# Rutherford's Scattering Experiment

**BACKGROUND**: Using the tools of the day, it is difficult to understand how Ernest Rutherford was able to determine the existence and relative size of the nucleus of gold atoms. His famous "gold foil experiment" seems ingenious in concept and procedures.

**PURPOSE**: To measure the size of a penny using techniques similar to those used by Rutherford to study the size of gold nuclei.

**MATERIALS**: sheet of paper sharp pencil penny metric ruler

**PROCEDURE**:

1. On a sheet of paper, RANDOMLY trace a circle around a penny 9 times – you will have a total of nine circles. Make 2 half-penny (or half-circles) along the edge of the paper. You will then have a total of 10 penny sized circles. Make sure your circles are evenly scattered – DON'T CLUSTER circle in any one spot on the page.
2. Turn you paper over so the circles are not visible.
3. Exchange papers with a partner, but DO NOT TURN THE PAPERS OVER.
4. Using the point of a sharp pencil, RANDOMLY & EVENLY punch 100 small holes through your partner's paper. DO NOT try to either hit or miss circles. Just scatter the holes evenly. Do not forget the edges of the paper when punching holes. Return the paper to your partner.
5. Count the number of "HITS" in/on circles. Record this on your answer sheet.
6. In millimeters, measure the length and width of the paper and record on your answer sheet.
7. Calculate the area of the paper (length x width) and record on your answer sheet.
8. Using the following ratio, CALCULET the area of 10 pennies. Shoe your work on you answer sheet.

$$\frac{Area\ of\ 10\ pennies}{\#\ \boldsymbol{Hits\ on\ pennies}} = \frac{\boldsymbol{Area\ of\ paper}}{100\ holes}$$

9. CALCULATE the area of 1 penny and record on your answer sheet.
10. If $area = \pi r^2$, and the $diameter = 2r$, CALCULATE a penny radius and diameter and record on your answer sheet.
11. CALCULATE an average estimate of a penny diameter using the diameter estimates from your partner and 2 other students. Record these diameters on your answer sheet.

**ANALYSIS AND CONCLUSIONS:**

1. Summarize how this experiment is similar to Rutherford's Gold Foil Experiment.
2. List "parts" of Rutherford's experiment and the analogous, corresponding parts of this experiment.
3. Do you think your data is accurate? Explain why/why not?
4. Provide at least 2 possible sources of error.

# Rutherford's Scattering Experiment

Name_____

Date_____ Period _____

Partner:_____

Number of "HITS" in/on the circles: _____

Paper length: _____

Paper Width: _____

CALCULATED area of paper: _____

Ratio to calculate area of 10 pennies:

$$\frac{Area\ of\ 10\ pennies}{} = \frac{\qquad}{100\ holes}$$

CALCULATED area of 10 pennies: _____

CALCULATED area of 1 penny: _____

CALCULATED penny Radius: _____ Diameter: _____

Your diameter: _____

Partner diameter: _____

Other diameter: _____

Other diameter: _____

CALCULATED AVERAGE penny diameter: _____

**ANAYLSIS AND CONCLUSION:** On the back of this paper, answer the following question in complete sentences.

1. Summarize how this experiment is similar to Rutherford's Gold Foil Experiment.

2. List 'parts' of Rutherford's experiment and the analogous, corresponding parts of this experiment.

3. Do you think your data is accurate? EXPLAIN why/why not?

4. Provide at least 2 possible sources of error?

# Teacher Information

## Background:

The Rutherford experiment, or the "Gold Foil Experiment" was an experiment used to probe the structure of the atom. The unexpected results of the experiment demonstrated for the first time the existence of the atomic nucleus, leading to the downfall of the plum pudding model of the atom, and the development of the Rutherford (or planetary) model. In this experiment, Rutherford and his coworkers aimed a beam of alpha particle at a sheet of gold foil surrounded by a fluorescent screen. Most of the particle passed through the foil with no deflection at all. A few particles were greatly deflected. Rutherford concluded that most of the alpha particles pass through the gold foil because the atom is mostly empty space. The mass and positive charge are concentrated in a small region of the atom. Rutherford called this region the nucleus. Particle that approach the nucleus closely are greatly deflected.

## Standards:

- Habits of Mind:
    - SCSh1 – Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
        a. Exhibit the above traits in their own scientific investigations.
        c. Explain that further understanding of scientific problems relies on the design and execution of new experiments, which may reinforce or weaken opposing explanations.
    - SCSh2 - Students will use standard safety practices for all classroom laboratory and field investigations.
        b. Demonstrate appropriate techniques in all laboratory situations.
        c. Follow correct protocol for identifying and reporting safety problems and violations.
    - SCSh3 - Students will identify and investigate problems scientifically.
        a. Suggest a reasonable hypothesis for identified problems.
        b. Develop procedures for solving scientific problems.
        c. Collect, organize and record appropriate data.
        e. Develop reasonable conclusions based on data collected.
        f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.
    - SCSh6- Students will communicate scientific investigations and information clearly.
        c. Use data as evidence to support scientific arguments and claims in written or oral presentations.
        d. Participate in group discussions of scientific investigations and current scientific issues.

- The Nature of Science:
    - SCSh7 – Students will analyze how scientific knowledge is developed.
      b. Universal principles are discovered through observation and experimental verifiation.
- Content:
    - SC3 – Students will use the modern atomic theory to explain the characteristics of atoms.
        a. Discriminate between the relative size, charge, and position of protons, neutrons, and electrons in the atom.

## Safety:

The only materials students will be using during this activity are a sheet of paper, a penny, a ruler, and their pencil. Keep a Band-Aid on hand for the occasional paper cut or in-case they poke themselves with their pencil. With that being said, there are no real safety issues.

## Instructions to the Teacher/ Tips

- **Materials:**
  A sheet of paper (one for each student)
  A penny (one for each student)
  A metric ruler (on for each group, let them share)
  A pencil (one for each student)
  Rutherford Analogy worksheets (one for each student)

- **Estimated Time:** approximately 30 minutes

Attached is a copy of the Rutherford analogy procedure and data worksheets. This activity was used in our ACP Chemistry classes. My mentor teacher got this activity from another teacher at our school. This hands-on activity is used as an analogy to put Rutherford's Gold Foil Experiment into perspective. This activity is a good introduction into the structure of the atom. Once students recognize the nucleus as the dense region of the atom, we can discuss how we use the mass number to calculate the number of protons, and neutrons. The worksheet provided guides students step-by-step through the analogy; however, (depending on the class) students can develop their own formulas/ procedures for determining the radius. This is something you, the teacher, will have to decide based on how comfortable y your students are with mathematically manipulating formulas and variables. When introducing this activity, I would be very clear on the background information and perhaps, get the students to research about Rutherford's Gold Foil Experiment. I found that, if this information was not clear, students had a hard time making the connection with the analogy (only seeing this activity as a penny, a sheet of paper, and a pencil). In addition, when asked the radius and diameter of the penny, many students wanted to simply measure with the metric ruler, rather than manipulate the formulas. After students completed this activity, we discussed how the activity was similar to Rutherford's experiment, we ask the student what were the sources of error, and how they would have conducted

Rutherford's "Golf Foil Experiment" differently. We also, discussed what we learned about the structure of the atom and how we can calculate the number of protons, and neutrons, based on this information.

In the future, I would have students measure the diameter of the penny with their metric ruler and compare the value to their calculated diameter. Then I would have them calculated the percent difference. In the final discussion, we would relate this small percent difference to the reality of determining the size of something as small as the nucleus of the atom.