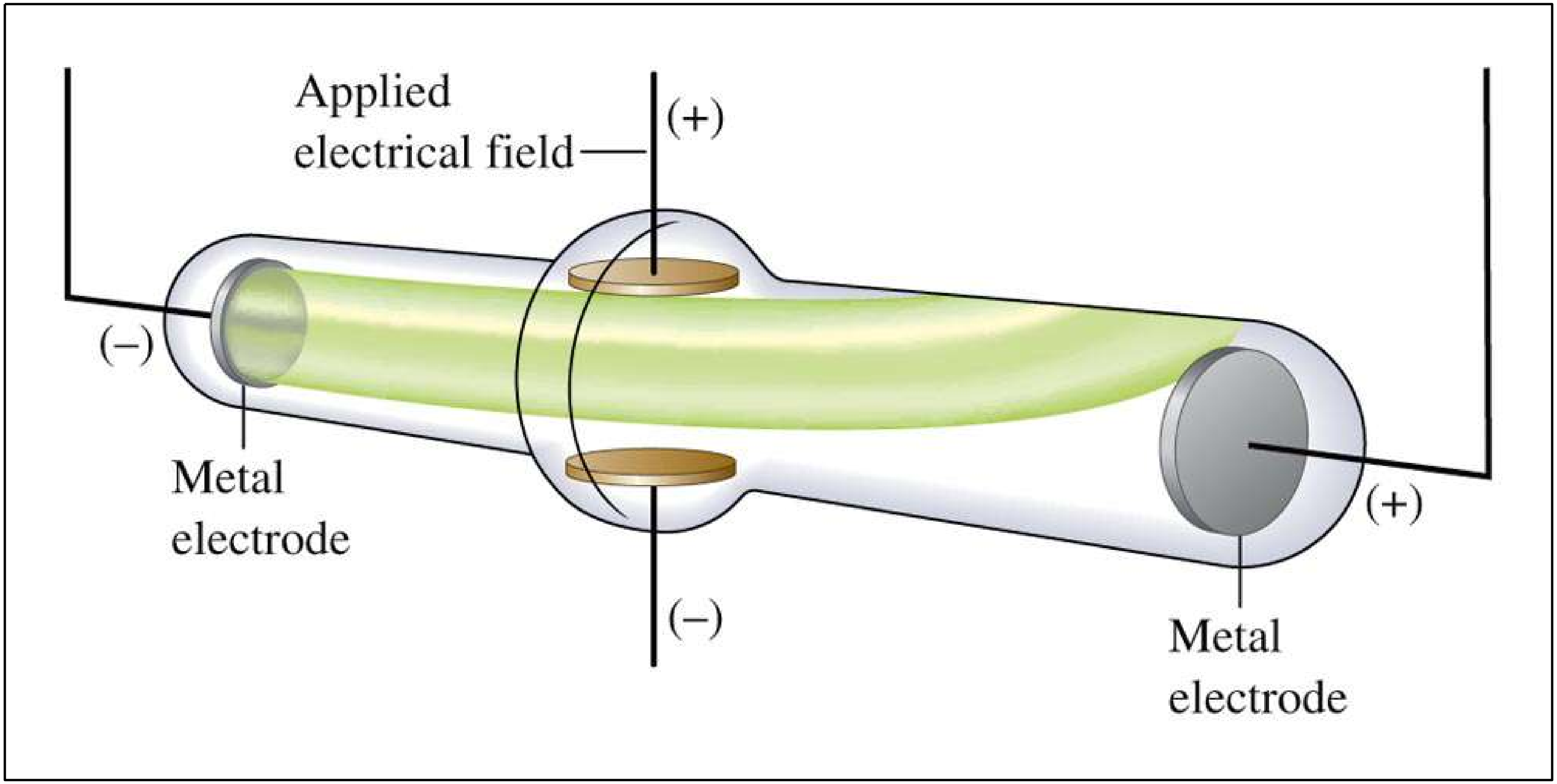
Early Experiments to Characterize the Atom

Early Experiments to Characterize the Atom

- J. J. Thomson - postulated the existence of electrons using cathode ray tubes.
- Ernest Rutherford - explained the nuclear atom, containing a dense nucleus with electrons traveling around the nucleus at a large distance.

Figure 2.7 A Cathode-Ray Tube

Figure 2.8 Deflection of Cathode Rays by an Applied Electric Field



Cathode Ray Tube

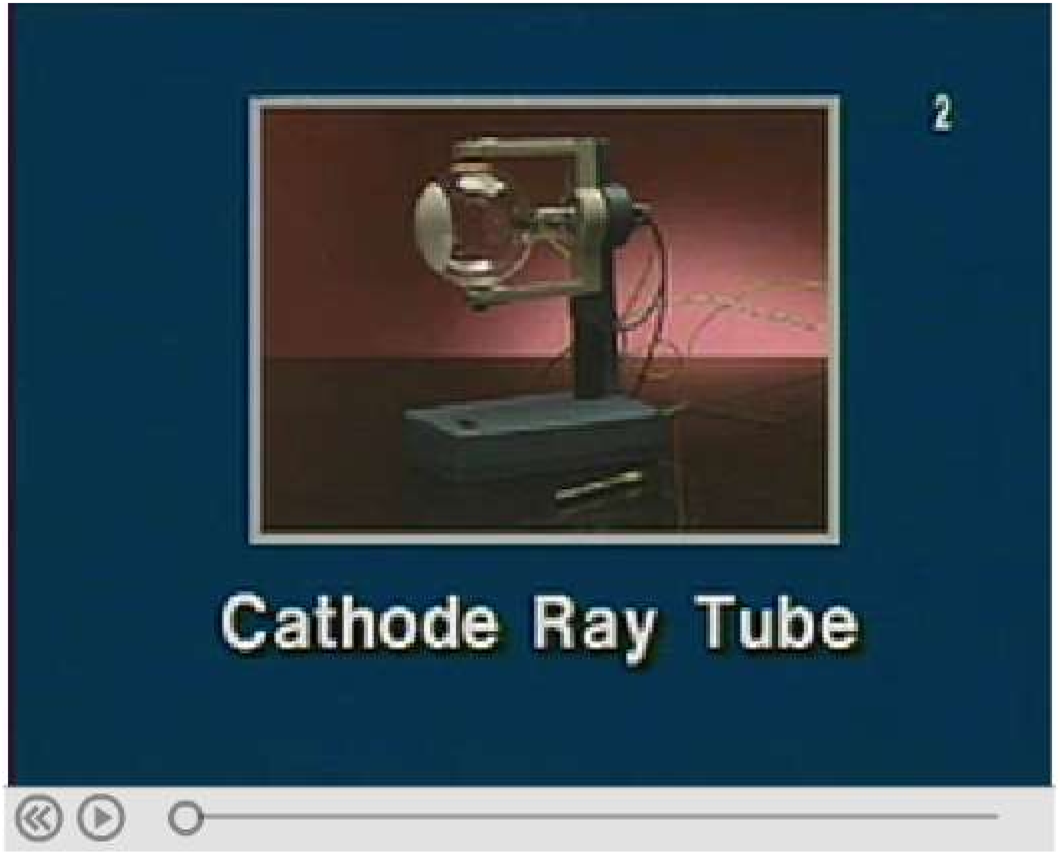


Figure 2.9 The Plum Pudding Model of the Atom

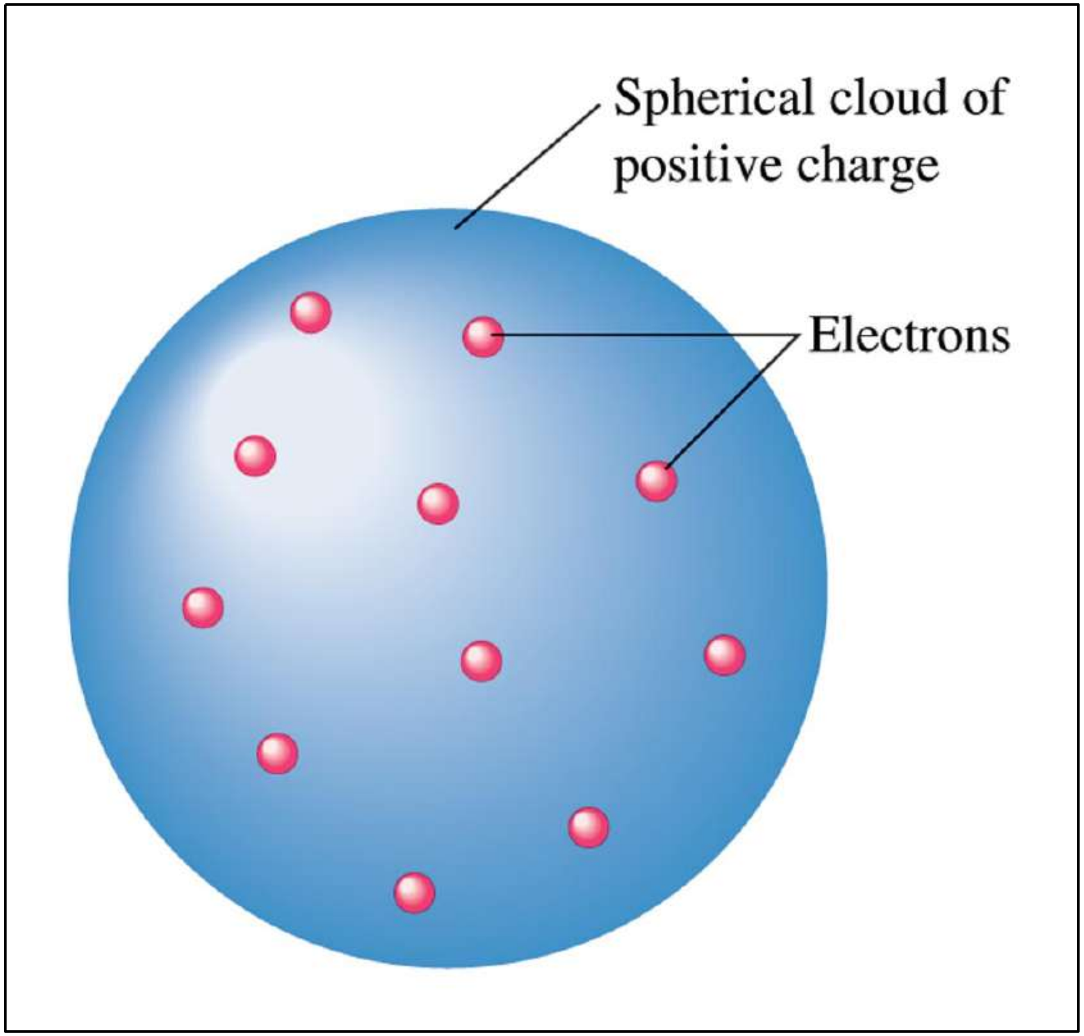
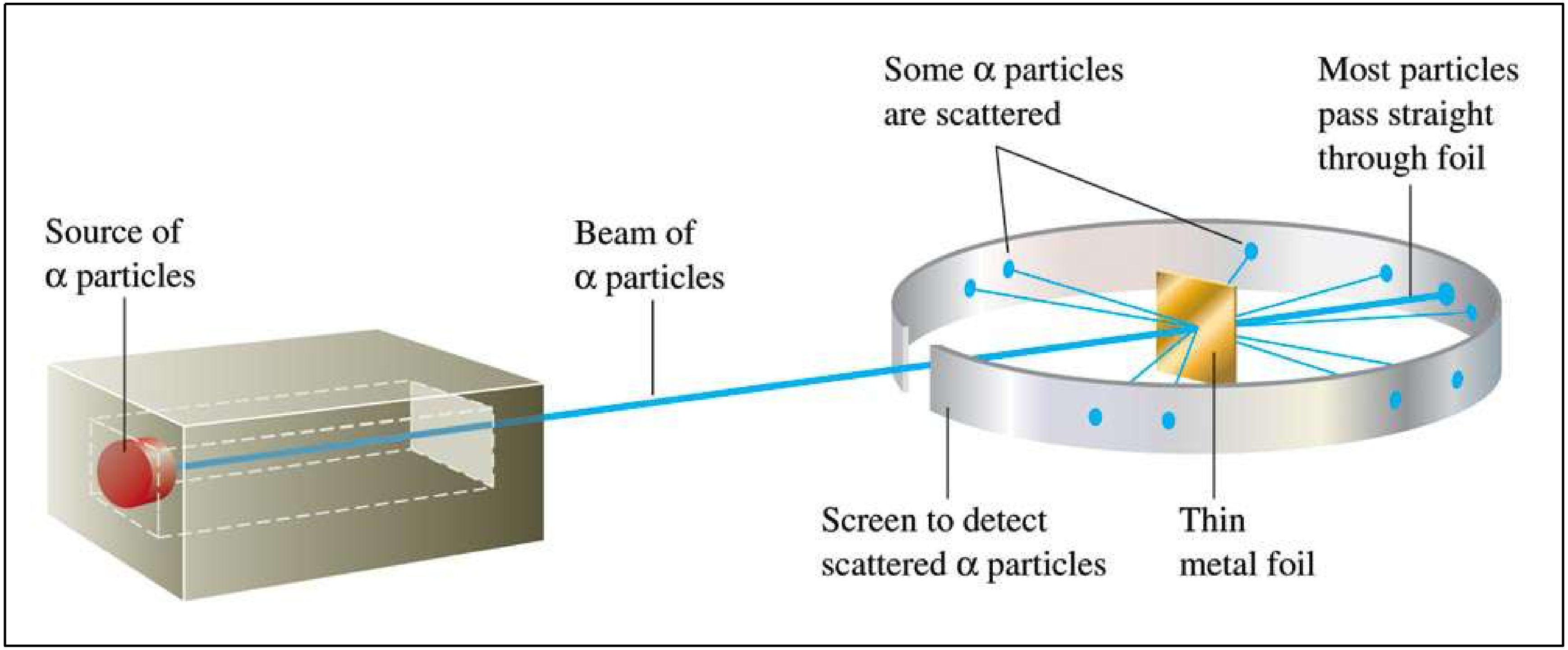


Figure 2.12 Rutherford's Experiment On *a*-Particle Bombardment of Metal Foil



Rutherford’s Gold Foil Experiment

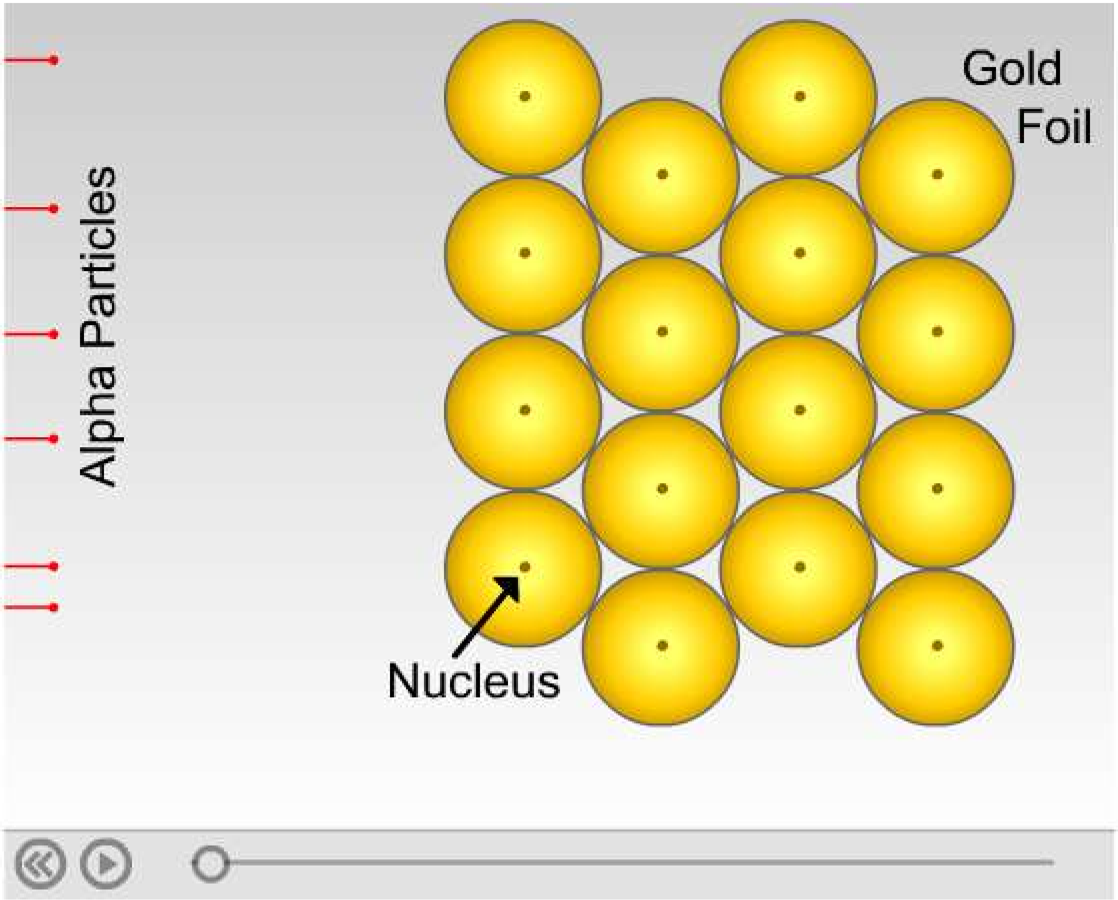


Figure 2.13 a & b
(a) Expected Results of the Metal Foil Experiment if Thomson's Model Were Correct
(b) Actual Results

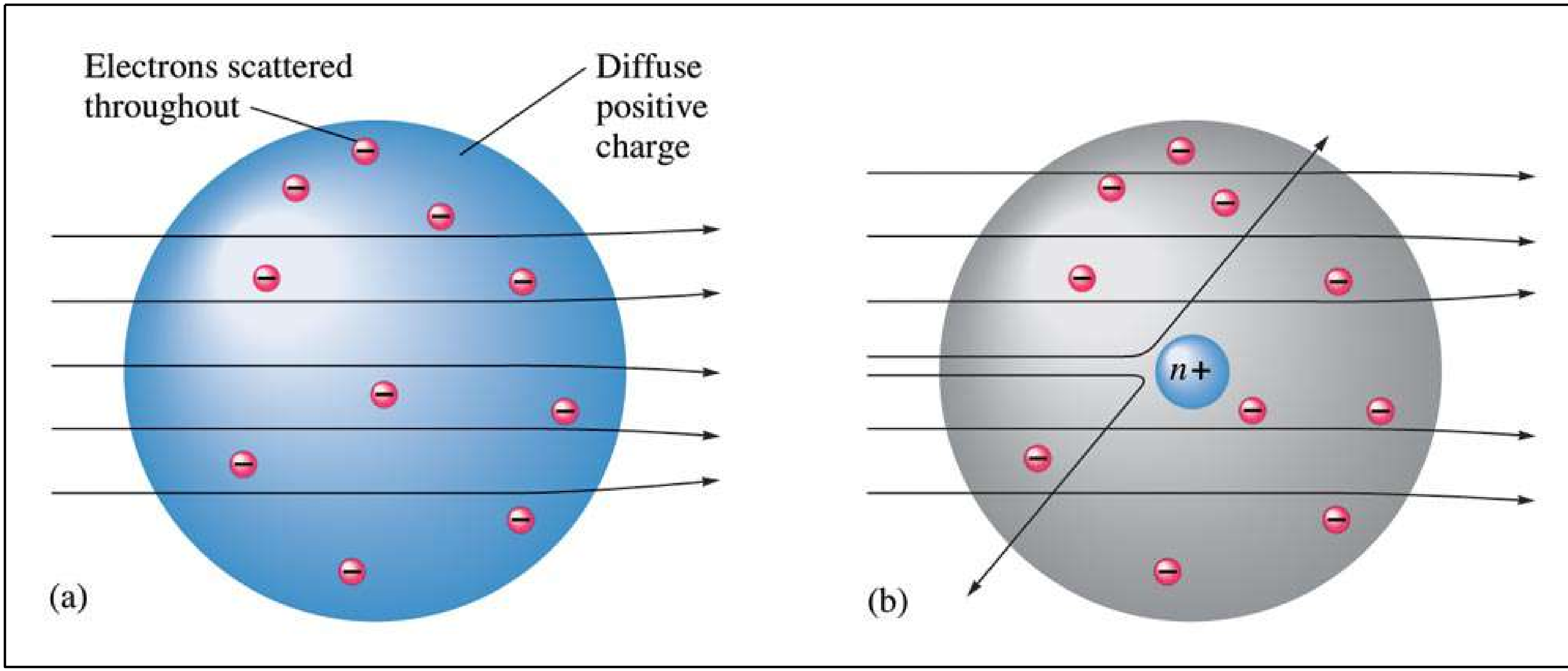
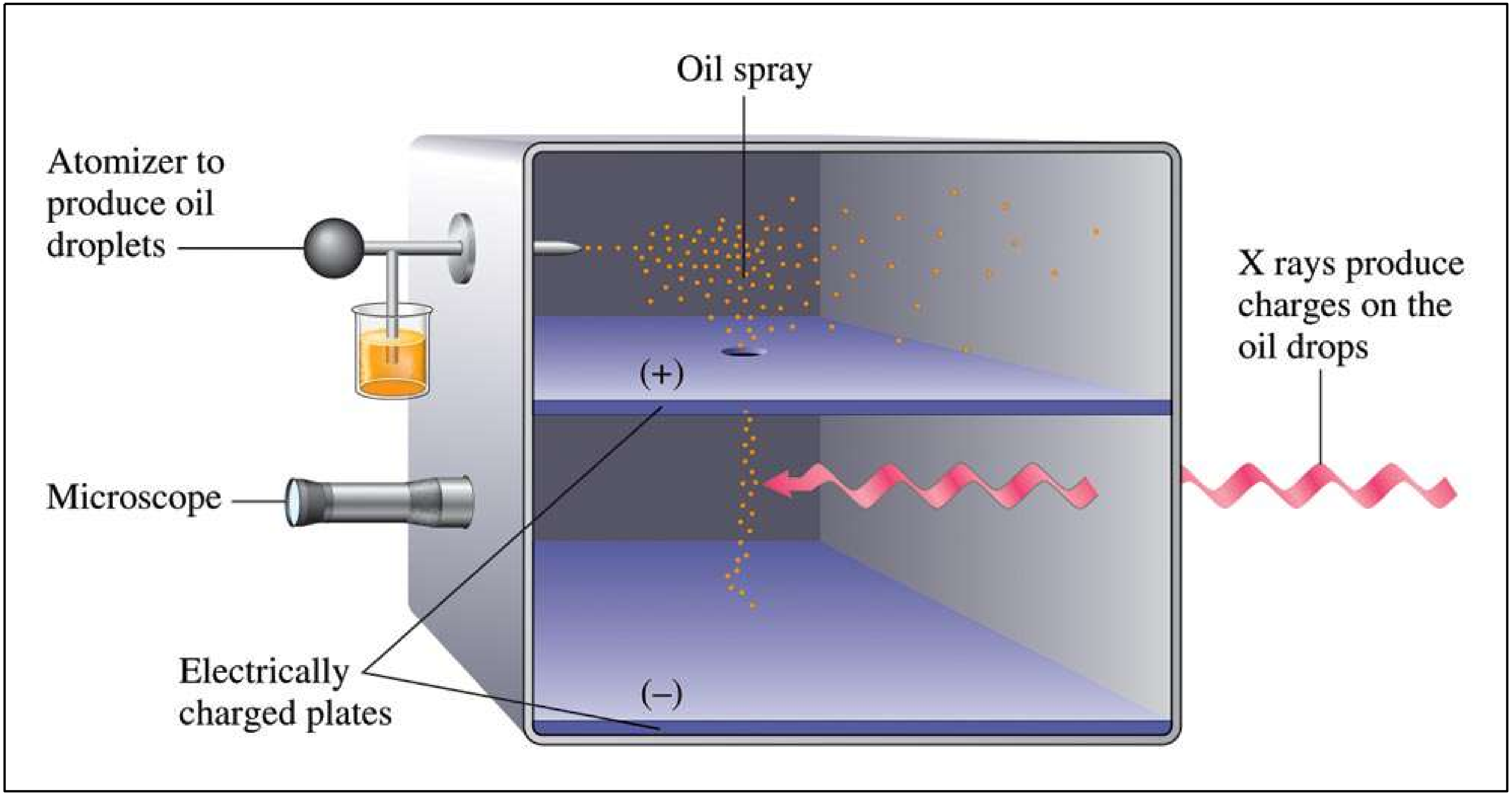
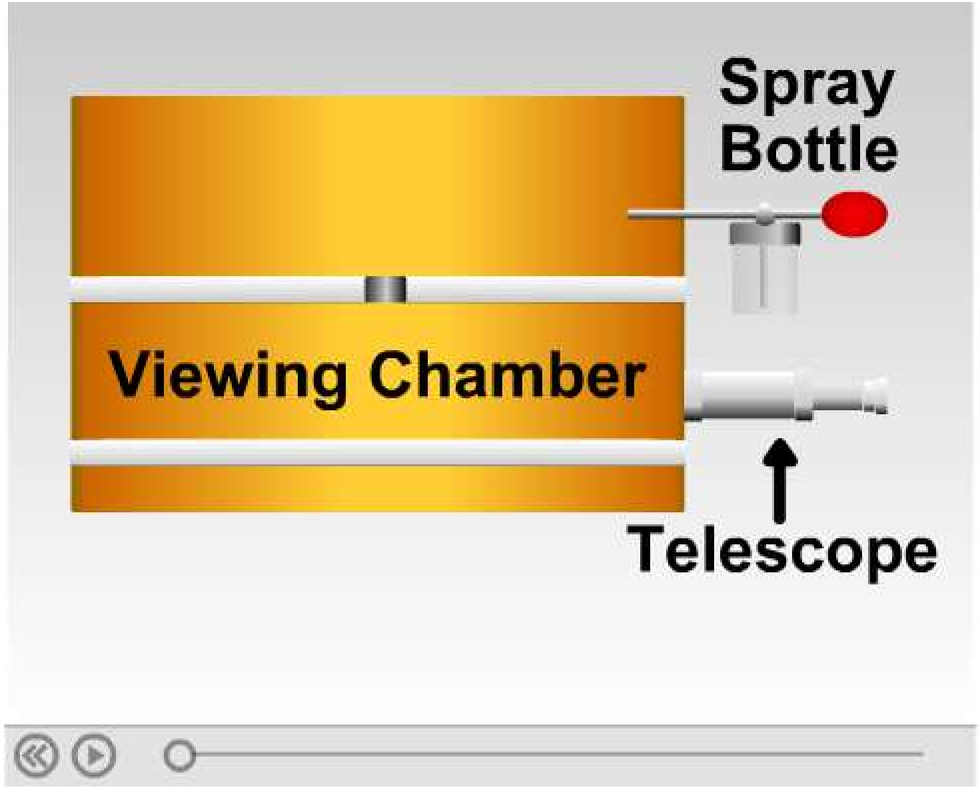
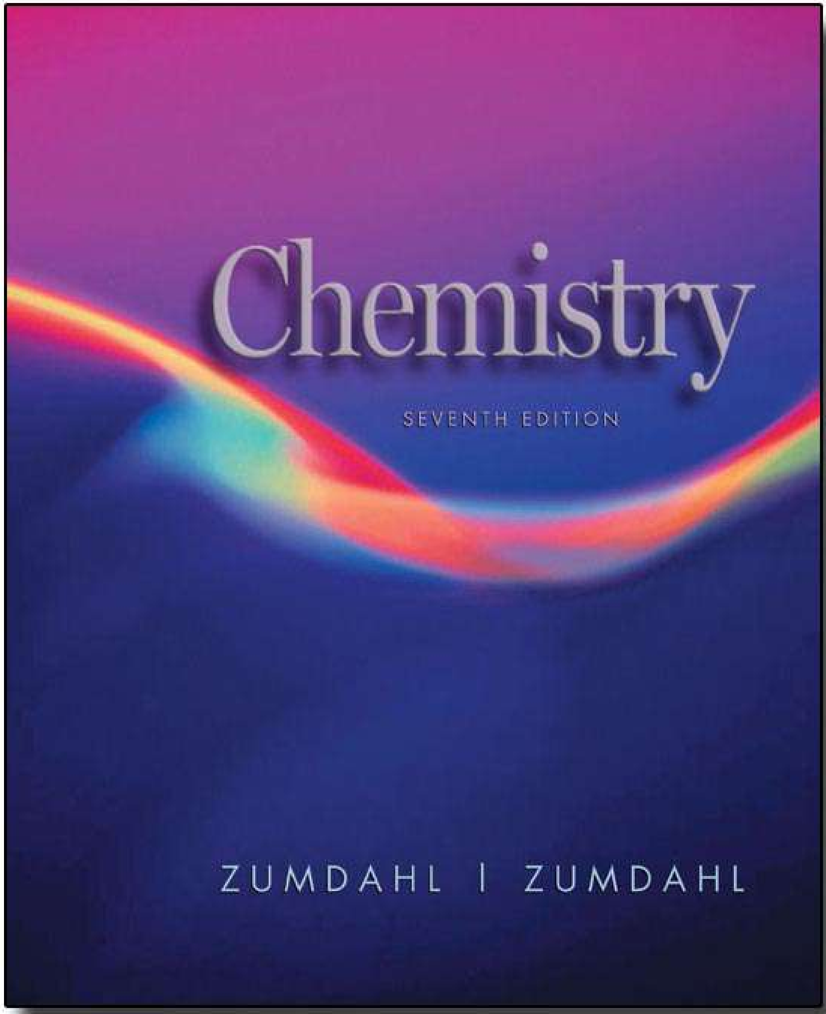


Figure 2.10 A Schematic Representation of the Apparatus Millikan Used to Determine the Charge on the Electron



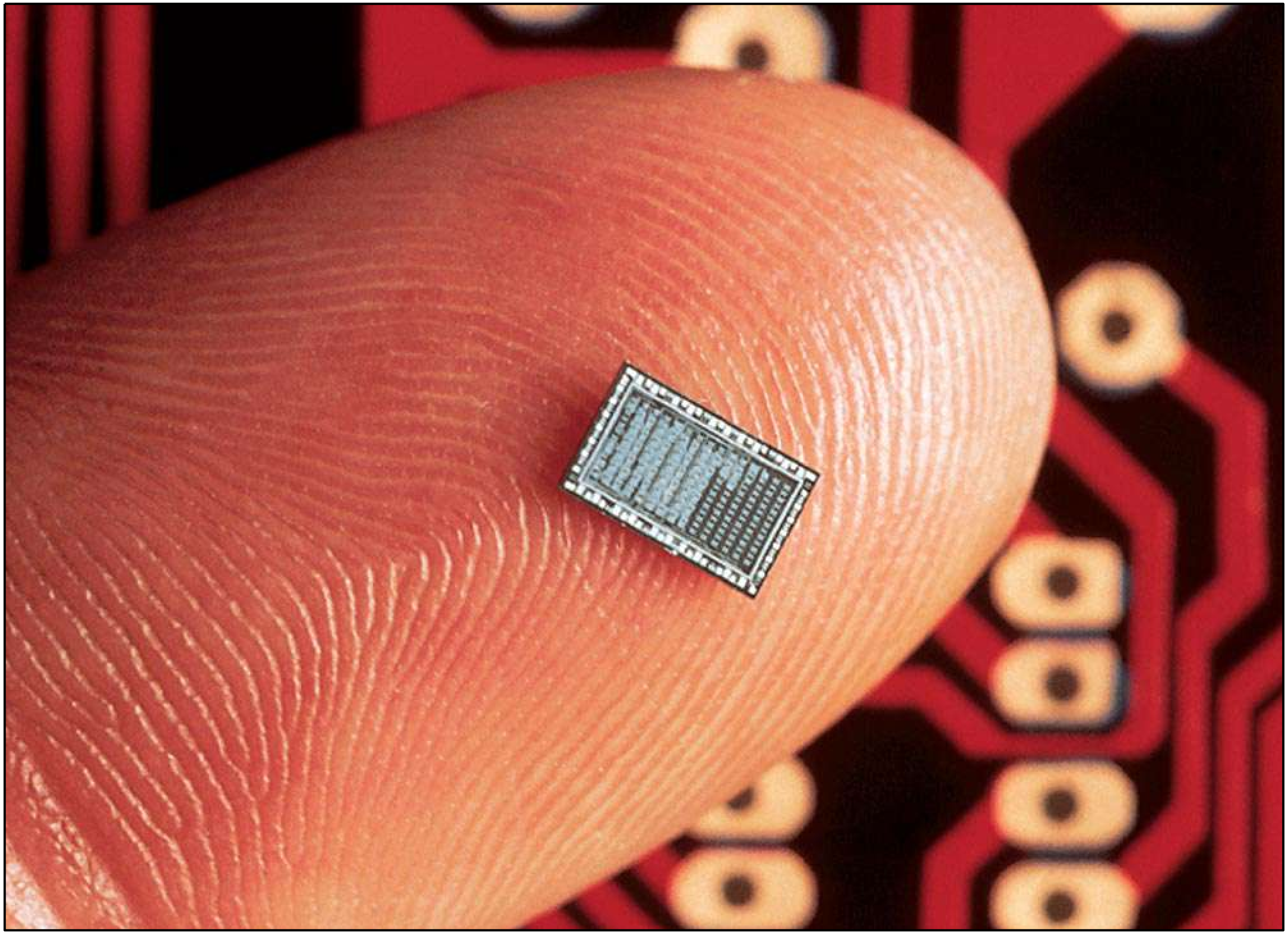
Milliken Oil Drop Experiment





The Modern View of Atomic Structure: An Introduction

A Silicon Chip



The Modern View of Atomic Structure

- The atom contains:
  - electrons
  - protons: found in the nucleus; positive charge equal in magnitude to the electron's negative charge.
  - neutrons: found in the nucleus; no charge; virtually same mass as a proton.

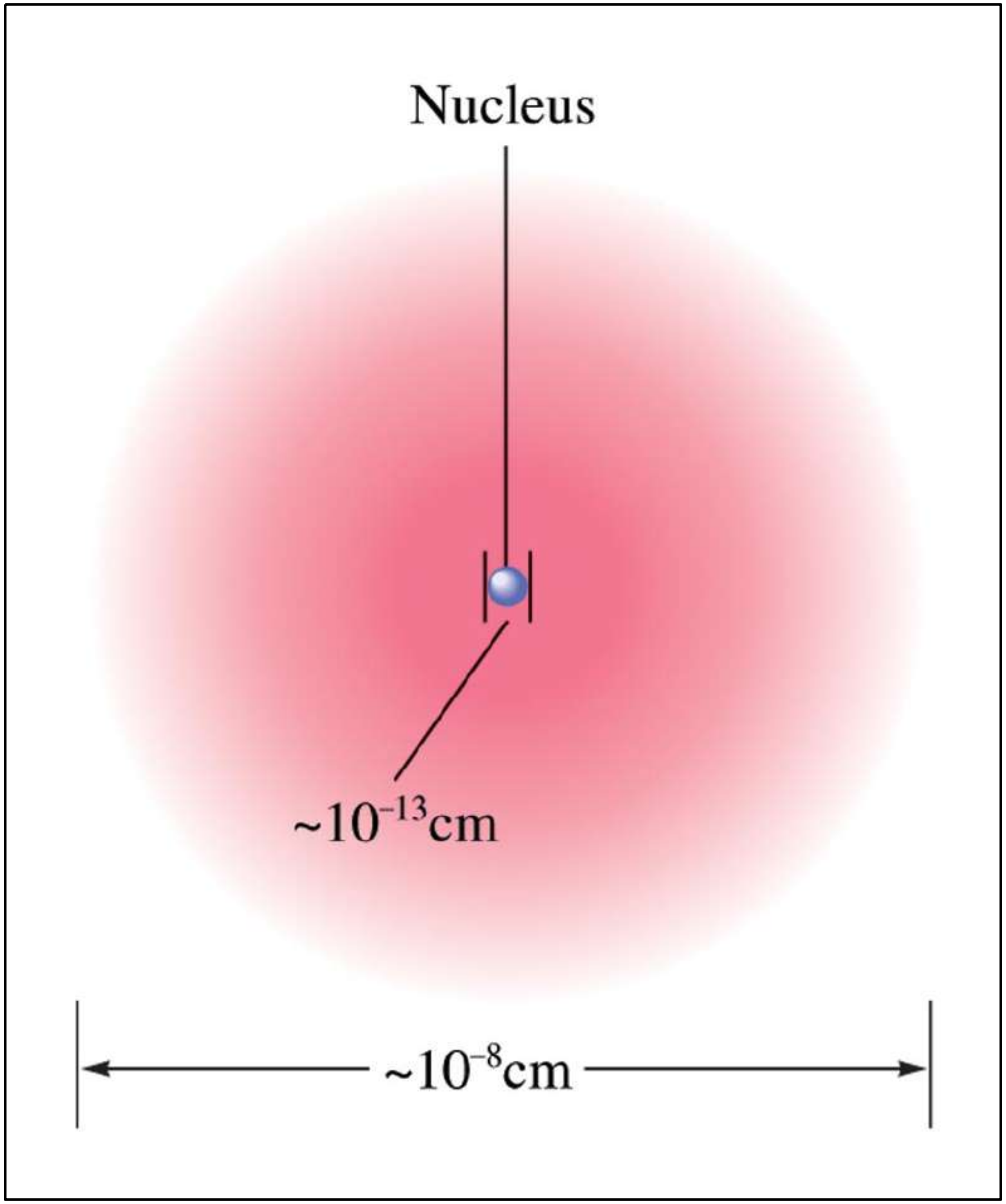
Table 2.1 The Mass and Charge of the Electron, Proton, and Neutron

TABLE 2.1 The Mass and Charge of the Electron, Proton, and Neutron

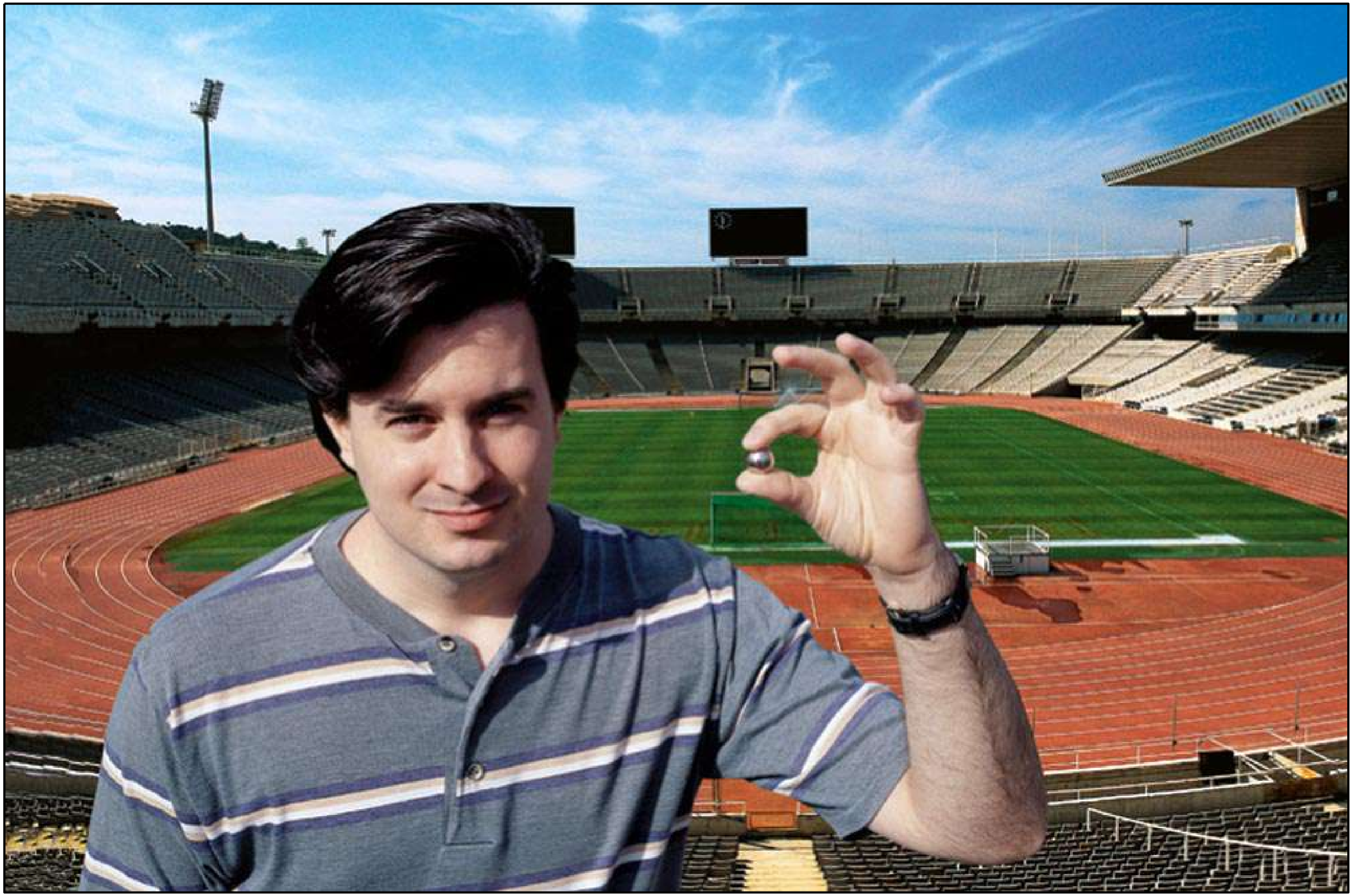
Particle	Mass	Charge*
Electron	9.11×10^{-31} kg	1−
Proton	1.67×10^{-27} kg	1+
Neutron	1.67×10^{-27} kg	None

*The magnitude of the charge of the electron and the proton is 1.60×10^{-19} C.

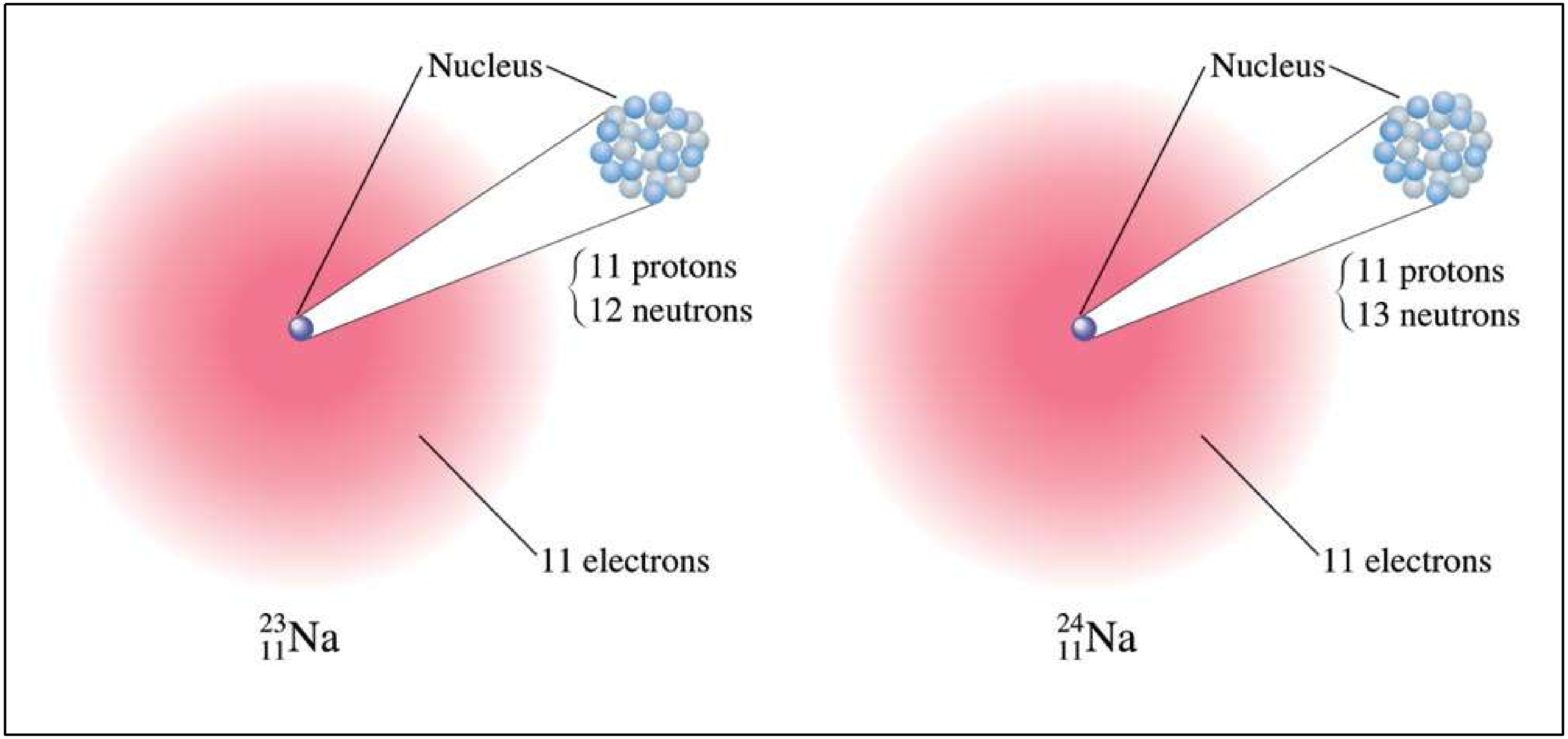
Nuclear Atom Viewed in Cross Section

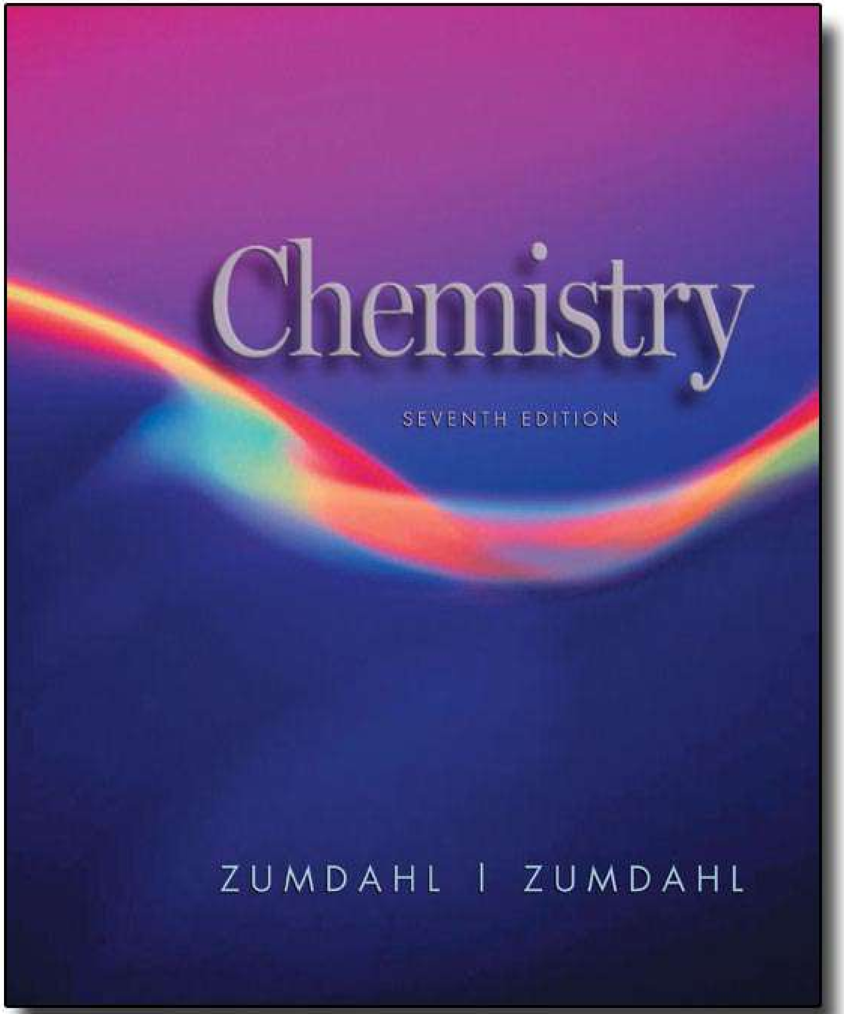


Atomic Nucleus



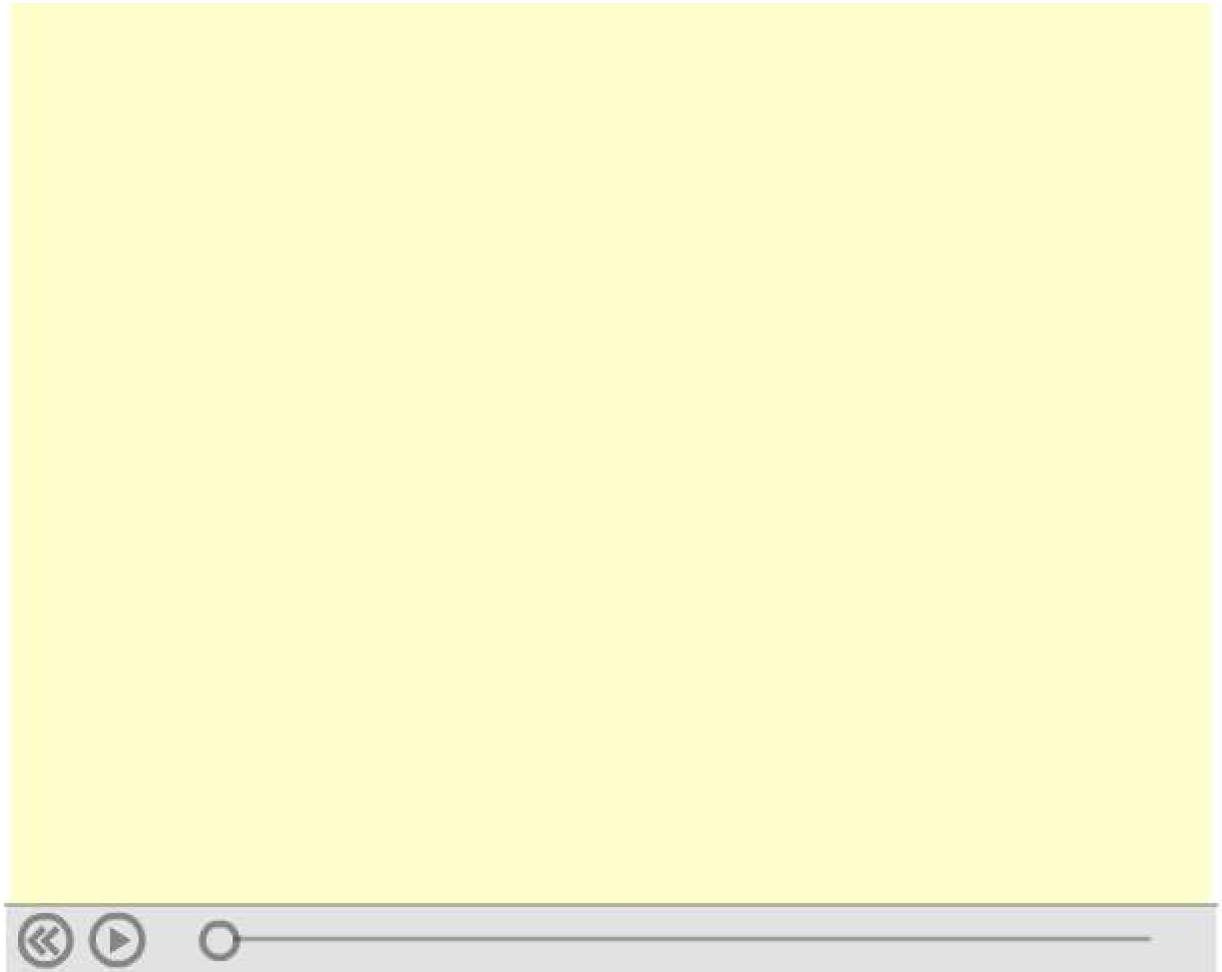
Two Isotopes of Sodium





Molecules and Ions

Molecular vs. Ionic Compounds



Covalent Bonding

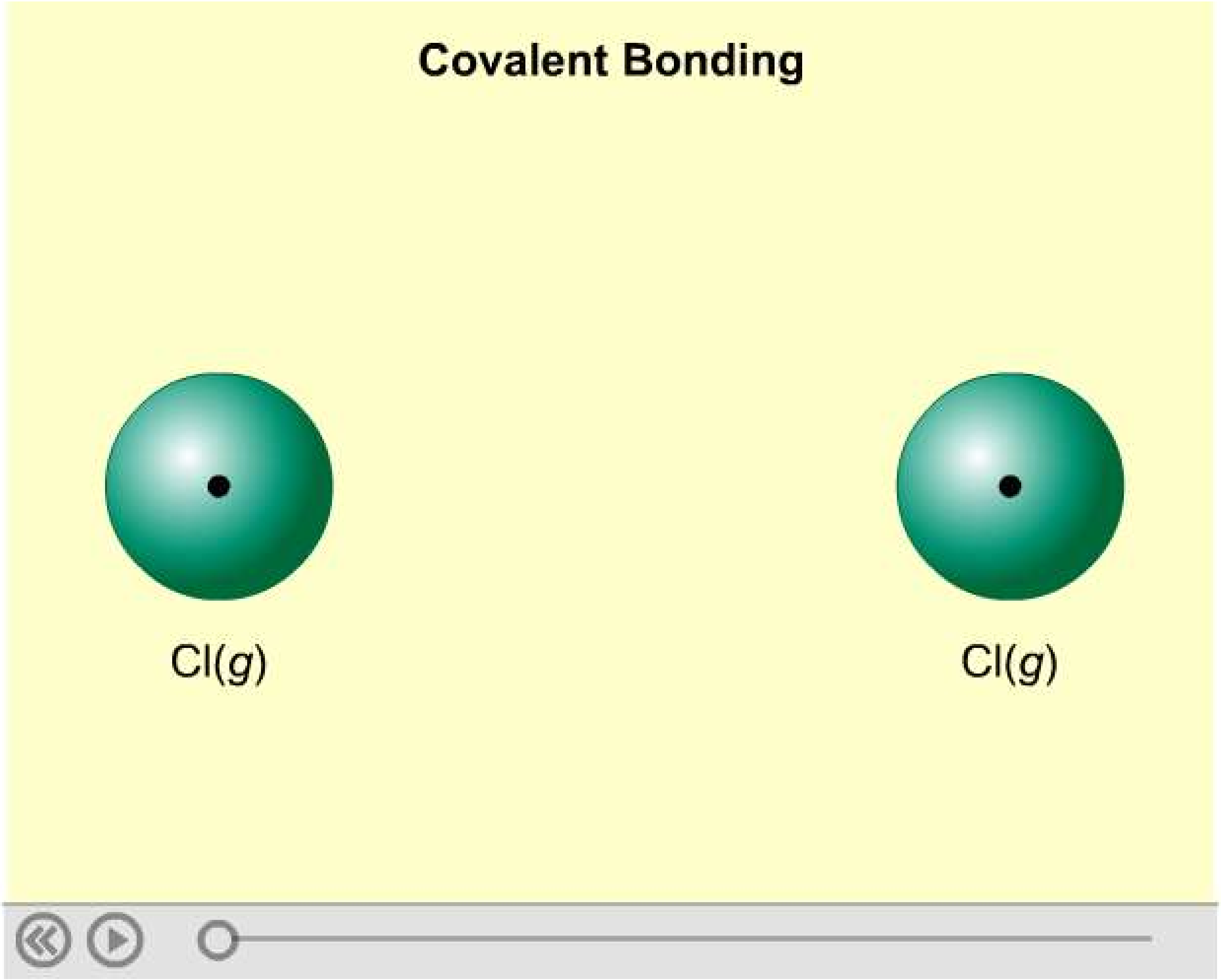


Figure 2.17 Space-Filling Model of Methane

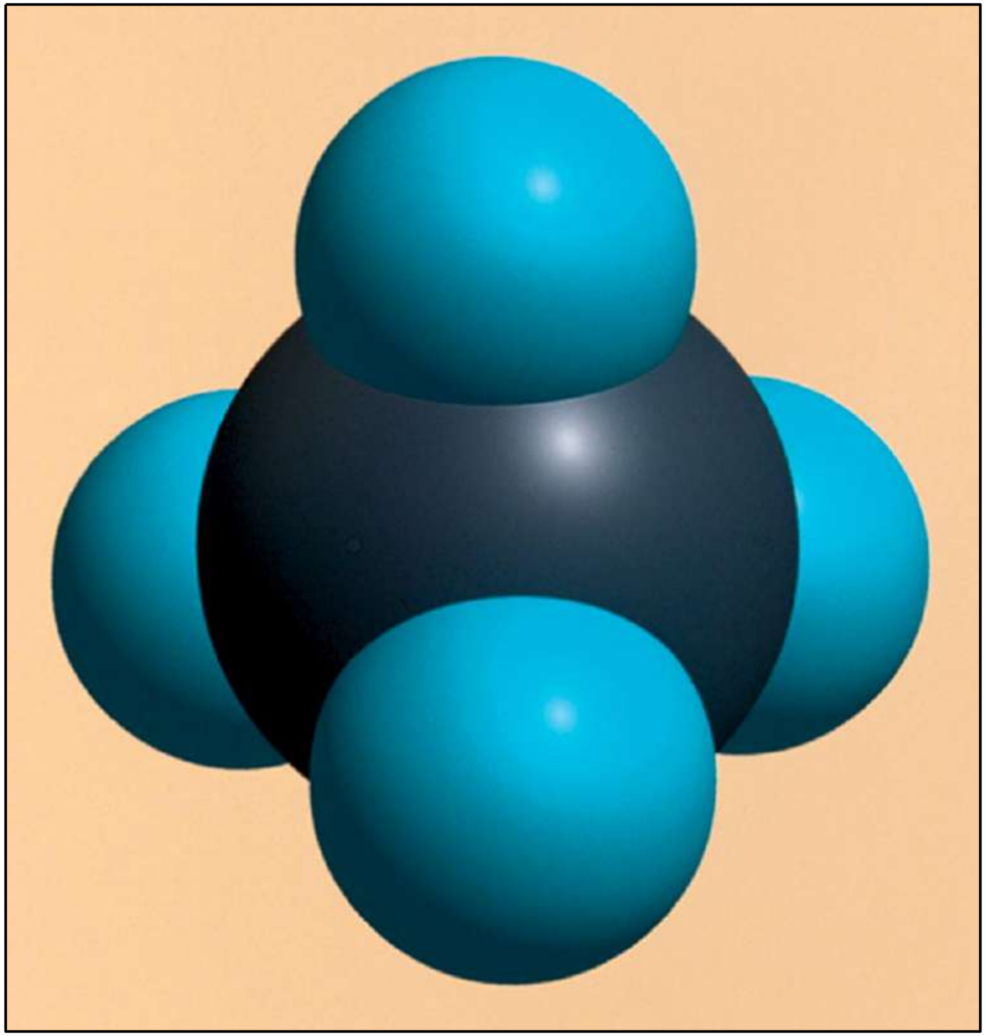


Figure 2.18 Ball-and-Stick Model of Methane

Formation of Ionic Compounds

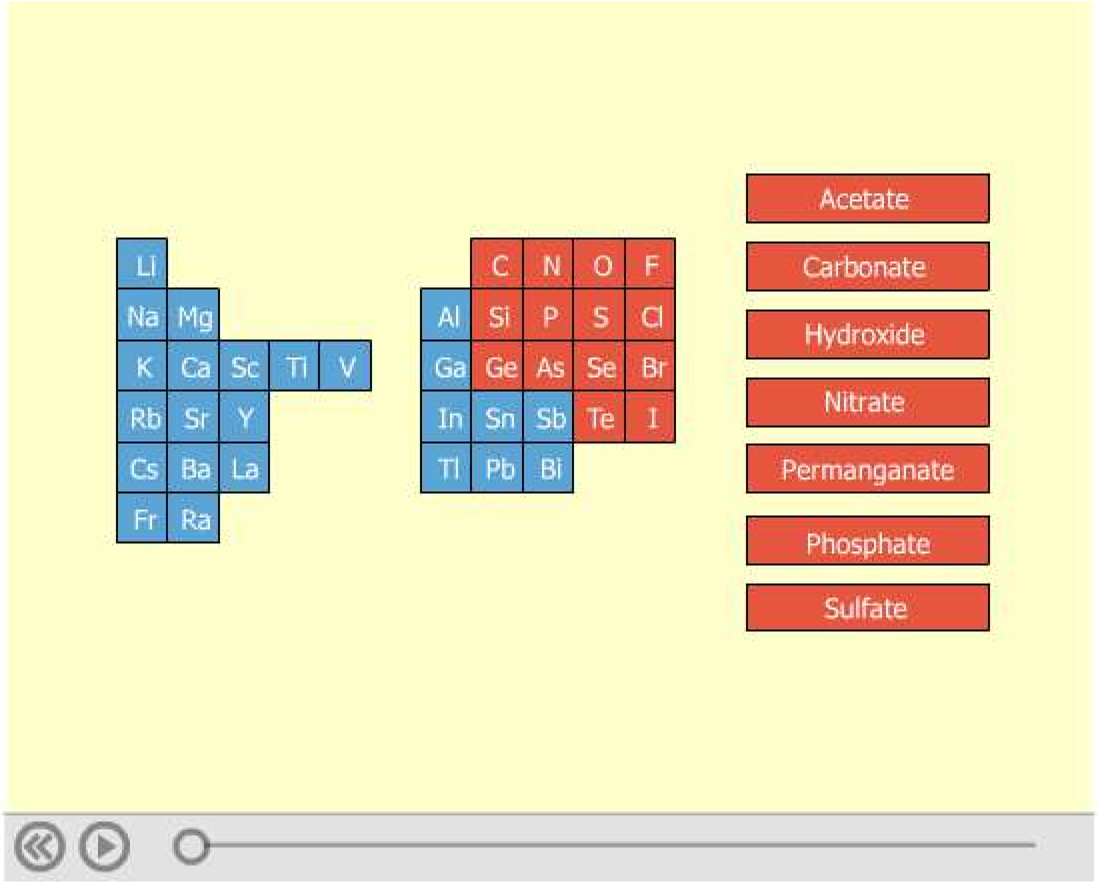
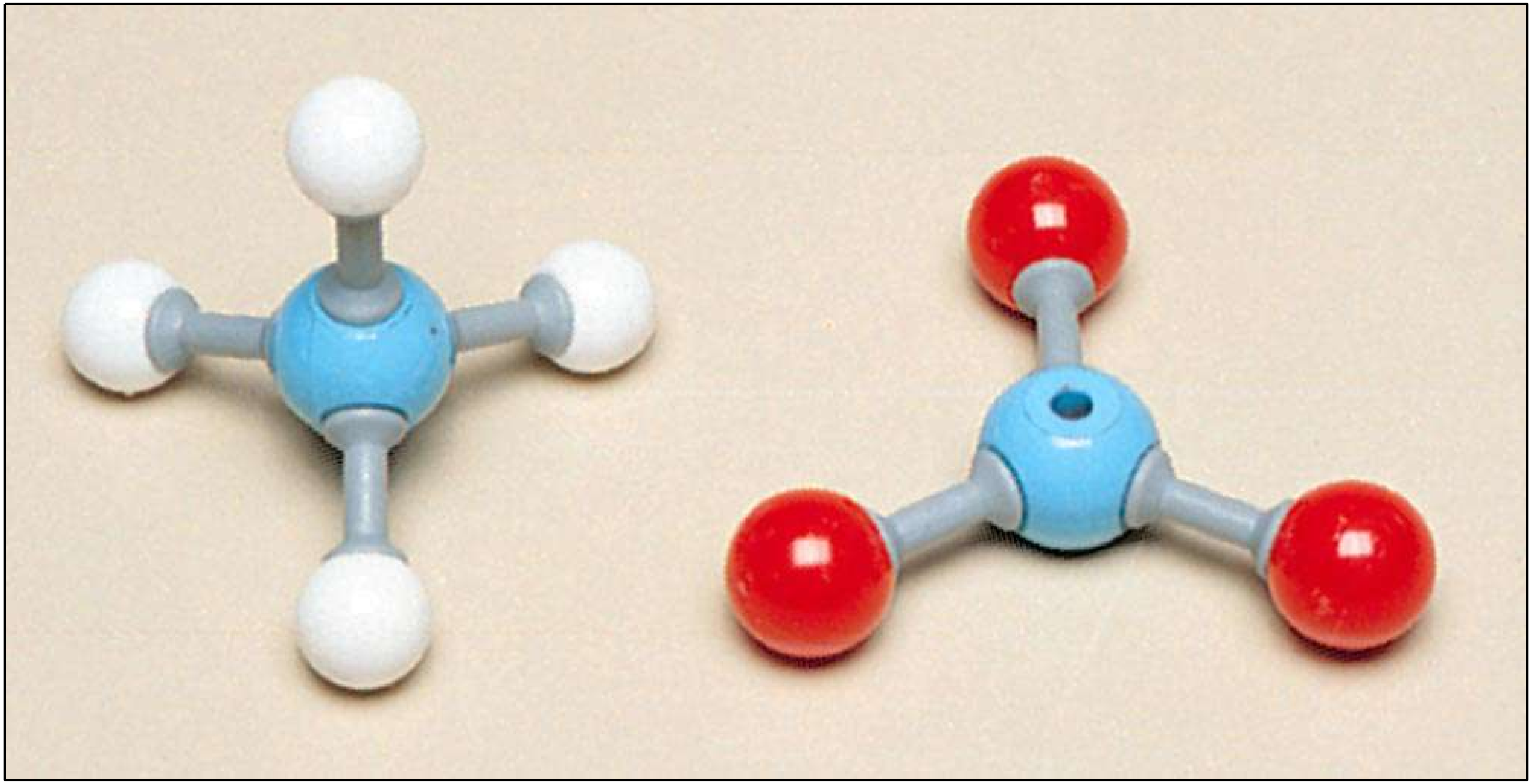
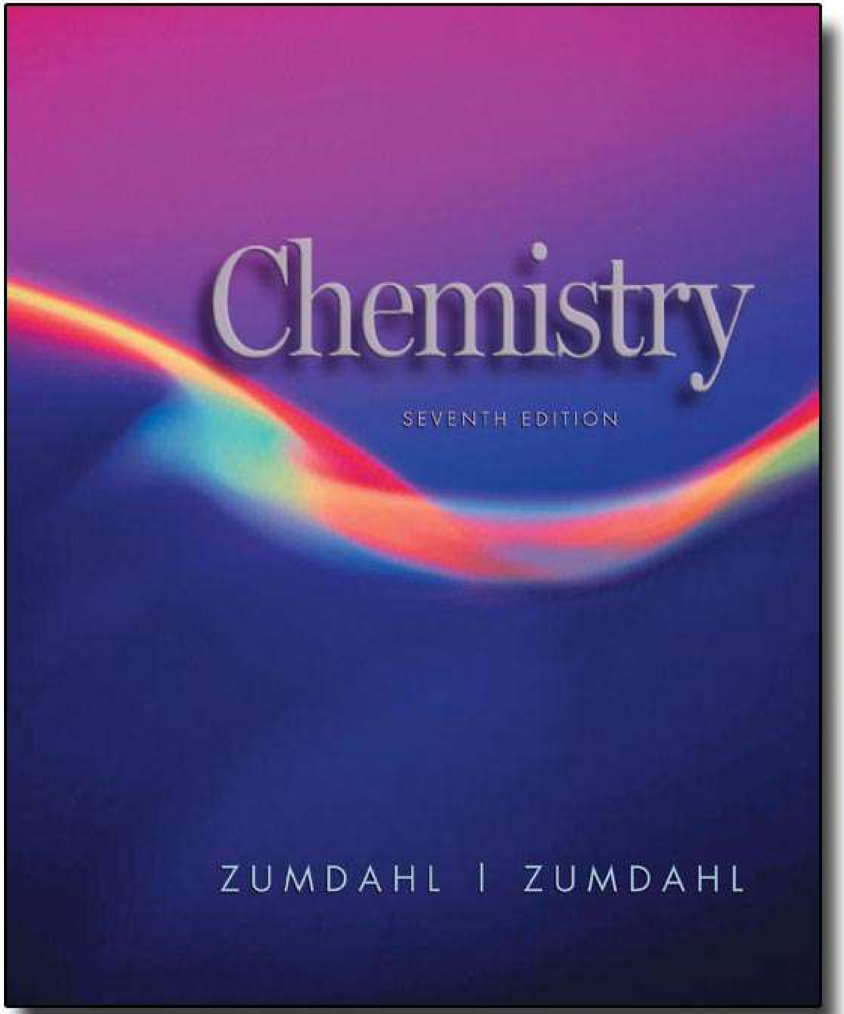


Figure 2.20 Ball-and-Stick Models of the Ammonium Ion and the Nitrate Ion





An Introduction to the Periodic Table

The Periodic Table

Alkali metals (group 1); Alkaline earth metals (group 2); Transition metals (groups 3–12); Halogens (group 17); Noble gases (group 18)

1 1A	2 2A	3	4	5	6	7	8	9	10	11	12	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac†	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup			

*Lanthanides	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
†Actinides	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Table 2.2 The Symbols for the Elements That Are Based on the Original Names

TABLE 2.2 The Symbols for the Elements That Are Based on the Original Names

Current Name	Original Name	Symbol
Antimony	Stibium	Sb
Copper	Cuprum	Cu
Iron	Ferrum	Fe
Lead	Plumbum	Pb
Mercury	Hydrargyrum	Hg
Potassium	Kalium	K
Silver	Argentum	Ag
Sodium	Natrium	Na
Tin	Stannum	Sn
Tungsten	Wolfram	W

Crystals of Copper(II) Sulfate

Table 2.3 Common Monatomic Cations and Anions

TABLE 2.3 Common Monatomic Cations and Anions

Cation	Name	Anion	Name
H^+	Hydrogen	H^-	Hydride
Li^+	Lithium	F^-	Fluoride
Na^+	Sodium	Cl^-	Chloride
K^+	Potassium	Br^-	Bromide
Cs^+	Cesium	I^-	Iodide
Be^{2+}	Beryllium	O^{2-}	Oxide
Mg^{2+}	Magnesium	S^{2-}	Sulfide
Ca^{2+}	Calcium	N^{3-}	Nitride
Ba^{2+}	Barium	P^{3-}	Phosphide
Al^{3+}	Aluminum		
Ag^+	Silver		

Figure 2.22 Common Cations and Anions

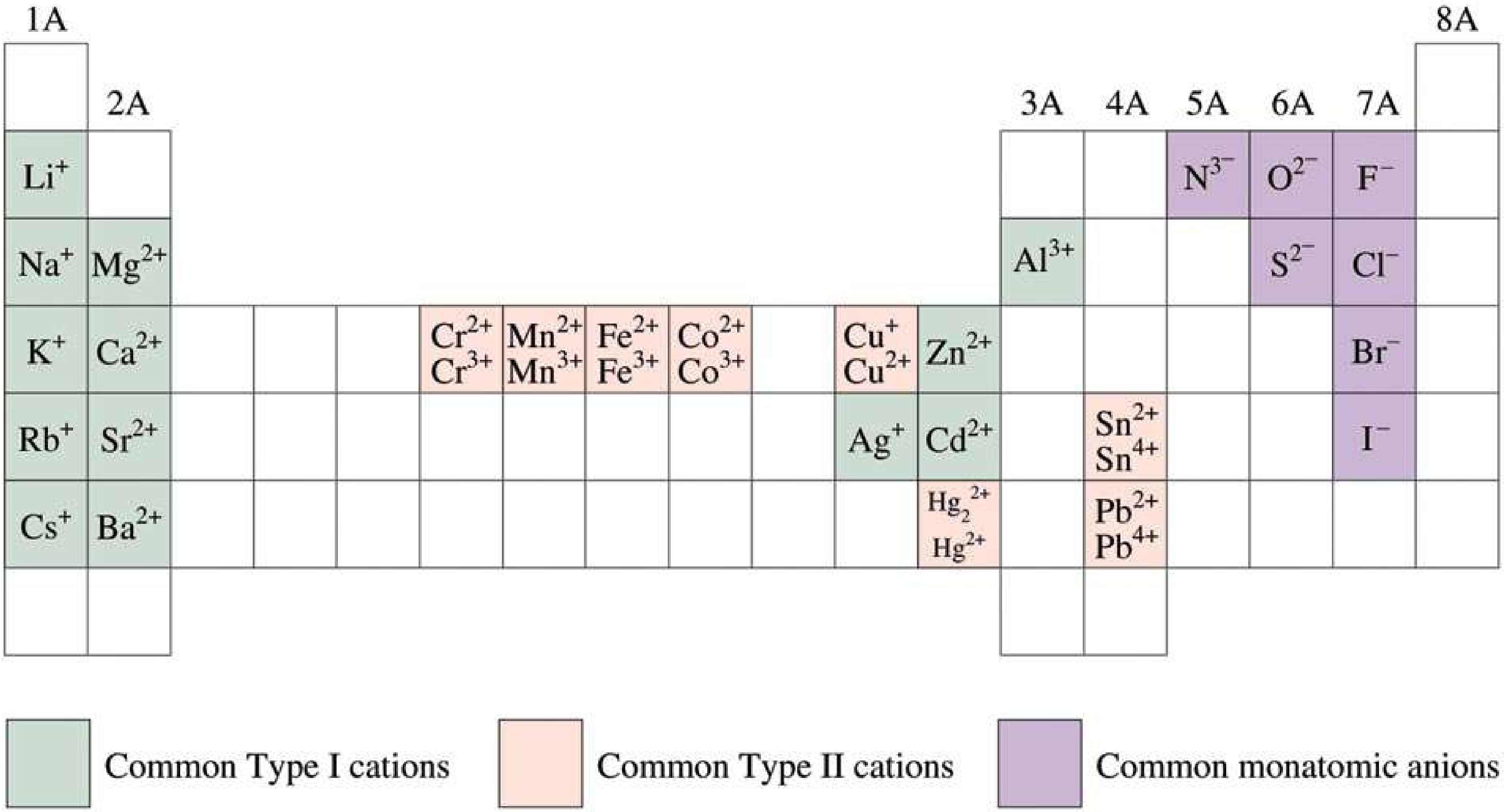


Table 2.4 Common Type II Cations

TABLE 2.4 Common Type II Cations

Ion	Systematic Name
Fe^{3+}	Iron(III)
Fe^{2+}	Iron(II)
Cu^{2+}	Copper(II)
Cu^{+}	Copper(I)
Co^{3+}	Cobalt(III)
Co^{2+}	Cobalt(II)
Sn^{4+}	Tin(IV)
Sn^{2+}	Tin(II)
Pb^{4+}	Lead(IV)
Pb^{2+}	Lead(II)
Hg^{2+}	Mercury(II)
Hg_2^{2+*}	Mercury(I)
Ag^{+}	Silver†
Zn^{2+}	Zinc†
Cd^{2+}	Cadmium†

*Note that mercury(I) ions always occur bound together to form Hg_2^{2+} ions.

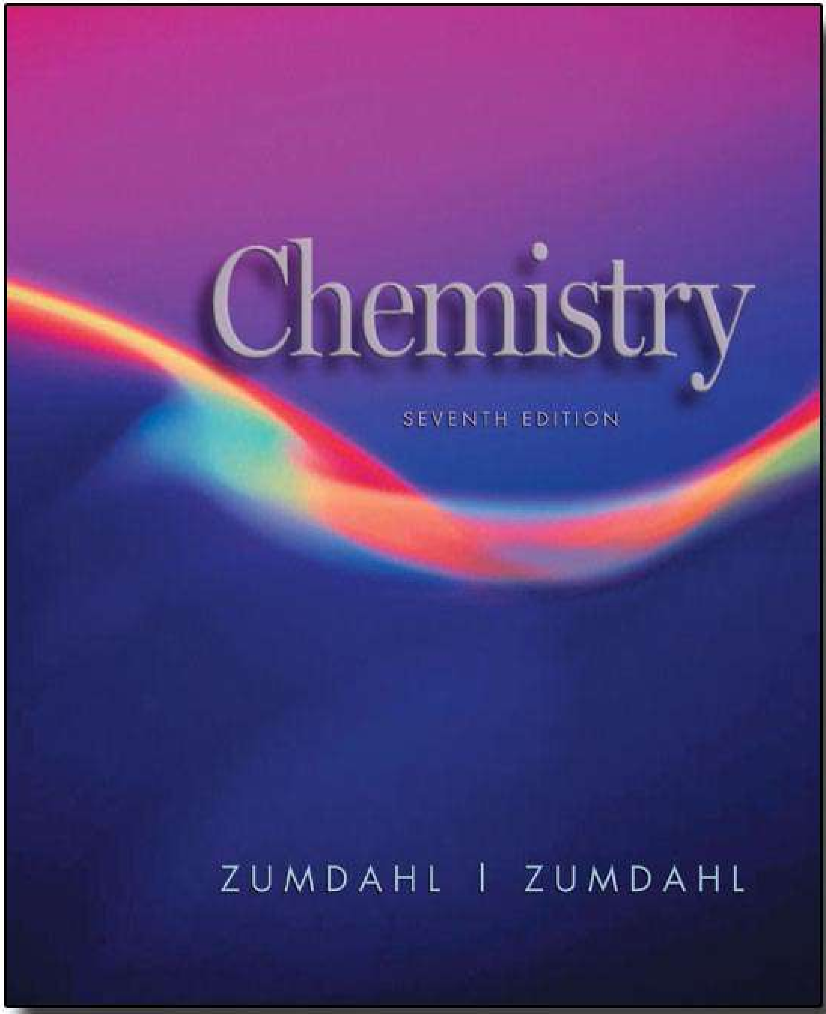
†Although these are transition metals, they form only one type of ion, and a Roman numeral is not used.

Various Chromium Compounds Dissolved in Water

Table 2.5 Common Polyatomic Ions

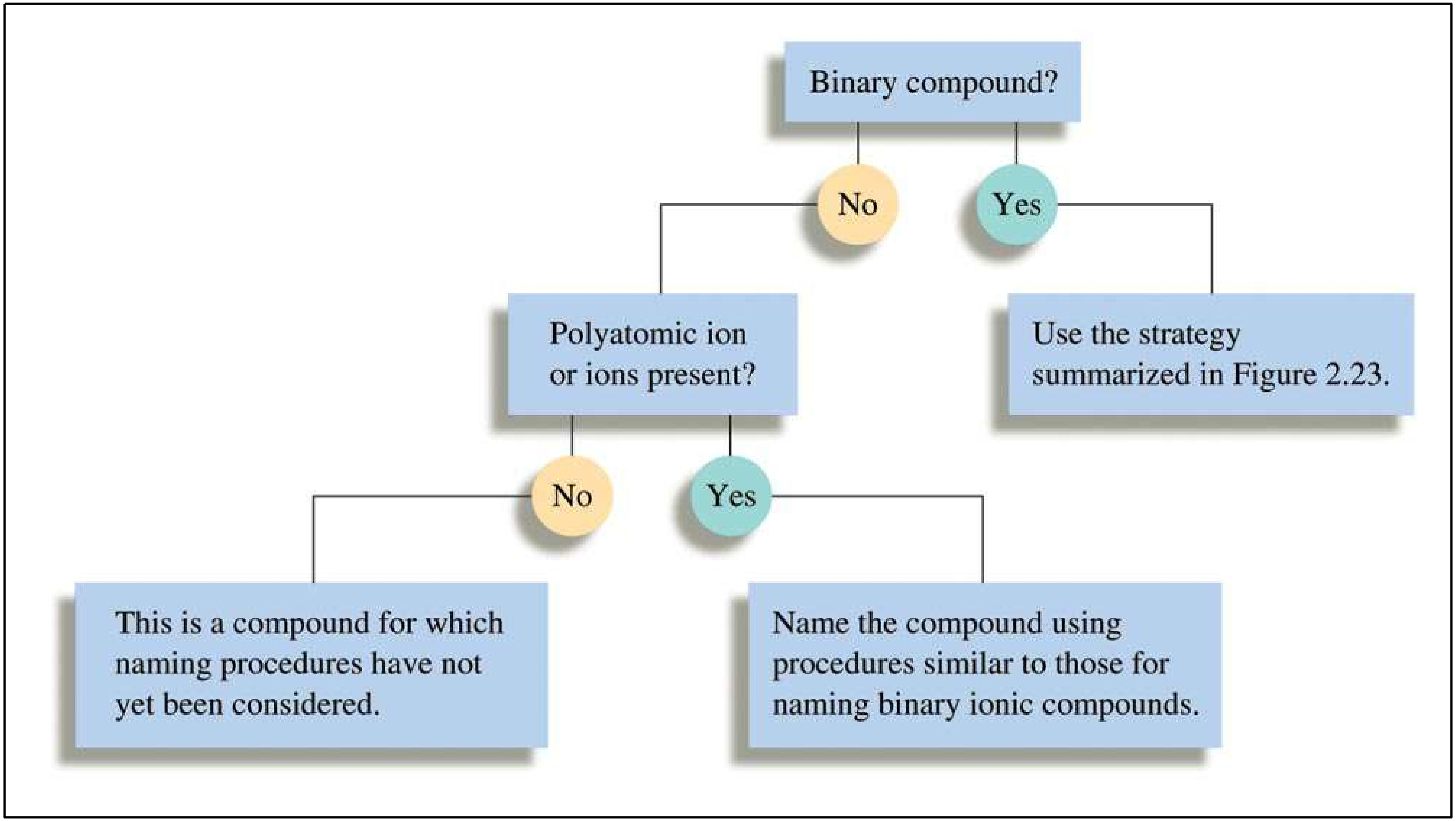
TABLE 2.5 Common Polyatomic Ions

Ion	Name	Ion	Name
Hg_2^{2+}	Mercury(I)	NCS^-	Thiocyanate
NH_4^+	Ammonium	CO_3^{2-}	Carbonate
NO_2^-	Nitrite	HCO_3^-	Hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	Nitrate		
SO_3^{2-}	Sulfite		
SO_4^{2-}	Sulfate	ClO^-	Hypochlorite
HSO_4^-	Hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	Chlorite
		ClO_3^-	Chlorate
		ClO_4^-	Perchlorate
OH^-	Hydroxide	$C_2H_3O_2^-$	Acetate
CN^-	Cyanide	MnO_4^-	Permanganate
PO_4^{3-}	Phosphate	$Cr_2O_7^{2-}$	Dichromate
HPO_4^{2-}	Hydrogen phosphate	CrO_4^{2-}	Chromate
$H_2PO_4^-$	Dihydrogen phosphate	O_2^{2-}	Peroxide
		$C_2O_4^{2-}$	Oxalate



Naming Simple Compounds

Overall Strategy for Naming Chemical Compounds



Flowchart for Naming Binary Compounds

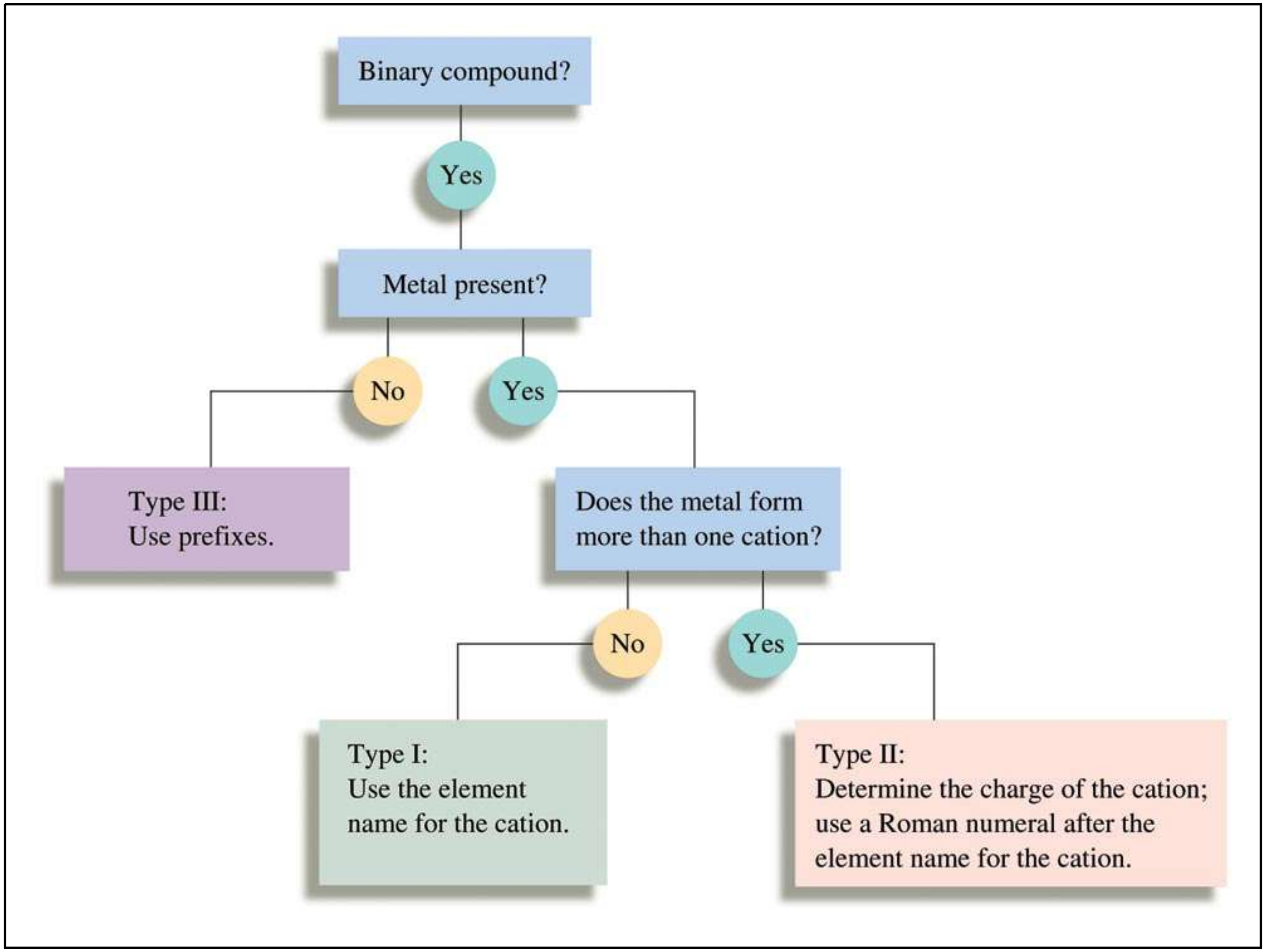


Table 2.6 Prefixes Used to Indicate Number in Chemical Names

TABLE 2.6 Prefixes Used to Indicate Number in Chemical Names

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

Flowchart for Naming Acids

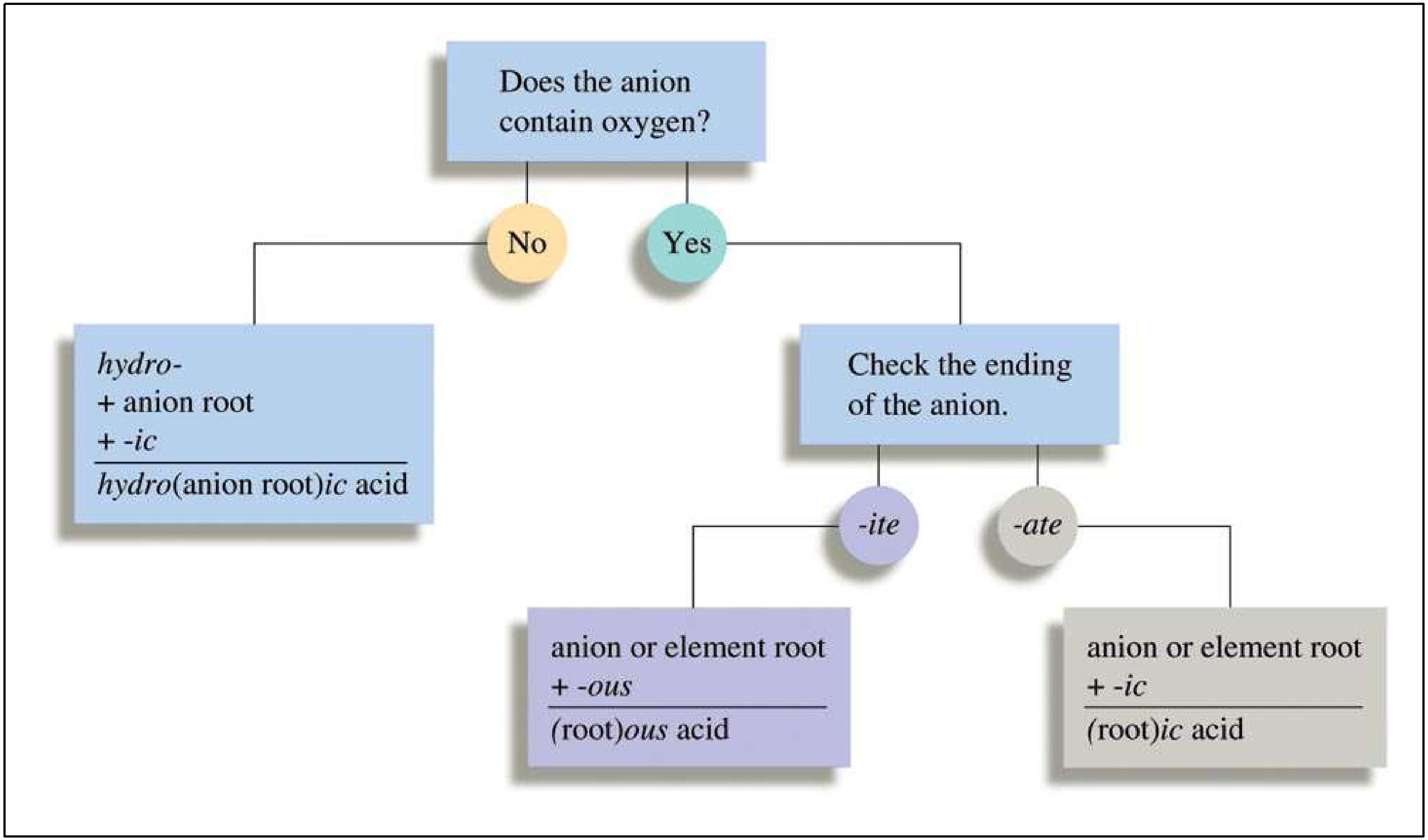


Table 2.7 Names of Acids* that Do Not Contain Oxygen

TABLE 2.7 Names of Acids* That Do Not Contain Oxygen

Acid	Name
HF	Hydrofluoric acid
HCl	Hydrochloric acid
HBr	Hydrobromic acid
HI	Hydroiodic acid
HCN	Hydrocyanic acid
H_2S	Hydrosulfuric acid

*Note that these acids are aqueous solutions containing these substances.

Table 2.8 Names of Some Oxygen-Containing Acids

TABLE 2.8 Names of Some Oxygen-Containing Acids

Acid	Name
HNO_3	Nitric acid
HNO_2	Nitrous acid
H_2SO_4	Sulfuric acid
H_2SO_3	Sulfurous acid
H_3PO_4	Phosphoric acid
$HC_2H_3O_2$	Acetic Acid

React 1

- Explain any problems with each of the names given in the table in your Interactive Course Guide.
- Complete the table.

React 2

- Determine the number of particles in solution and either the name or formulas for the compounds given in your Interactive Course Guide.