The McGraw-Hill Companies

Unit 1 - Lecture 4

Chemistry

The Molecular Nature of Matter and Change

Fifth Edition

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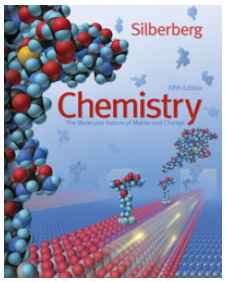
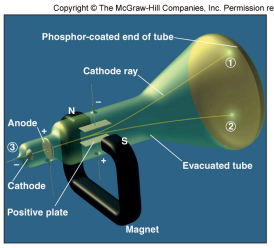


Figure 2.4

Experiments to determine the properties of cathode rays.

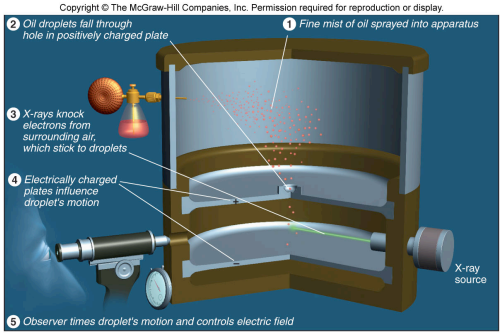


OBSERVATION	CONCLUSION
1. Ray bends in magnetic field	Consists of charged particles
2. Ray bends toward positive plate in electric field	Consists of negative particles
3. Ray is identical for any cathode	Particles found in all matter

Observation	Conclusion
Ray bends in magnetic field	Consists of charged particles
Ray bends toward positive plate in electric field	Consists of negative particles
Ray is identical for any cathode	Particles found in ALL matter

Figure 2.5

Millikan's oil-drop experiment for measuring an electron's charge.



Millikan used his findings to also calculate the mass of an electron.

determined by J.J. Thomson and others

$$\text{mass of electron} = \frac{\text{mass}}{\text{charge}} \times \text{charge}$$

$$= (-5.686\times10^{-12}\ \text{kg/C}) \times (-1.602\times10^{-19}\ \text{C})$$

$$= 9.109\times10^{-31}\ \text{kg} = 9.109\times10^{-28}\ \text{g}$$

Figure 2.6

Rutherford's α-scattering experiment and discovery of the atomic nucleus.

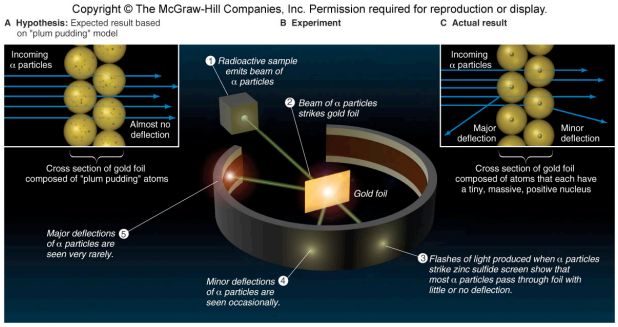


Figure 2.7 General features of the atom today.

- The atom is an electrically neutral, spherical entity composed of a positively charged central nucleus surrounded by one or more negatively charged electrons.

•The atomic nucleus consists of protons and neutrons.

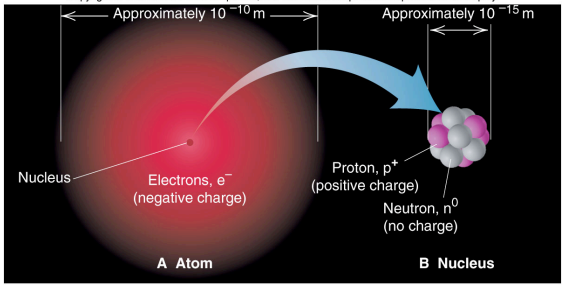


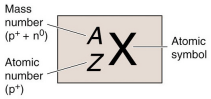
Table 2.2 Properties of the Three Key Subatomic Particles

Name(Symbol)	Charge Relative	Charge Absolute(C)*	Mass Relative(amu)†	Mass Absolute(g)	Location in the Atom
Proton (p^+)	1+	$+1.60218 \times 10^{-19}$	1.00727	1.67262×10^{-24}	Nucleus
Neutron (n^0)	0	0	1.00866	1.67493×10^{-24}	Nucleus
Electron (e^-)	1-	-1.60218×10^{-19}	0.00054858	9.10939×10^{-28}	Outside Nucleus

* The coulomb (C) is the SI unit of charge.

† The atomic mass unit (amu) equals 1.66054×10^{-24} g.

Atomic Symbols, Isotopes, Numbers



$^{A}_{Z}X$ = The symbol of the atom or isotope

X = Atomic symbol of the element

A = mass number; A = Z + N

Z = atomic number
(the number of protons in the nucleus)

N = number of neutrons in the nucleus

Isotope = atoms of an element with the same number of protons, but a different number of neutrons

See Laboratory Tools

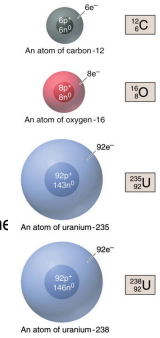


Figure 2.8

Sample Problem 2.4 Determining the Number of Subatomic Particles in the Isotopes of an Element

PROBLEM: Silicon (Si) has three naturally occurring isotopes: ^{28}Si, ^{29}Si, and ^{30}Si. Determine the number of protons, neutrons, and electrons in each silicon isotope.

PLAN: Mass number (A), protons + neutrons, is given for the listed isotopes. Atomic number (Z), number of protons, for each element is given in the periodic table and equal to the number of electrons. Number of neutrons is determined using equation 2.2.

SOLUTION: The atomic number of silicon is 14. Therefore

^{28}Si has $14p^+$, $14e^-$ and $14n^0$ (28-14)

^{29}Si has $14p^+$, $14e^-$ and $15n^0$ (29-14)

^{30}Si has $14p^+$, $14e^-$ and $16n^0$ (30-14)

Sample Problem 2.5 Calculating the Atomic Mass of an Element

PROBLEM: Silver's(Ag: Z = 47) naturally occurring isotopes, ^{107}Ag and ^{109}Ag, give this mass spectrometric data, calculate the atomic mass of Ag:

Isotope	Mass(amu)	Abundance(%)
^{107}Ag	106.90509	51.84
^{109}Ag	108.90476	48.16

PLAN: Find the weighted average of the isotopic masses.

mass(g) of each isotope

multiply by fractional abundance of each isotope

portion of atomic mass from each isotope

add isotopic portions

atomic mass

SOLUTION:

mass portion from ^{107}Ag = 106.90509 amu x 0.5184 = 55.42 amu

mass portion from ^{109}Ag = 108.90476amu x 0.4816 = 52.45amu

atomic mass of Ag = 55.42amu + 52.45amu = 107.87amu

The Modern Reassessment of the Atomic Theory

1. ***All matter is composed of atoms.*** The atom is the smallest body that *retains the unique identity* of the element.

2. ***Atoms of one element cannot be converted into atoms of another element in a chemical reaction.*** Elements can only be converted into other elements in nuclear reactions.

3. ***All atoms of an element have the same number of protons and electrons, which determines the chemical behavior of the element.*** Isotopes of an element differ in the number of neutrons, and thus in mass number. A sample of the element is treated as though its atoms have an *average* mass.

4. ***Compounds are formed by the chemical combination of two or more elements in specific ratios.***

Figure 2.9 The modern periodic table.

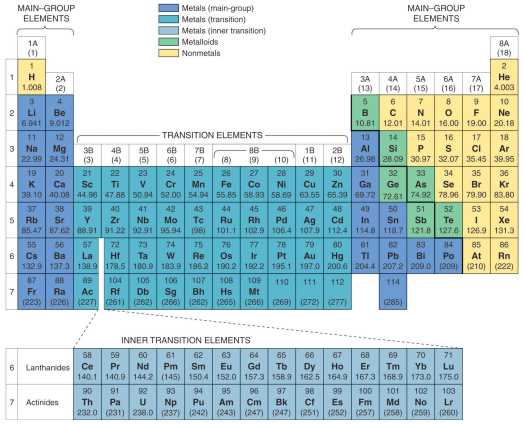


Figure 2.10 Metals, metalloids, and nonmetals