Name:____Date:_________Period:_____

POGIL: Atomic Models and the Development of the Atom

Background:

Models are used in science as a way to represent what we cannot see. They help us work with, visualize, and understand scientific concepts. However, models are constantly changing as we develop new technology and continue to make advancements. We are going to study the atom in this unit, and it is important to learn about the process of developing our most current model.

Model 1: Dalton

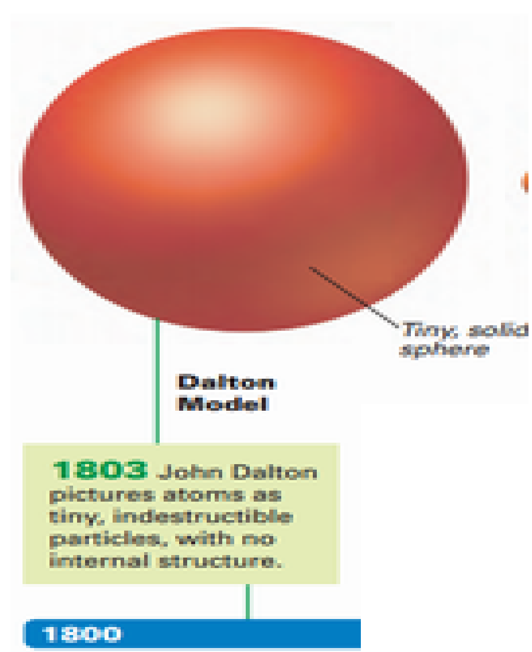
Dalton came up with the theory that described atoms in five postulates, meaning, a set of concepts or theories proposed by scientists. Dalton used experimentation to develop his postulates through testing gases. He first differentiated atoms via atomic weight. His data was flawed, however, but he is known as the father of atomic theory due to his immense strides in this topic. His five postulates are listed below:

1. All elements are composed of tiny indivisible particles called atoms that *cannot* be broken down further. *
2. Atoms of a given element are all similar in their physical and chemical properties. *
3. Atoms of different elements differ in their physical and chemical properties.
4. Atoms of different elements combine in simple, whole number ratios to form compounds.
5. In chemical reactions, atoms are combined, separated, or rearranged, but never created, destroyed, or changed.

*Indicates that the postulate is still held as true today.

Dalton's model summarizes these principles by showing that an atom is made up of solid, indivisible particles. This was originally stated by Greek philosopher Democritus, and he called the indivisible particle **atomos** (which means indivisible). However, Democritus did not have any support for his claim.

Dalton's model of the atom:

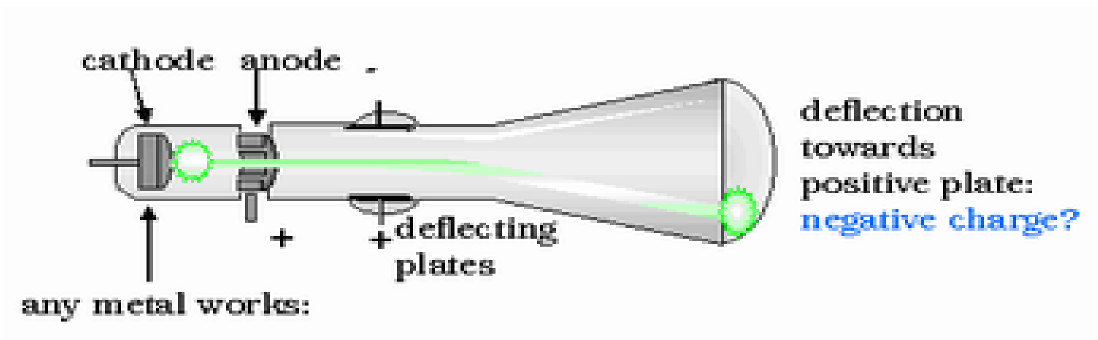


Key Content Questions:

1. Even though new models were discovered after Dalton created his five principles, which of these principles still holds true? (actually write them out)

Model 2: JJ Thomson

Using a cathode ray tube, **JJ Thomson** discovered the electron. A **cathode ray tube** is composed of a cathode or negative electrode, and an anode or positive electrode inside of an evacuated glass container. (Electrodes are metal plates with positive or negative charges on the surface). Thomson applied a charge to the cathode ray and observed the flow of electrons from cathode to anode through the open space of the container. These observations changed the way that atoms were portrayed since it was now determined that atoms *could* be further broken down.



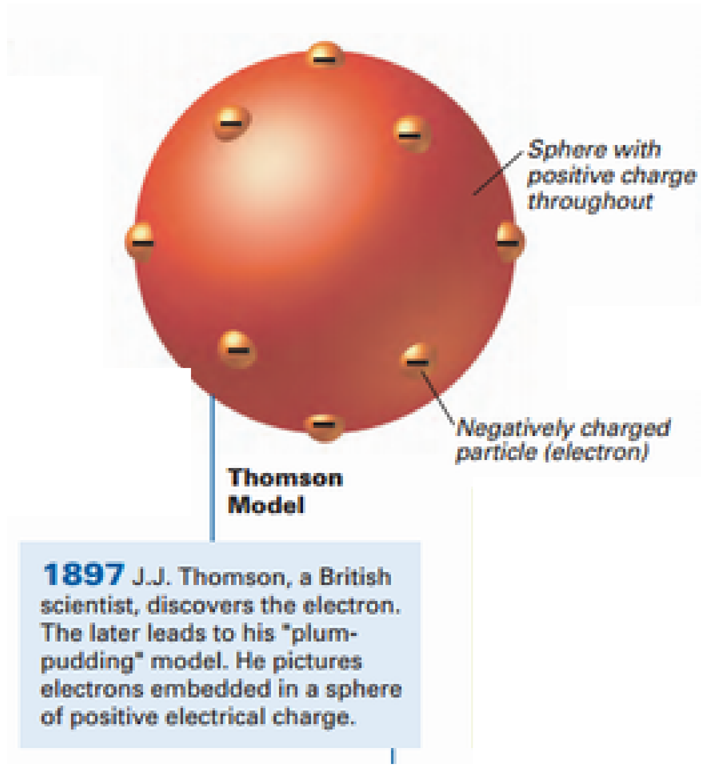
Thomson's model shows electrons scattered throughout an atom that is mostly a positively-charged cloud. In addition to the beam traveling from the negative cathode to the positive anode, Thomson put a magnetic field on the tube and noticed the beam was attracted to the positive end of the field. This allowed him to conclude there are negatively charged particles in the atom. Thomson also concluded that there must be an opposing positive charge surrounding the negative charge.

Thomson's "Plum Pudding" Model:

Key Content Questions:

2. What did Thomson determine the charge of an electron to be? (positive or negative)

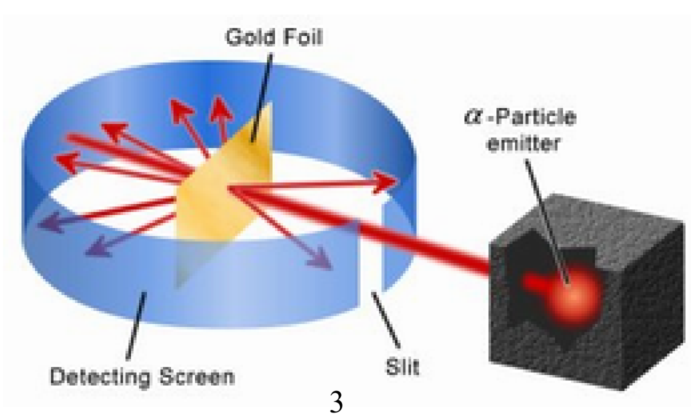
3. How did he determine this charge based on his experimentation?



Model 3: Rutherford

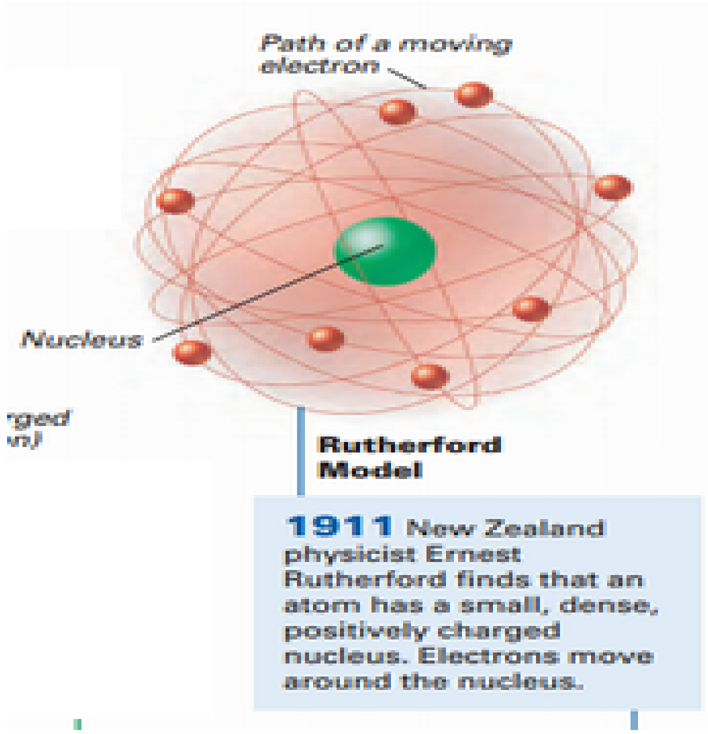
In 1911, the model of the atom changed once again after Ernest **Rutherford** discovered the nucleus. Rutherford aimed alpha particles (positively charged particles that represent a helium nucleus) at a thin sheet of gold foil. Based on Thomson's model, he expected the particles to travel straight through the foil. However, this was not the case.

Rutherford observed some particles that went straight through, but he also noticed some deflections back towards him and off to the side. This showed that protons and electrons were not evenly dispersed. Rutherford determined that protons are located in a concentrated area in the center of atom, and the electrons are dispersed in the empty space around it.



This means that Thomson's model was no longer correct, and that protons were found in a dense area of the atom called the nucleus. Electrons, on the other hand, are found in the empty space around the atom.

Rutherford's Model of the atom



Key Content Questions:

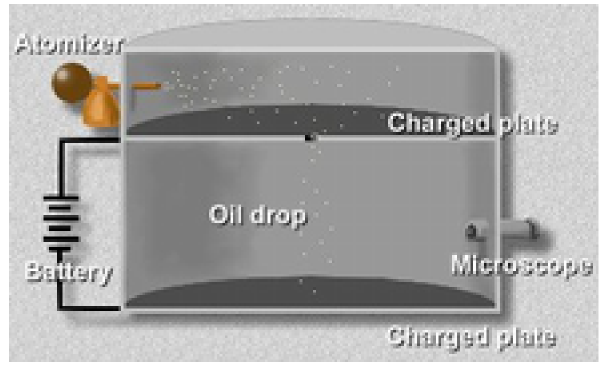
4. What did Rutherford expect to happen in his experiment?

5. What actually happened? What did this mean about the make-up of the atom?

6. What part of the atom is Rutherford credited for discovering?

Model 4: Millikan

An experiment performed by Robert Millikan in 1909 determined the size of the charge on an electron. He also determined that there was a smallest 'unit' charge, or that charge is 'quantized'. He received the Nobel Prize for his work. We're going to explain that experiment here, and show how Millikan was able to determine the size of a charge on a single electron.



What Millikan did was to put a charge on a tiny drop of oil, and measure how strong an applied electric field had to be in order to stop the oil drop from falling. Since he was able to work out the mass of the oil drop, and he could calculate the force of gravity on one drop, he could then determine the electric charge that the drop must have. By varying the charge on different drops, he noticed that the charge was always a multiple of -1.6 x 10 -19 C, the charge on a single electron. This meant that it was electrons carrying this unit charge.

Key Content Questions:

7. What was Millikan's main contribution to atomic theory? Give the value for this discovery.

8. What was the experiment he used to do make this discovery?

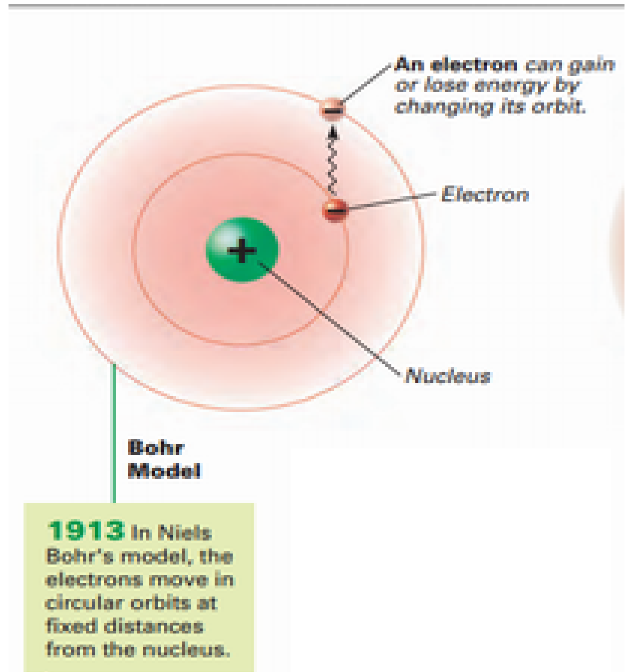
Model 5: Bohr

In 1912, Niels **Bohr** came up with a theory that explained why electrons do not spiral inward (as they should based upon classical physics and particle movement). He stated that electrons follow two rules.

1. Electrons orbit at specific distances from the nucleus. In other words, all electrons can be found at a certain distance from the nucleus in an orbital.
2. Atoms radiate (give off) energy when an electron jumps from a higher-energy orbit to a lower-energy orbit, and absorbs (take in) energy when the electron gets boosted from a low-energy orbit to a high-energy orbit.

This model is known as the planetary model since the electrons are orbiting around the nucleus much like the planets orbit around the sun. The first orbital only holds two electrons. Orbital two can hold up to eight electrons, orbital three can hold up to eighteen electrons, and orbital four and higher can hold up to thirty-two electrons. (2-8-18)

Bohr's Model of the Atom



Key Content Questions:

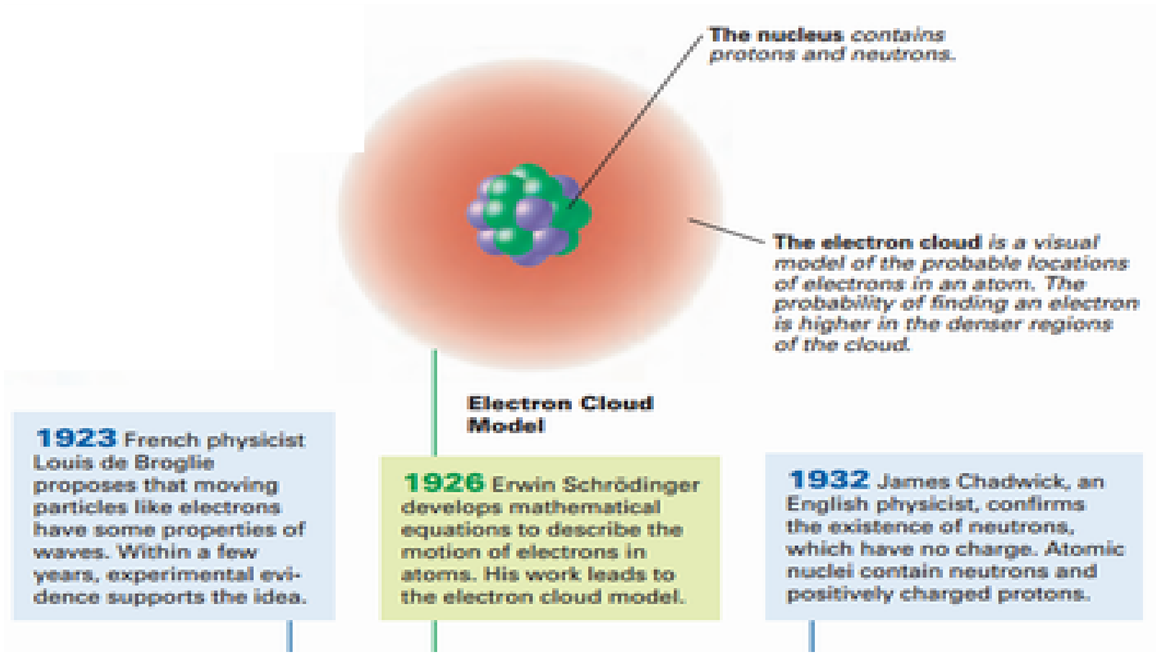
What are the circles around the nucleus called? What particle resides in them?

How can electrons move from one orbital to another?

Model 6: Today's Model…Quantum Mechanical Model

Fifteen years passed before another model of the atom was put into the mix. The next model, the **quantum mechanical model**, is a mathematical model that predicts the probability of electron locations and paths within an electron cloud. This model resulted from scientists such as deBroglie, Schrödinger, and Heisenberg. These scientists started to look at electrons acting as both particles and waves, and determined that there can be no certainty in finding the position of an electron if you know the momentum at which it travels. This led to the idea of electrons existing in an electron cloud moving as both a particle and a wave at the same time. Hence came the quantum mechanical model.

Quantum Mechanical Model:

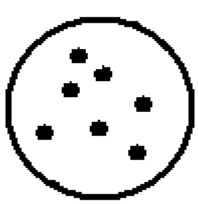
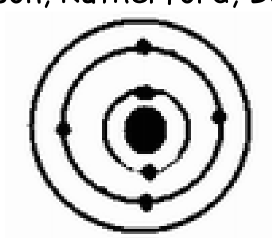
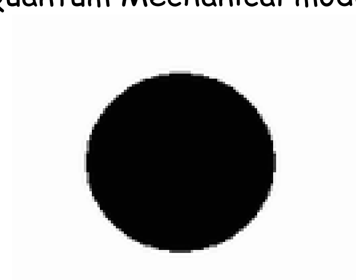


Key Content Questions:

In the Quantum Mechanical model, how do electrons travel? Where are they located?

Extension Question:

Label the models (Dalton, Thomson, Rutherford, Bohr, or Quantum Mechanical model).

_______________ _______________ _______________