Chapter Goals

Upon completion of this chapter, you should be able to:

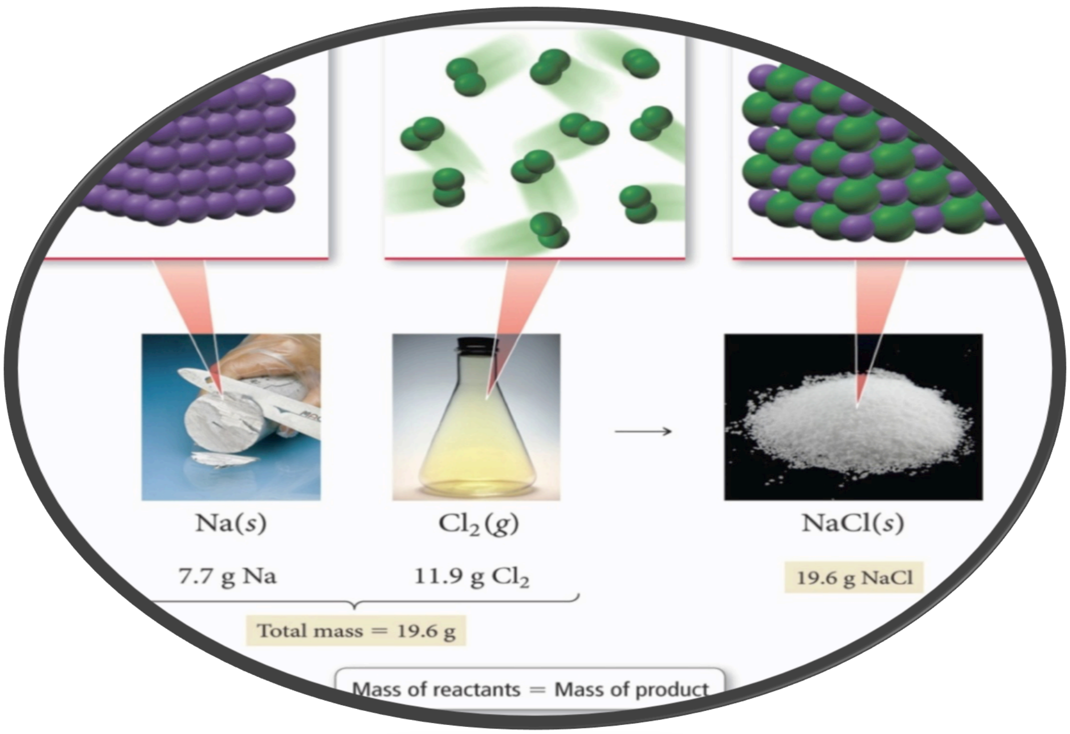
- ✓ Apply the law of multiple proportions, and conservation of mass.
- ✓ Describe what evidence about atomic structure was revealed by the experiments of Thomson, Millikan, and Rutherford.
- ✓ Know the atom in terms of composition and mass.
- ✓ Given the symbol atom or ion, determine the number of protons, neutrons, and electrons.
- ✓ Given the mass and natural abundance of all isotopes of a given element, calculate the average atomic mass of that element.
- ✓ Know the periodic table.
- ✓ Convert from mass to number of moles and to number of atoms.

- **Reading Assignement**: Sec 2.1 – 2.5 in Ch. 2 . Read and know the main concepts of: Atomic Theory of Matter, Dalton's Atomic Theory, Rutherford's experiment, nuclear model of the atom and Modern Atomic Theory and the Laws That Led to It**.**

Atomic Theory of Matter: that atoms are the fundamental building blocks of matter.

Three laws led to the development and acceptance of the atomic theory are as follows:

1. **Law of conservation of mass:**



2. **Law of Definite Proportions:** ***All samples of a given compound, regardless of their source or how they were prepared, have the same proportions of their constituent elements.***

3. **<u>The Law of Multiple Proportions:</u>** ***<u>When two elements form two different compounds, the weights of one element that combine with a fixed weight of the other are in a ratio of small whole numbers the masses.</u>***

- J. J. Thomson had discovered the electron, a negatively charged, low mass particle present within all atoms. (Cathode ray experiment)
- Millikan's Oil Drop Experiment: Determined the charge of an electron
- **Rutherford's Gold Foil Experiment:**
  - ✓ Alpha (α) particles are helium nuclei
  - ✓ Particles were fired at a thin sheet of gold foil
  - ✓ Particle hits on the detecting screen (film) are recorded
- ✓ **https://www.khanacademy.org/science/chemistry/electronic-structure-of-atoms/history-of-atomic-structure/v/rutherfords-gold-foil-experiment**

- **<u>Atom: is the smallest identifiable unit of an *element*.</u>**

  ► **<u>Diameter of a nucleus is only about 10^{-15} m.</u>**

  ➢ **<u>Diameter of an atom is only about 10^{-10} m.</u>**

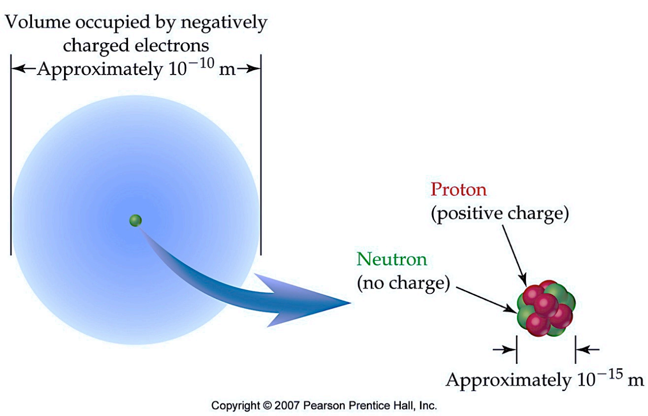


TABLE 2.1 Subatomic Particles

	Mass (kg)	Mass (amu)	Charge (relative)	Charge (C)
Proton	1.67262×10^{-27}	1.00727	+1	$+1.60218 \times 10^{-19}$
Neutron	1.67493×10^{-27}	1.00866	0	0
Electron	0.00091×10^{-27}	0.00055	−1	-1.60218×10^{-19}

► **<u>The relative size of a nucleus in an atom is the same as that of a pea in the middle of this stadium.</u>**

<u>Periodic Table →</u>

<u>Elements are symbolized by one or two letters</u>

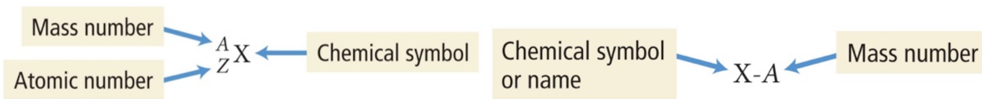
6
C
12.01

<u>Atomic Number:</u>

<u>Atomic Mass :</u>

<u># of Neutrons:</u>

Isotope: Atoms of the same element have the same number of protons but a different number of neutrons.



Isotope	^{12}C	^{13}C
Mass	12.00 amu	13.00 amu
% abundance	98.90%	1.10%

→ atomic mass unit (amu), An amu is a very, very, very,…. tiny fraction of a gram

$$\mathbf{1\ amu} = \frac{1\ \text{gram}}{6.022 \times 10^{23}} = \mathbf{1.661 \times 10^{-24}\ g}$$

We must account for the **natural abundance** of each isotope when we determine the **atomic mass** of an element

$$\begin{aligned}\text{Atomic mass} &= \sum_n (\text{fraction of isotope } n) \times (\text{mass of isotope } n)\\ &= (\text{fraction of isotope 1} \times \text{mass of isotope 1})\\ &+ (\text{fraction of isotope 2} \times \text{mass of isotope 2})\\ &+ (\text{fraction of isotope 3} \times \text{mass of isotope 3}) + \ldots\end{aligned}$$

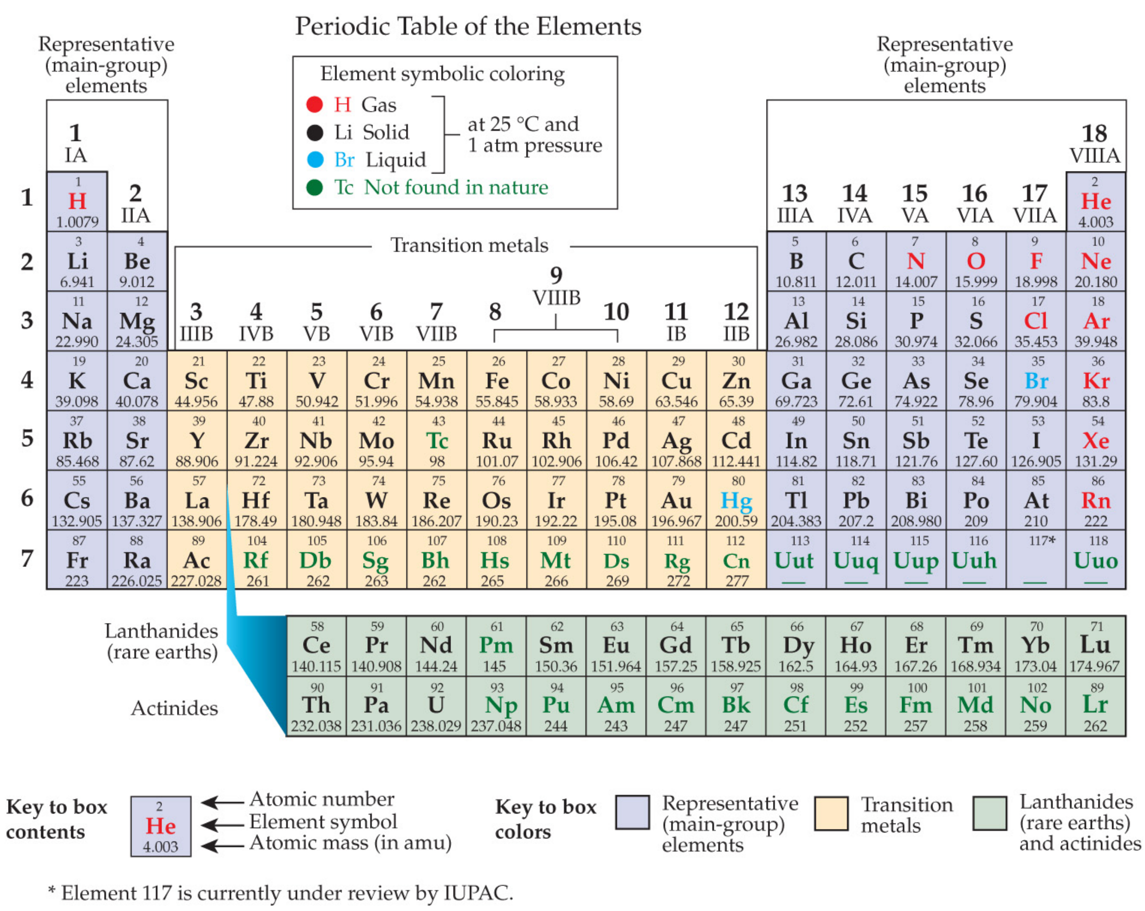
Naturally occurring chlorine consists of 75.77% chlorine-35 atoms (mass 34.97 amu) and 24.23% chlorine-37 atoms (mass 36.97 amu). We can calculate its atomic mass:

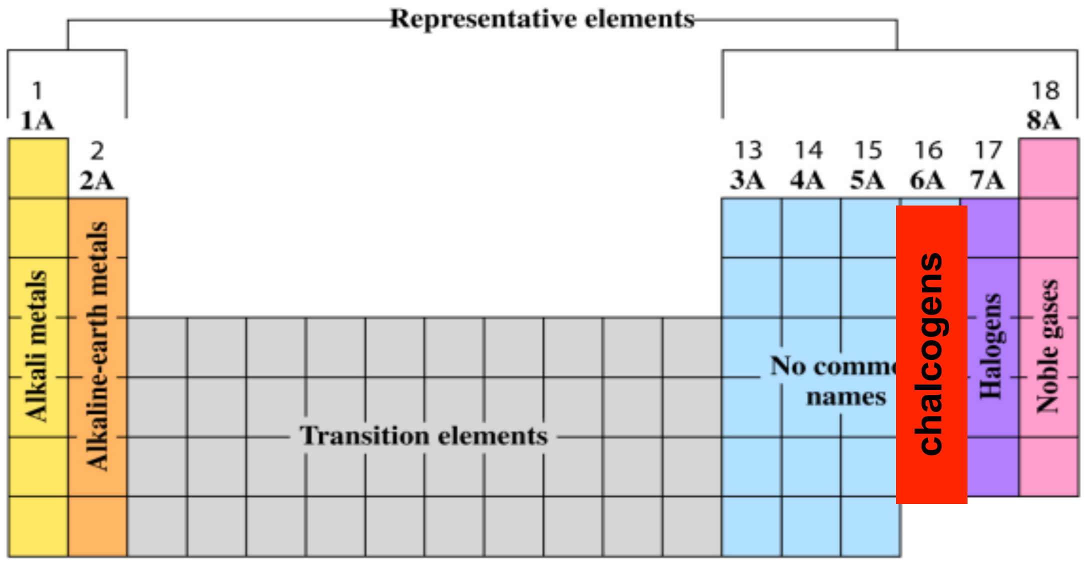
Boron is 19.9% ^{10}B and 80.1% ^{11}B. That is, ^{11}B is 80.1 percent abundant on earth. What is the atomic weight for Boron?

Periodic Table:

- Elements are arranged in order of increasing **atomic number**.
- The rows on the periodic chart are periods.
- Columns are groups.
- Elements in the same group have similar chemical properties.
- A repeating pattern of reactivities.

Periodic Table of the Elements lists all known elements according to their **atomic numbers**





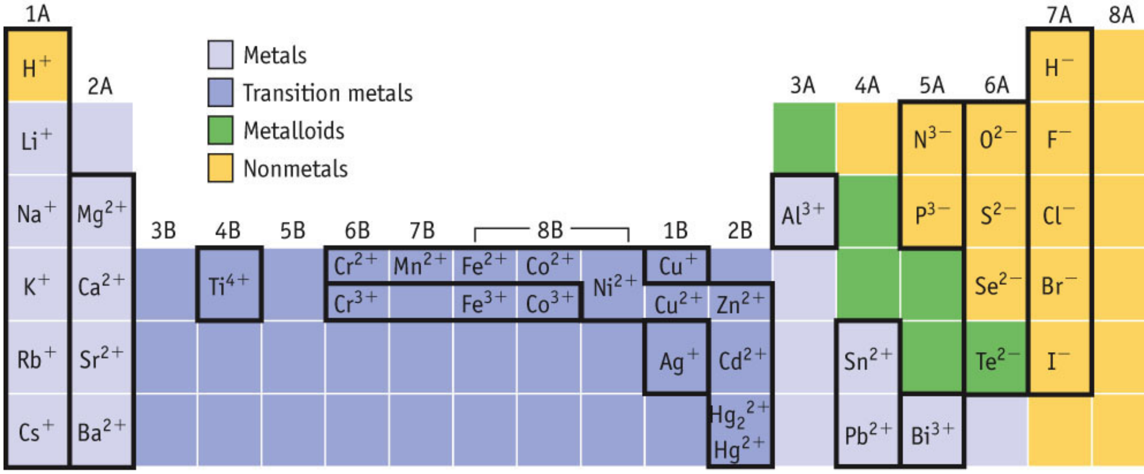
- ✓ Atoms are neutral due to balanced numbers of protons and electrons.
- ✓ **Ions** are when this balance is not present. Either an electron is added or removed

➢ **Charges on Common Ions:**

Complete the following

Element	# e lose or gain	charge of ion	symbol of ion	cation or anion
Al	_______	______	_____	______
Cl	_______	______	_____	______
Ca	_______	______	_____	______
N	_______	______	_____	______

For main group elements: atoms tend to have the same number of e-'s as nearest Group 8A atom. **(Isoelectroic)**



Now let's scale things up:

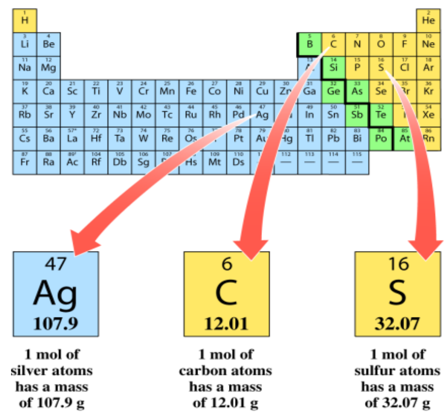
- **Molar mass**
  - is the atomic mass expressed in grams.

OR

- The mass of one mole of substance in grams
- **Molar mass** = Mass of 1 mole of a substance.

  = Mass of 6.022 x 10^{23} molecules of a substance.

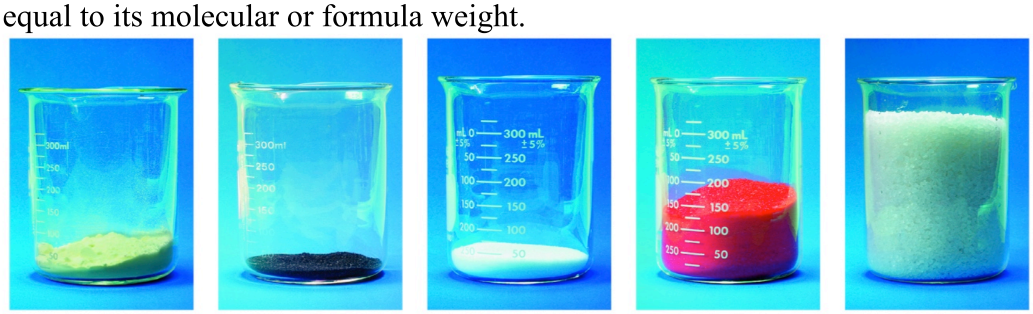
  = Molecular (formula) weight of substance in grams.



- **Molecular weight**: The sum of atomic weights of all atoms in a molecule. Used for **covalent compounds.**

- **Formula weight**: The sum of atomic weights of all atoms in one formula unit of any compound. Used for **Ionic compounds**.

- **Mole**: One mole of any substance is the amount whose mass in grams (molar mass) is numerically equal to its molecular or formula weight.



S Fe NaCl $K_2Cr_2O_7$ $C_{12}H_{22}O_{11}$

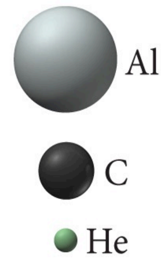
Avogadro's number and the mole (A Chemist's "Dozen")

- **Avogadro's number**: The number of molecules or formula units in a mole. $N_A = 6.022 \times 10^{23}$
  - 6.022×10^{23} marbles = (This many marbles would cover the earth to a depth of 50 miles)

26.98 g aluminum = 1 mol aluminum = 6.022×10^{23} Al atoms

12.01 g carbon = 1 mol carbon = 6.022×10^{23} C atoms

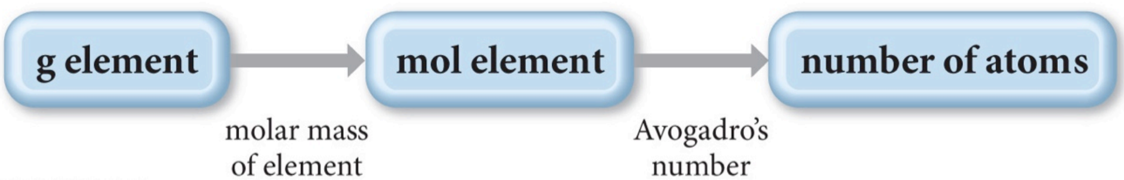
4.003 g helium = 1 mol helium = 6.022×10^{23} He atoms



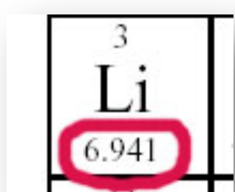
12 eggs = 12 carbon atoms =

6.022×10^{23} eggs = 6.022×10^{23} carbon atoms =

Conceptual Plan



How many grams of lithium are in 3.50 moles of lithium?



How many moles of lithium are in 18.2 grams of lithium?

How many <u>atoms</u> of lithium are in 3.50 moles of lithium?