Announcements for Wednesday, 11SEP2024

For those who just recently joined the class:

- Check Canvas Announcements and e-mails often and read through all the posted material as soon as possible to get current with the class

For everyone:

- Homework Assignments available on Canvas
  - Week 2: **Readiness Assessment** will be **re-opened** on **Friday, 13SEP2024, for 24 hours**
  - Week 2: *Study Skills* and *Time Management* Digital Badge Assignments due **Friday, 13SEP2024, at 11:59 PM (EDT)**
  - Week 3: Beginning of Semester Chemistry surveys due **Monday, 16SEP2024, at 11:59 PM (EDT)**
  - Week 3: *Metacognition* Digital Badge Assignment due **Friday, 20SEP2024, at 11:59 PM (EDT)**
- In-person/online recitations begin this week
  - Students interested in ALWs should attend regular recitations until officially accepted
- First Day Course Materials – See Canvas announcement about opting-out (deadline: 17SEP2024)

ANY GENERAL QUESTIONS? Feel free to see me after class!

The Conversion Factor Approach to Problem Solving

- convert 568 cm to yards (2.54 cm = 1 in)

$$568\ \mathrm{cm} \times \frac{1\ \mathrm{in}}{2.54\ \mathrm{cm}} \times \frac{1\ \mathrm{ft}}{12\ \mathrm{in}} \times \frac{1\ \mathrm{yd}}{3\ \mathrm{ft}} = \mathbf{6.21\ yd}$$

- What is the volume, in nm^3, of a 155.6 lb-sample of pure copper given that the density of copper = 8.96 g/cm^3 and 1.000 lb = 453.6 g?

$$155.6\ \mathrm{lb} \times \frac{453.6\ \mathrm{g}}{1.000\ \mathrm{lb}} \times \frac{1\ cm^3}{8.96\ g} \times \frac{1^3\ \mathrm{m}^3}{100^3\ \mathrm{cm}^3} \times \frac{(10^9)^3\ \mathrm{nm}^3}{1^3\ \mathrm{m}^3} = \mathbf{7.88 \times 10^{24}\ nm^3}$$

- The wheel of a child's tricycle has 12 metal spokes, and each spoke has a mass of 15 g. What mass of metal, in kg, is needed to provide enough material for the spokes in 2.5 dozen tricycles?

$$2.5\ \text{dozen tricycles} \times \frac{12\ \text{tricycles}}{1\ \text{dozen tricycles}} \times \frac{3\ \text{wheels}}{1\ \text{tricycle}} \times \frac{12\ \text{spokes}}{1\ \text{wheel}} \times \frac{15\ \mathrm{g}}{1\ \text{spoke}} \times \frac{1\ \mathrm{kg}}{1000\ \mathrm{g}} = \mathbf{16\ kg}$$

- A sunscreen preparation contains 2.50% benzyl salicylate by mass (in other words, there are 2.50 g of benzyl salicylate in every 100 g of sunscreen). If a tube contains 4.0 ounces of sunscreen, how many kilograms of benzyl salicylate are needed to manufacture 325 tubes of sunscreen? 16 ounces = 453.6 g

$$325\ \text{tubes sunscreen} \times \frac{4.0\ \text{ounces sunscreen}}{1\ \text{tube sunscreen}} \times \frac{453.6\ \mathrm{g}}{16\ \text{ounces}} \times \frac{2.50\ \text{g benzyl sal.}}{100\ \text{g sunscreen}} \times \frac{1\ \mathrm{kg}}{1000\ \mathrm{g}} = \mathbf{0.92\ kg\ benzyl\ salicylate}$$

Chapter 1: Atoms

Some questions we'll try to answer

- What is matter composed of and how can we understand the behavior of matter?
- How can we compare and contrast the different types of matter?
- How does science approach gaining knowledge about the world around us and how does this approach differ from other approaches?
- What observations and experiments led to our Modern Atomic Theory of Matter?
- Of what are atoms composed?
- What are isotopes and how do they impact an atom's average atomic mass?
- What is the concept of the mole and how should it be used?
- What is molar mass and for what can it be used?

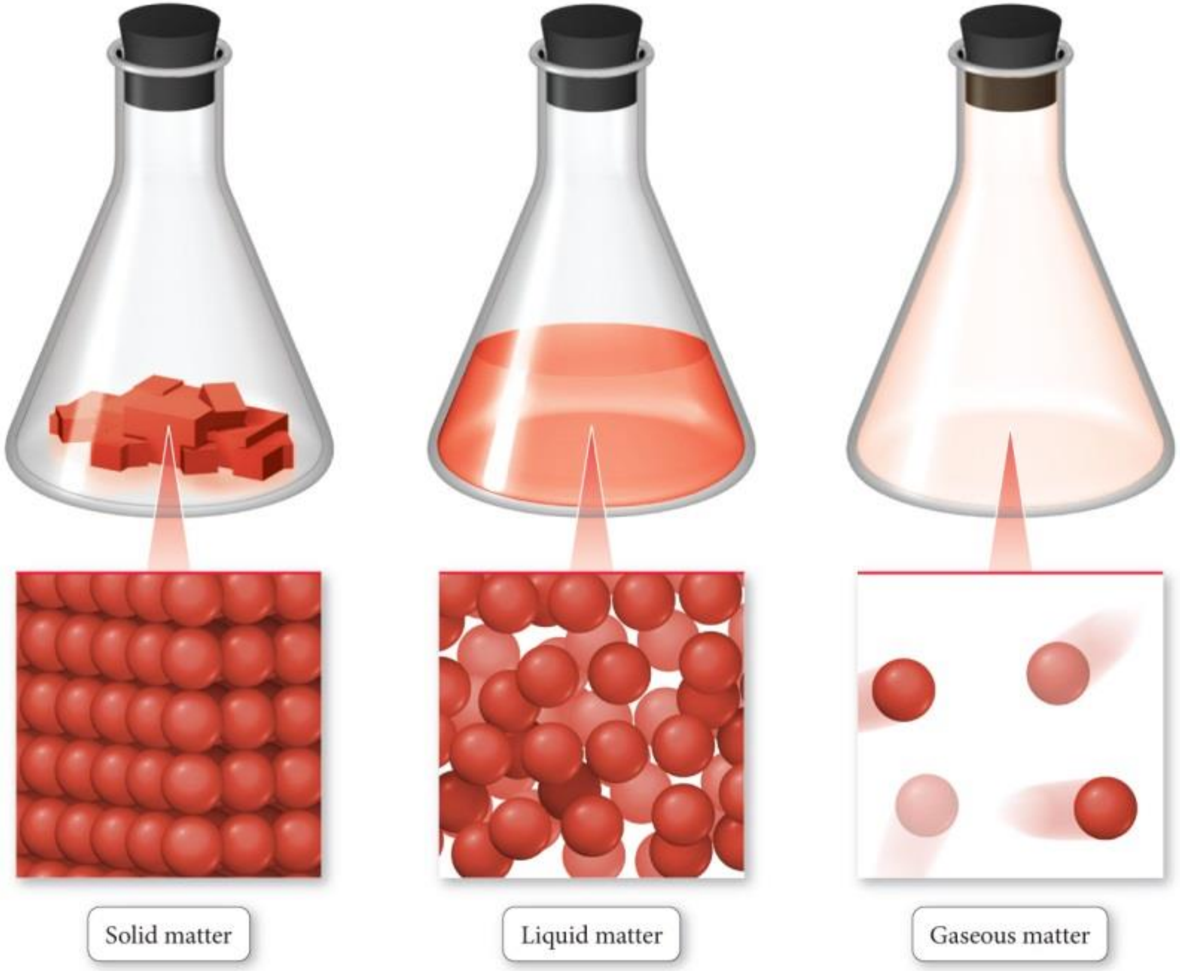
Structure Determines Properties

- **matter**: has mass, occupies volume
- all matter is composed of **particles**: atoms, ions, molecules
- the structure of the particles determines the properties of matter
  - physical properties vs. chemical properties (more on this later…)
  - Why does water dissolve some substances but not others?
  - Why is it so difficult to melt salt but not sugar?
  - Why does sodium metal cause an explosion when exposed to water but gold doesn’t?
  - Why do drugs work?

★ Changing the ***structure*** of the particles of a substance changes the ***properties*** of that substance!

Classifying Matter by State

- based on the strength of interactions that occur between particles making up the substance at a given temperature
- stronger interactions = less space, less mobility, more rigidity, more condensed state
- changing temperature can change the state



Classifying Matter by Composition

- pure substance vs. mixture
  - element vs. compound
  - homogeneous mixture vs. heterogeneous mixture

when classifying matter by composition, consider these questions:

- How many types of **particles (?!?)** make up the matter?
- How many different types of atoms make up the matter?
- Is the composition of the matter *fixed and definite*?
- Can the matter be separated into simpler components? If yes, then by what kinds of methods?
  - **physical (?!?)** methods vs. **chemical (?!?)** methods
- Is the composition of the matter *uniform* throughout the sample?

Classifying Matter by Composition

pure substances

element:

hydrogen, carbon, gold, uranium, etc.

composed of atoms of one type

cannot be separated into simpler components by chemical or physical methods

compound:

water, sodium chloride, carbon dioxide, glucose, etc.

composed of at least two types of atoms

fixed, definite composition from sample to sample

can be separated into simpler components by chemical methods only

Classifying Matter by Composition

mixtures

- composed of at least two types of elements or compounds
- composition can change from sample to sample
- can be separated into simpler components by physical methods (e.g., filtration, distillation, crystallization, decanting, etc.)

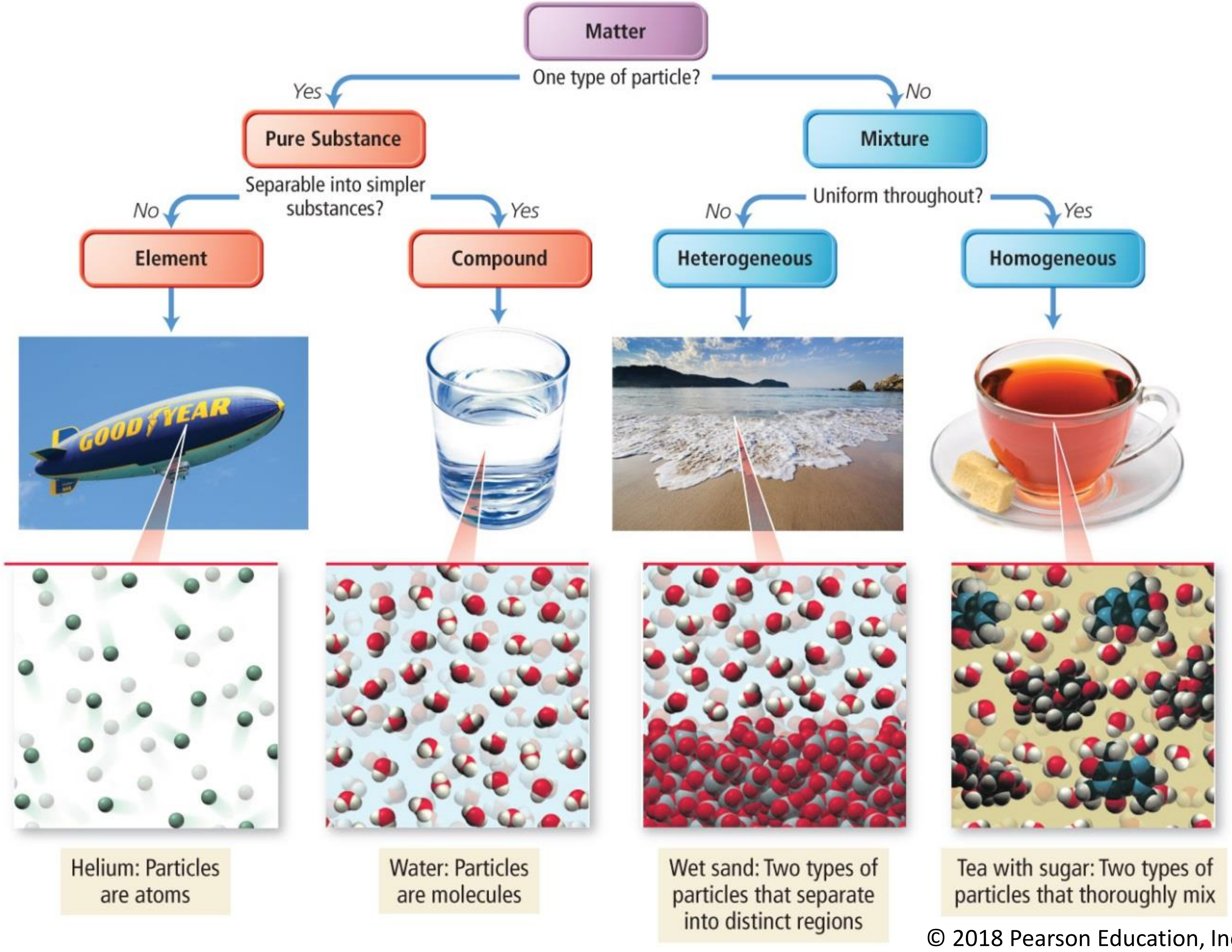
homogeneous: ***uniform*** properties and composition <u>within the same sample</u>

sugar water, black coffee, vinegar, 14k gold, etc.

heterogeneous: properties and/or composition change within the same sample

oil/water mixture, water/sand mixture, chicken noodle soup, concrete, etc.

Classifying Matter by Composition (Figure 1.3)



Classify the following samples of matter

- a marble countertop? heterogeneous mixture
- white vinegar? homogeneous mixture
- hydrogen chloride gas? compound
- pure table sugar? compound
- argon gas? element
- sand from the beach? heterogeneous mixture
- a brass ring? homogeneous mixture (a metal alloy)

Early Ideas about the Building Blocks of Matter

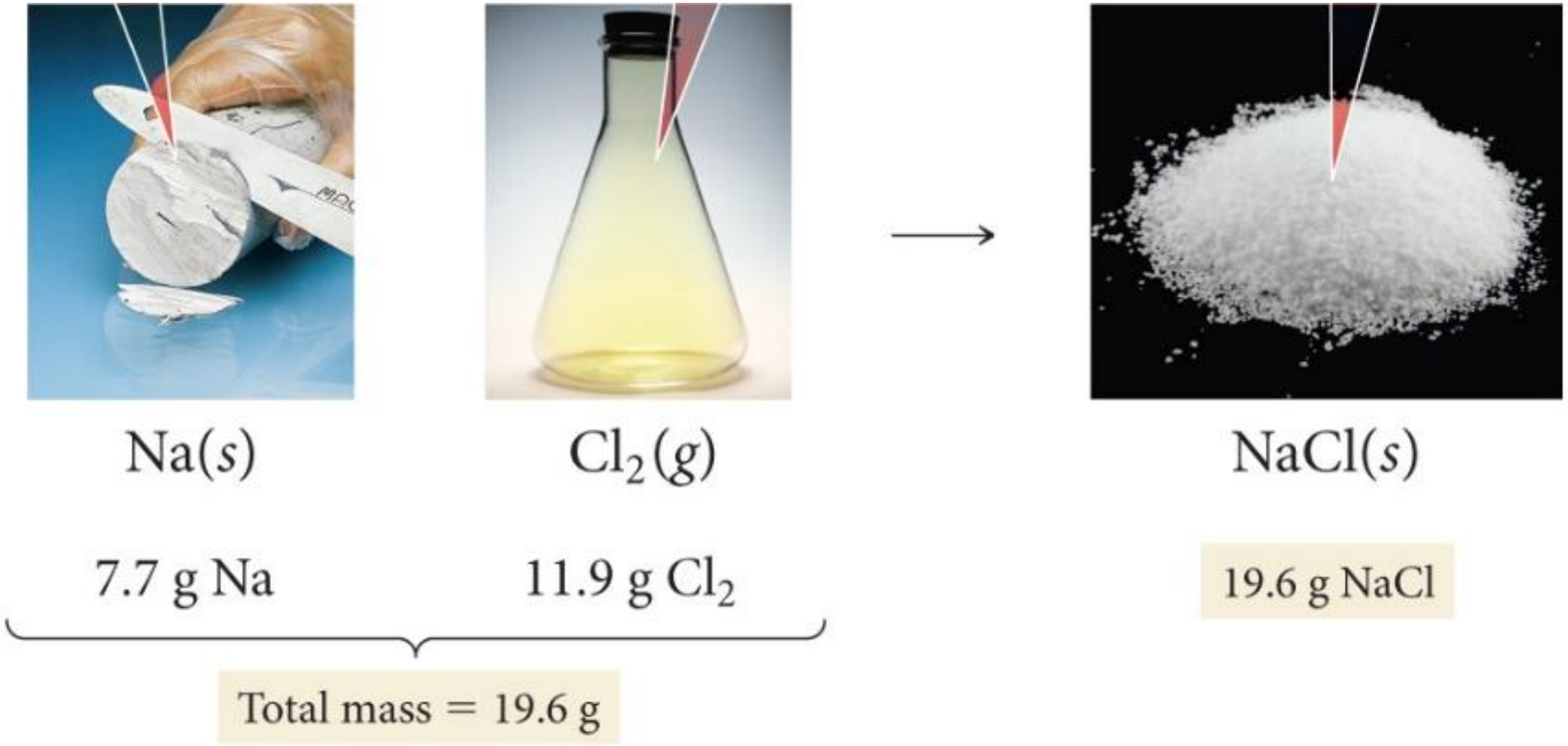
- we are very familiar with the idea of matter being composed of atoms
  - that has not always been the case

- How did scientist progress to the idea of the atom?

- **focus on the progression of thought and *the scientific process* employed over $\sim$ 20 years**

The Law of Conservation of Mass

- 1789, Antoine Lavoisier
- "In a chemical reaction, matter is neither created nor destroyed."



- consequence: if mass is conserved during a reaction, whatever is making up the matter must still be present somehow

The Law of Definite Proportions (the Law of Constant Composition)

- 1797, Joseph Proust
- “Samples of a given compound, regardless of source or method of preparation, have the same proportions of their constituent elements.”
- for example it was found that when 18.0 g of water was decomposed into its constituent elements, 16.0 g oxygen and 2.0 g hydrogen were formed

$$Mass\ ratio = \frac{16.0\ g\ oxygen}{2.0\ g\ hydrogen} = \frac{8.0\ g\ O}{1.0\ g\ H}\ \text{or } 8{:}\,1$$

- if a pure sample of matter is suspected to be water, regardless of origin, it **must (!!)** have an oxygen-to-hydrogen mass ratio of 8:1.
- this law hints that the make-up of matter must be due to the combination of elements in *fixed and discrete* amounts

John Dalton's Atomic Theory (1808)

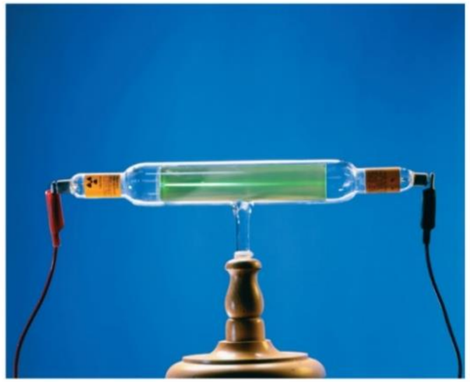
- Dalton realized that the Laws of Conservation of Mass, Definite Proportions, and Multiple Proportions can all be explained if a ***particulate*** view of matter is taken:

1. Each element is composed of tiny, indestructible particles called atoms
2. All atoms of a given element have the same mass and other properties that distinguish them from the atoms of other elements
3. Atoms combine in simple, whole-number ratios to form compounds
4. Atoms of one element cannot change into atoms of another element. In a chemical reaction, atoms only change the way that they are bound together with other atoms

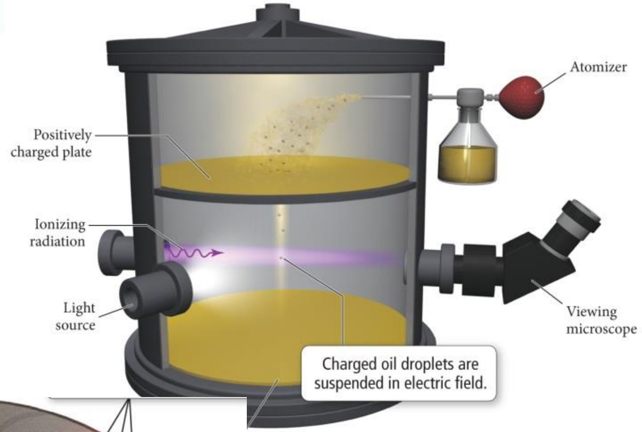
- 1, 2, and 4 found not to be exactly true, but still VERY impressive
  - such an important theory coming from such simple observations regarding mass information

Development of Our Modern Understanding of the Atom

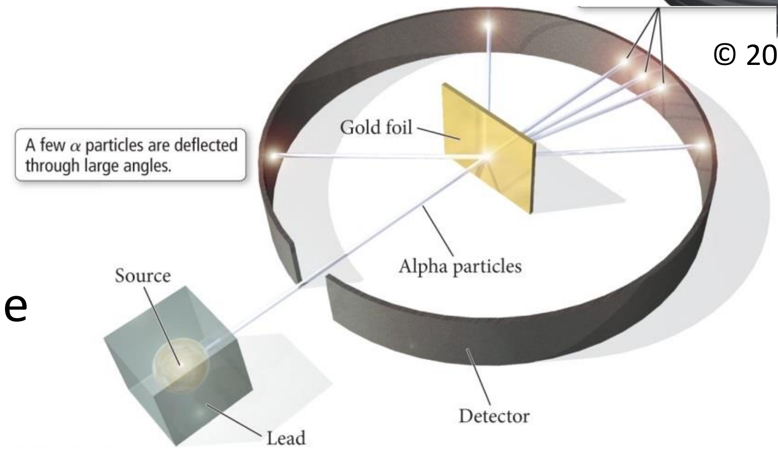
- J.J. Thompson’s cathode ray experiment
  - atoms ARE divisible and the electron was discovered



- Robert Millikan’s oil drop experiment
  - charges on oil drops are whole-number multiples of the charge of a single electron
  - the charge of an electron was determined



- Ernest Rutherford’s gold foil experiment
  - the discovery of the nucleus and the disproving of the plum-pudding model of an atom



The Truth About Atoms

- All atoms are composed of protons, neutrons, and electrons (…sorry, Mr. Dalton)

TABLE 1.1 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}

- **atomic mass unit (amu or u) =** a unit of mass well suited for dealing with individual protons, neutrons, atoms, molecules, etc.
  - an amu is defined as 1/12 the mass of a single carbon-12 atom (six protons + six neutrons)
  - *1 amu = 1.6605×10^{-24} g = 1.6605×10^{-27} kg*
- protons and neutrons have approximately same masses; electrons are much less massive
- charge of 1 proton equal in magnitude to charge of 1 electron, but opposite sign
- no need to memorize this information (will be provided on exams if needed)

Elements and Ions

- identity of an element determined by the number of protons (atomic number, Z)
    - for neutral atoms, Z also is number of electrons
- each element can be identified by a unique chemical symbol (i.e., an elemental symbol)
    - many symbols come from the Latin names of the elements:
    - sodium = Na (natrium), lead = Pb (plumbum), iron = Fe (ferrum), etc.
- all atoms of a given element **must** have the same number of protons, but not necessarily the same number of neutrons (more in a moment…)
- **ions: NOT the same as atoms(!)**
    - formed by loss or gain of ***electrons*** (not protons) to make cations and anions, respectively. Al^{3+} cation, Cl^{-} anion
    - Na vs. Na^{+}
    - don't be lazy or careless when designating a species as either an atom or ion!

Isotopes

Dalton: "All atoms of a given element have the same mass and other properties…"

…***Not Quite***

- **isotopes =** atoms with the same number of protons but different number of neutrons (and, therefore, slightly different masses)
  - different isotopes of an element generally exhibit the same ***chemical*** behavior
- a naturally occurring sample of a given element may be made up of more than one isotope
  - example: carbon (6 p^+) with 6, 7, or 8 neutrons
- **mass number (A) =** number of protons + number of neutrons
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