Ms. Randall
Regents Chemistry
Lab Activity: Number of Aluminum Atoms

Background: Details about the size and structure of the atom arose over time with the help of many different scientists. **Democritus**, fourth century B.C. Greece, first suggested the idea of atoms. The belief was that the atom was the indestructible, indivisible fundamental unit of matter. Atoms became more meaningful when English schoolteacher **John Dalton** published his atomic theory (1803-1807). According to Dalton, an element was a collection of indivisible atoms of the same type, which can chemically combine to form compounds. In a chemical reaction, atoms can re-arrange to form new compounds, but they cannot be changed into atoms of another element. The model of the atom changed as scientists made new discoveries. Dalton's Solid sphere model was changed when **J.J. Thomson** discovered the electron and proposed the Plum Pudding Model. **Ernest Rutherford's** Gold Foil Experiment led to the discovery of a small dense nucleus where he proposed a Nuclear model for the atom. **Niels Bohr** modified the model to reflect electrons in orbit around the nucleus providing a Planetary model. Many scientists contributed to what is now called the **Quantum Mechanical Model**(Wave mechanical, electron cloud). Today scientists can "see" atoms with the use of a scanning tunneling microscope, STM, which uses electron current to map out the surfaces of atoms.

Using some simple math and basic calculations, we can calculate the amount of atoms in the height of a sheet of aluminum foil. We will assume the aluminum atoms are stacked on top of each other directly and that the atoms behave as solid spheres during the stacking process. The size of an aluminum atom was measured by a process called x-ray diffraction and found to be about **2.5×10^{-8} cm** in diameter. As all the previous scientist's had described, the diameter of an atom is very small.

Objective: To calculate the number of atoms in the height (thickness) of a thin sheet of regular aluminum foil and heavy duty aluminum foil. To conceptualize the size of the atom.

Pre Lab: Copy and complete these statements in your lab notebook.

1.______________ was the first scientist to suggest the idea of atoms.
2. Dalton proposed the ___________________theory.
3. J.J Thomson discovered the _____________and proposed the ______________model of the atom.
4.__________________conducted the gold foil experiment and proposed the ________________model of the atom.
5. Bohr suggested that _______________are in orbit around the nucleus and proposed the ____________model for the atom.
6. Today's scientists "see" atoms using a _____________________________________.

Materials:
Balance, aluminum foil, graduate cylinder, scissors, metric ruler

Procedure:

1. Each member of your group will predict the number of Al atoms that make up the thickness of a piece of aluminum foil. Record in your notebook.

   Regular aluminum_____________atoms
   Heavy Duty aluminum__________atoms

2. Using a metric ruler, cut a square piece of regular aluminum foil 10 cm by 10 cm. Measure the exact width and length of the foil and record it including units.

3. Crumple the 10 cm by 10 cm piece of foil into a ball and obtains its mass using the analytical balance. Record the mass including units below.

4. Repeat steps two and three for the heavy duty foil.

Data:

Regular Aluminum Foil	**Heavy Duty Aluminum foil**
Width	Width
Length	Length
Mass	Mass

Calculations: Remember to show all formulas, work and units in your lab notebook!

1. Using the **actual** density of aluminum (2.70 g/ml) and the measured mass of the foil, calculate the volume of the aluminum foil.

Regular Foil | **Heavy Duty Foil**

2. Using the length width and volume of the aluminum foil, calculate the **height** using the formula V= l x w x h. **Remember one mL is equivalent to 1 cm^3.**

Regular Foil | **Heavy Duty Foil**

3. The size of an aluminum atom was measured by a process called x-ray diffraction and found to be about **2.5×10^{-8} cm** in diameter.

Determine the thickness of the foil in "atoms". In other words, determine how many atoms are stacked on top of each other and would be found in the thickness(**height**) of aluminum foil (see picture).

Regular Foil

Heavy Duty Foil

Analysis

1. "How big is an atom?" If we were to enlarge an atom to the size of a basketball, then a dime would become as big as our entire planet. If an apple were enlarged to the size of the Earth, its individual atoms would be the size of regular apples. Another way to illustrate the sizes of an atom's parts is to imagine that the nucleus of an atom is the size of our sun; in which case the closest electron would be beyond Mars.

   a) Is the number of aluminum atoms that you calculated in the thickness (height) of the foil very large or very small?

   b) How well did your predicted number of aluminum atoms compare to the actual number of aluminum atoms in the thickness of your aluminum foil? Did your results surprise you?

Ms. Randall
Regents Chemistry
<u>Lab Conclusion:</u> Number of Aluminum Atoms

1. Write a paragraph summarizing what you have learned about the scientific concept of the lab from doing the lab. Back up your statement with details from your lab experience.

2. Aluminum is not the only element that can be made into foil. Gold is another metal that can be flattened into sheets. Gold foil was used in an experiment that helped to determine the structure of the atom. As a result of the gold foil experiment, it was concluded that an atom:

A) contains protons, neutrons, and electrons
B) contains a small, dense nucleus
C) has positrons and orbitals
D) is a hard, indivisible sphere

3. Which sequence represents a correct order of historical developments leading to the modern model of the atom?

A) the atom is a hard sphere → most of the atom is empty space → electrons exist in orbitals outside the nucleus
B) the atom is a hard sphere → electrons exist in orbitals outside the nucleus → most of the atom is empty space
C) most of the atom is empty space → electrons exist in orbitals outside the nucleus → the atom is a hard Sphere
D) most of the atom is empty space → the atom is a hard sphere → electrons exist in orbitals outside the nucleus

4. Base your answer to the following question on the information below.

In 1897, J. J. Thomson demonstrated in an experiment that cathode rays were deflected by an electric field. This suggested that cathode rays were composed of negatively charged particles found in all atoms. Thomson concluded that the atom was a positively charged sphere of almost uniform density in which negatively charged particles were embedded. The total negative charge in the atom was balanced by the positive charge, making the atom electrically neutral.
In the early 1900s, Ernest Rutherford bombarded a very thin sheet of gold foil with alpha particles. After interpreting the results of the gold foil experiment, Rutherford proposed a more sophisticated model of the atom.

State *one* aspect of the modern model of the atom that agrees with a conclusion made by Thomson.

5. A very thin layer of gold plating was applied to the top of a metal tray that measured 22.22 cm by 13.22 cm. The mass of the tray before the gold plating was 75.3455 grams. After the gold plating the mass was 75.3967 grams. The density of gold can be found in Reference table S. Calculate the thickness of the applied plating. (Show all work)