Guided Practice Activities

**Module:** Course Introduction

**Section:** Early Experiments - Key
Early Experiments

Activity 1

The purpose of this activity is to guide your mastery of the history of the development of modern atomic theory by becoming familiar with some of the early experiments that led to scientists’ ability to think of matter on the atomic scale.

   
The Law of Conservation of Mass states that matter is neither created nor destroyed only arranged differently during a reaction.

   Consider an experiment wherein you burn a substance in a closed container. The mass of the closed system will remain the same even if the mass of the burned substance itself changes. The products formed by the combustion will retain the same mass as the reactants before the combustion.

2. State the Law of Definite Proportions and give an example of an experiment to prove the Law of Definite Proportions.
   
The Law of Definite Proportions states that a particular compound always has the same proportion of elements in its mass.

   Proust discovered this truth in the 18th century. Due to this law, we can say water always contains two hydrogen atoms and one oxygen atom. A different proportion of elements would produce a different compound. If you perform electrolysis on water (splitting H₂O into hydrogen and oxygen gas) you will observe that there is twice as much hydrogen gas produced as there is oxygen gas produced. This illustrates the fact that a sample of pure water always has twice as many hydrogen atoms as oxygen atoms.

3. State the Law of Multiple Proportions and give an example of an experiment to prove the Law of Multiple Proportions.
   
The Law of Multiple Proportions states that if two particular elements can form multiple compounds together then a ratio of whole numbers (relatively small) will exist between the mass of the variable element in one compound to the mass of that element in the other compound.

   Copper II bromide (CuBr₂) will decompose into copper I bromide (CuBr) and bromine gas by heating. The copper II compound is a dark grey powder while the copper I compound is a greenish powder. You can observe the color change as you heat the substance and therefore see the law of multiple proportions holding true.
The relative amount of copper stays the same in both compounds but the amount of bromine does not.

4. Dalton leaned on the above laws to develop his theory of the atom. Please list the statements that Dalton made to define his theory of the atom.

- All matter is made of atoms, which are indivisible and indestructible particles.
- Atoms of a given element have identical mass and properties.
- Compounds result from the simple whole number combinations of two or more different kinds of atoms.
- Compounds of different atoms have different chemical properties and masses.
- When a chemical reaction occurs, atoms rearrange.

Activity 2

The purpose of this activity is for you to briefly describe the following experiments and outline what was discovered about the subatomic structure of the atom from the experiments so that you can understand that the development of the subatomic structure of atoms took many years and many experiments.

1. Describe the set up and outcomes for each of the following experiments:

Thomson’s Cathode Ray Experiment

- **Description:** A cathode ray tube is an evacuated glass tube with electrodes at either end. An applied voltage sends a beam of electrons from one side to the other. Thomson was able to deflect this beam with magnetic and electric fields.
- **Discoveries:**
  - Thomson discovered that the particles in the beam were extremely small due to how far they traveled (smaller than an atom).
  - Thomson discovered that the particles in the beam were negatively charged by the way they deflected in the presence of a magnetic field.
  - Thomson accurately measured the mass-to-charge ratio of the particle.
  - In this way Thomson discovered the existence of electrons.

Millikan’s Oil Drop Experiment

- **Description:** Millikan sprayed oil droplets above parallel plates. The oil droplets would pick up a charge due to friction as they exited the nozzle of the spraying apparatus. The droplets would fall between the parallel plates until terminal velocity reached. Then the voltage would be turned on and the plates would become charged. An oil drop would be caught between the downward pull of gravity and the upward pull of the electric field. By adjusting the electric field the droplet could be forced to rise up or fall.
- **Discoveries:**
  - The charge of a single electron could be determined ($1.6\times10^{-19}$ C)
Rutherford’s Gold Foil Experiment

• **Description:** A beam of alpha particles (a helium nucleus with two protons and two neutrons) was aimed at a piece of gold foil. When the alpha particles bounced off something of comparable size (i.e. not an electron) they were deflected and hit a surrounding wall of detecting material.

• **Discoveries:**
  o Most of the alpha particles passed straight through the gold foil and only a small percentage were deflected.
  o This indicated that there was a very small positively charged portion of the gold atoms deflecting the positively charged alpha particles.
  o This also indicated that most of the gold atom was “empty space” and the small positively charged portion was a tiny percentage of the atom’s volume.
  o In this way Rutherford discovered the structure of an atom.