FOUNDATIONS OF ATOMIC THEORY
With the invention of the balance, matter was studied quantitatively.

This lead to the discovery of several basic chemistry laws:
- Law of conservation of mass
- Law of definite proportions
- Law of multiple proportions
- **Law of conservation of mass**: law which states that mass is neither created nor destroyed during ordinary chemical reactions or changes.
- **Law of definite proportions**: law which states that a given compound always contains elements in a certain proportion by mass (constant composition)
- **Law of multiple proportions**: law which states that elements can combine in different ways to form different substances, whose mass have a small whole-number ratio.
John Dalton (1808)

- English teacher
- Proposed an explanation for the law of conservation of mass, law of definite proportions, and the law of multiple proportions
Dalton’s theory summarized:

1. All matter is composed of atoms.
2. Atoms of a given element are the same in size, mass, and other properties.
3. Atoms cannot be subdivided, created, or destroyed.
4. Atoms of different elements combine in simple whole-number ratios to form chemical compounds.
5. In chemical reactions, atoms are combined, separated, or rearranged.
- Not all of Dalton’s theories were correct

- What has changed:
  - Atoms can be subdivided into smaller particles
  - Can break down atom into *subatomic particles*
  - A given element can have atoms with different masses
    - Some elements have *isotopes*

- Concepts that remain unchanged:
  - All matter is made up of atoms
  - Atoms of any one element *differ in properties* from atoms of another element
THE STRUCTURE OF THE ATOM
All atoms consist of 2 regions:

1. **Nucleus**: very small region located near the center of the atom
   - **Proton**: positively charged particle
   - **Neutron**: neutrally charged particle
2. **Electron**: negatively charged particle surrounding the nucleus of an atom

The nucleus, protons, neutrons, and electrons are also known as *subatomic particles*

- Most of the mass of the atom is in the nucleus
- Most of the volume of the atom is empty space
The first discovery of a subatomic particle resulted from investigating the relationship between electricity and matter. Cathode Rays & Electrons

- In 1897, J.J. Thomson used a cathode ray tube to reason the presence of a negatively charged particle.
- Cathode ray tubes pass electricity through a gas that is contained at a very low pressure.
- **Result of Thomson’s experiment**: all cathode rays are composed of identical negatively charged particles, which were later named **electrons**.
CATHODE RAY EXPERIMENT
Proposed a rationale for existence of positive particles:
- Atoms are neutral, so there must be positive particles in the atom to balance the negative charge of the electrons
- Electrons have so little mass that atoms must contain other particles that account for most of the mass
- Experiments have found the mass of an electron to be $9.109 \times 10^{-31}$ kg
Dalton’s Atomic Model
- Atoms are solid and indivisible
- Found to be wrong after the discovery of the electron

Thomson’s Atomic Model
- Solid blob of positive charge with negative electrons embedded on the surface
- Known as the “plum pudding” model
In 1911, Ernest Rutherford and associates provided more detail to the atom’s structure. Scientists fired a thin, gold foil with fast moving alpha particles (positively charged particles). Expected the particles to pass through.
Rutherford's Gold Foil Experiment

Rutherford Experiment: Nuclear Atom
**Conclusion:**

- Reasoned that the particles that bounced back experienced a powerful force within the atom.
- Force must be caused by a very densely packed bundle of matter with a positive electric charge at the core of atom—*the nucleus*!
- Disproved Thomson’s model of the atom!
- Discovered that the volume of a nucleus was very small compared with the total volume of an atom.
Rutherford’s Atomic Model

- Planetary model of the atom
- Rutherford suggested that the electrons surrounded the nucleus like planets around the sun
All atomic nuclei are made of two kinds of particles: protons & neutrons.

Atoms are neutral because they contain equal numbers of protons and electrons.

- A proton has a mass of $1.673 \times 10^{-27}$ kg
- A neutron has a mass of $1.675 \times 10^{-27}$ kg

### COMPOSITION OF THE ATOMIC NUCLEUS

<table>
<thead>
<tr>
<th>Subatomic Particle</th>
<th>Charge</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron</td>
<td>-1</td>
<td>$9.109 \times 10^{-31}$</td>
</tr>
<tr>
<td>Neutron</td>
<td>0</td>
<td>$1.675 \times 10^{-27}$</td>
</tr>
<tr>
<td>Proton</td>
<td>+1</td>
<td>$1.673 \times 10^{-27}$</td>
</tr>
</tbody>
</table>
Construct an essay comparing & contrasting the atomic models of Dalton, Thomson, and Rutherford. (You may include other atomic models in your comparison, if you choose.)

- Explain the similarities and differences between the models
- Describe how the models look like and what subatomic particles are present, if any
- Explain how the model was theorized and how it changed

Construct an image progression of the atomic models from Dalton through Rutherford. (You may include other models as well, if you would like.)

- Illustrations must be labeled appropriately (ex: protons, neutrons, electrons, nucleus)
- Briefly describe how it was discovered