# **Build an Atom Experiment**

**This activity supports the following unit and course objectives:**

(CLO4) Demonstrate knowledge of basic laboratory skills and operations in the areas of safety, measurement, chemical and physical properties of matter, atomic and molecular structure, chemical reactions, reactivity, structure, periodicity, and bonding.

Atomic Structure and Symbolism (2.3)

* (2.3.1) Write and interpret symbols that depict the atomic number, mass number, and charge of an atom or ion (CLO2)
* (2.3.2) Define the atomic mass unit and average atomic mass (CLO1)
* (2.3.3) Calculate average atomic mass and isotopic abundance (CLO2)

**In addition to the unit and course objectives, this activity supports the following activity objectives:**

* Use the number of protons, neutrons, and electrons to draw a model of the atom, identify the element, and determine the mass and charge. (2.3.1) (2.3.2) (2.3.3)
* Predict how addition or subtraction of a proton, neutron, or electron will change the element, the charge, and the mass. (2.3.1) (2.3.2)
* Use the element name, mass, and charge to determine the number of protons, neutrons, and electrons. (2.3.1) (2.3.2)
* Generate an isotopic symbol for an atom, given the number of protons, neutrons, and electrons. (2.3.1) (2.3.2)

**PART I: ATOM SCREEN**

[Build an Atom simulation](https://phet.colorado.edu/en/simulations/build-an-atom) (http://phet.colorado.edu/en/simulation/build-an-atom)

1. Explore the **Build an Atom** simulation with your group. As you explore, talk about what you find.
   1. List two things your group observed in the simulation.
   2. What particle(s) are found in the center of the atom?

1. Play until you discover which **particle(s)** determine(s) the name of the **element** you build. What did you discover?
2. What is the **name** of the following atoms?
3. An atom with 3 protons and 4 neutrons: \_\_\_\_\_\_\_\_\_\_\_\_\_
4. An atom with 2 protons and 4 neutrons: \_\_\_\_\_\_\_\_\_\_\_\_\_
5. An atom with 4 protons and 4 neutrons: \_\_\_\_\_\_\_\_\_\_\_\_\_
6. Play with the simulation to discover which particles affect the **charge** of an atom or ion.
7. Fill in the blanks below to show your results:

Neutral atoms have the same number of protons and electrons.

Positive ions have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ protons than electrons.

Negative ions have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ protons than electrons.

1. Develop a relationship (in the form of a single sentence or equation) that can predict the charge based on the number and types of particle.
2. Play with the simulation to discover what affects the **mass** number of your atom or ion.
3. What is a rule for determining the mass number of an atom or ion?

1. Practice applying your understanding by playing 1st and 2nd levels on the game screen.

PART II: Symbol SCREEN

1. Using the Symbol readout box, figure out **which particles** affect each component of the atomic symbol.
2. In the atomic symbol below, label each letter (a, b, c, and d) with:

* the **particle(s)** used to determine the letter, and
* **how** the value of each letter is determined.

Atomic Symbol


1. Create a definition (using a complete sentence) for each of these items based on your labels from the atomic symbol above.
   * + - 1. Element Symbol
         2. Charge
         3. Atomic Number
         4. Mass Number
2. Practice applying your understanding by playing the 3rd and 4th game levels. Play until you can get all the questions correct on the 4th level.
3. In addition to atomic symbol, we can represent atoms by name and mass number.
4. Complete the table below:

|  |  |
| --- | --- |
| Symbol | Name |
| Carbon 12 Atomic Symbol | Carbon-12 |
| Florine Atomic Symbol |  |
| Boron Atomic Symbol |  |

1. Each representation (Symbol and Name) in the table above provides information about the atom. Describe the similarities and differences between the Symbol and Name representations.

PART III: ISOTOPES

1. Play with the simulation to determine:
   1. Which particles affect the stability of the atom? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. Which particles do not affect the stability of the atom? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What are the names of the stable forms of oxygen?
3. Oxygen-16
4. Oxygen-\_\_\_\_
5. Oxygen-\_\_\_\_
6. List all of the things that are the same about these atoms (ignore the electrons).
7. List all of the things that are different about these atoms (ignore the electrons).
8. The atoms in the previous question are **isotopes** of each other. Based on this information, list the requirements for two atoms to be isotopes of each other.
9. Test your understanding of isotopes by examining the relationships between the pairs of atoms listed below:

|  |  |  |
| --- | --- | --- |
| Atom 1 | Atom 2 | Relationship between atom 1 and atom 2 |
| Carbon 12 Isotope | Carbon 13 Isotope | Isotopes  Same Atom, Not Isotopes of Each Other  Different Element |
| Carbon-12 | Carbon 12 Isotope | Isotopes  Same Atom, Not Isotopes of Each Other  Different Element |
| Argon-40 | Argon-41 | Isotopes  Same Atom, Not Isotopes of Each Other  Different Element |
| Boron Isotope | Boron-10 | Isotopes  Same Atom, Not Isotopes of Each Other  Different Element |
| An atom with 13 protons and 13 neutrons | An atom with 14 protons and 13 neutrons | Isotopes  Same Atom, Not Isotopes of Each Other  Different Element |

EXERCISES

1. The periodic table has a great deal of information about every atom. Using your periodic table, answer the following questions:
2. What is the atomic number of chlorine (Cl)? \_\_\_\_\_
3. What is the atomic number of tungsten (W)? \_\_\_\_\_
4. How many protons are there in any Cl atom?\_\_\_\_\_
5. How many protons are there in any Te atom? \_\_\_\_\_
6. ­Can you tell from the periodic table exactly how many neutrons are in an atom?
7. Complete the following table:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Name | Symbol | Atomic number | Mass Number | Number of neutrons | Number of Electrons | Charge |
| hydrogen-2 | 2H | 1 | 2 | 1 | 1 | 0 |
|  | 3H |  |  |  |  |  |
| sodium-22 | 22Na+ |  |  |  | 10 |  |
|  |  | 12 | 24 |  | 12 |  |
|  |  | 12 | 25 |  | 13 |  |
|  | 46Ti-2 |  |  |  |  |  |
|  | 107Ag |  |  |  |  |  |
|  | 19F-1 |  |  |  |  |  |
| carbon-12 |  |  |  |  | 6 |  |
| carbon-13 |  |  |  |  | 6 |  |
| carbon-14 |  |  |  |  | 6 |  |
| carbon-12 |  |  |  |  | 7 |  |
| carbon-12 |  |  |  |  | 5 |  |
|  | 4He |  |  |  |  |  |
|  |  | 8 |  | 8 | 10 |  |
| argon-40 |  | 18 |  |  | 18 |  |
|  | 70Ga |  |  |  |  |  |
|  | 70Ga+3 |  |  |  |  |  |
|  |  | 4 | 9 |  | 2 |  |
|  |  | 7 |  | 8 | 8 |  |

1. To test your knowledge of isotopes, draw arrows between all pairs of atoms in the table above that are isotopes of each other.

**Rutherford’s Scattering Experiment**

**This activity supports the following unit and course objectives:**

Evolution of Atomic Theory (2.2)

* (2.2.1) Outline milestones in the development of modern atomic theory (CLO1)
* (2.2.2) Summarize and interpret the results of the experiments of Thomson, Millikan, and Rutherford (CLO1)

**In addition to the unit and course objectives, this activity supports the following activity objectives:**

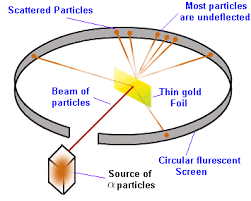
* Describe Rutherford’s gold foil experiment (2.2.1) (2.2.2)
* Describe Rutherford’s planetary model of the atom (2.2.1) (2.2.2)
* Describe JJ Thompson's model of the atom (2.2.1) (2.2.2)
* Discuss the limitations of JJ Thompson's model of the atom (2.2.1) (2.2.2)

Go to the [Rutherford Scattering Simulator](https://phet.colorado.edu/en/simulations/rutherford-scattering) https://phet.colorado.edu/en/simulations/rutherford-scattering

Click the play button to launch the simulator

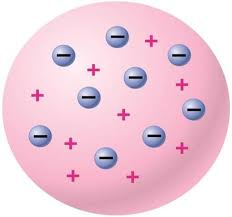
Once the simulation opens, click on the Rutherford Atom.

# Rutherford Atom



1. Set the number of protons to 20 and click on the blue button above the Alpha Particles to start firing Alpha particles towards the gold foil.
2. Click on the Traces button. What do you notice about the paths of most of the alpha particles?
3. Increase the number of protons to 60. Does it change how the alpha particles move? If so, how?
4. Now, increase the number of protons to 100. How does this increase change how the alpha particles move through the gold foil as compared to when you started? Why do you think this change occurred?
5. Repeat the above steps but vary how many neutrons are present with the protons. Does this change how the Alpha particles travel? Why or why not?
6. Click on the red/gray sphere and reset the number of protons to 20. Watch and describe how the alpha particles move in relationship to the nucleus. Make a sketch of the motion.
7. Click on the red/gray sphere and reset the number of protons to 20. Watch and describe how the alpha particles move in relationship to the nucleus. Make a sketch of the motion.
8. Now increase the number of protons to 100. Watch and describe how the alpha particles move in relationship to the nucleus. Make a sketch of the motion.
9. How are the situations in #6 and #7 different? Why do you think this is?

Plum-Pudding Atom

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1. Switch the simulation to the Plum-Pudding Atom.
2. Once the simulation opens, click on the trace button.
3. Click on the blue button on the Alpha Particle gun to turn on the Alpha particles.
4. What type of path do the Alpha particles take?
5. How is this different than the Rutherford simulation?