Modern View of Atomic Structure

- Since 1963, following the work of Murray Gell-Mann, physicists have described the structure of the atom in terms of quarks and electrons.
  - T Up quarks have a charge of +2/3 unit charge.
  - T Down quarks have a charge of –1/3 unit charge.
  - T Electrons have a charge of –1 unit charge.
  - T Protons and neutrons are made up of three quarks.

- proton = 2 up + 1 down
  = (2)(+2/3) + (–1/3) = +1

- neutron = 1 up + 2 down
  = (+2/3) + (2)(–1/3) = 0

L Quarks are not essential to understand general chemistry.

Subatomic Particles for Chemistry

Particle	Unit Charge	Mass
Proton (p)	1+	1.6726×10^{-24} g
Neutron (n)	0	1.6749×10^{-24} g
Electron (e)	1–	9.1095×10^{-28} g

Nuclear Parameters

1. All atoms of a given element have the same number of protons, which defines the element's **atomic number**, given the symbol Z.

2. Together, protons and neutrons are known as **nucleons**.

3. Any atom with a certain number of nucleons is called a **nuclide**.

4. The number of nucleons defines the nuclide's **mass number**, A:

$$A = \text{number of protons} + \text{number of neutrons}$$

K Note that A is an integer count of the number of nucleons, and *not* a statement of an atom's mass.

Isotopes and Isobars

Isotopes of an element have the same atomic number (Z) but have different numbers of neutrons and therefore different mass numbers (A).

Isobars are nuclides of different elements (different Z values) with the same mass number (A).

Nuclide Notation

$$^{A}_{Z}\mathrm{X}$$

X = element's symbol
Z = atomic number = number of protons
A = mass number = number of nucleons

Symbol	p	n	e
$^{16}_{8}\mathrm{O}$	8	8	8
$^{17}_{8}\mathrm{O}$	8	9	8
$^{15}_{8}\mathrm{O}$	8	7	8
$^{15}_{7}\mathrm{N}$	7	8	7

Monatomic Ions

Ion = electrically charged atom or molecule

Cation (kat! 23cn) = positively charged ion

Anion (an! 23cn) = negatively charged ion

Symbol	p	n	e
$^{16}_{8}O^{2-}$	8	8	10
$^{64}_{30}Zn^{2\%}$	30	34	28
$^{35}_{17}Cl^{-}$	17	18	18
$^{39}_{19}K^{\%}$	19	20	18

Isoelectronic = same number of electrons

Atomic Mass Units (amu or u)

One atomic mass unit is defined as 1/12 of the mass of a ${}^{12}_{6}C$ atom.

$$1 \text{ u} = 1.66054 \times 10^{-24} \text{ g}$$

Particle	Mass (u)
proton	1.007277 u
neutron	1.008665 u
electron	0.0005486 u

Binding Energy

The mass of a nuclide is not simply the sum of the masses of its fundamental particles.

Nuclide	Measured Mass	Calc'd Mass	Difference
${}^{12}_{6}C$	12 u (exactly)	12.098944 u	0.098944 u
${}^{16}_{8}O$	15.99491 u	16.13192_5 u	0.13702 u
${}^{15}_{7}N$	15.00011 u	15.12409_9 u	0.12399 u

K When atoms are formed from protons, neutrons, and electrons, some mass is converted into energy, called the **binding energy**.

K The mass equivalent of this energy can be calculated from the difference between the measured mass of the nuclide and the sum of the masses of its subatomic particles, using $E = mc^2$.

Atomic Weights

L Tabulated values of atomic weights of elements represent the average atomic mass of all isotopes comprising a naturally occurring sample.

- The average atomic mass is a weighted average, according to abundance of each isotope in a typical sample.

- Unless the element naturally occurs as only one isotope (e.g., F), atomic weights generally *do not* represent the masses of any individual atoms.