# Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Hour \_\_\_\_\_\_\_

Find the PhET Simulator site on your computer. [*Use your student notes to help*.]

a) Open the “[**Models** **of the** **Hydrogen Atom**](http://phet.colorado.edu/simulations/hydrogen-atom/hydrogen-atom.jnlp)” simulation. (“Chemistry”) or click on:

<http://phet.colorado.edu/new/simulations/sims.php?sim=Models_of_the_Hydrogen_Atom>

b) or use: [**https://screencast-o-matic.com/watch/cD6ZXZj5Ma**](https://screencast-o-matic.com/watch/cD6ZXZj5Ma)

1. Click on “Prediction” in the upper left corner of the simulation. The simulation should be on “Billiard Ball.” Otherwise click on that button.

2. Click the “O” just above the “light control” box. Allow the “light beam” to pass for about 10 seconds and click again, observing what happens to the center particle and the light particles.

a. RECORD your observations:

b. Who stated that all matter is made up of indivisible particles? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Return to the Hydrogen Atom simulation and click on “Plum Pudding” prediction mode. Allow the “light beam” to pass for about 10 seconds, observing what happens to the center particle and the light particles and then stop the light beam.

a. RECORD your observation of the “blue sphere” within the red blob:

b. Do the light particles “bounce” off the blob as the billiard balls in the previous simulation? What happens instead?

c. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (*scientist*) made the inference that atoms could be separated into a negative part and a positive part. He made the inference that \_\_\_\_\_\_\_\_\_ rays were made of \_\_\_\_\_\_\_\_\_\_\_\_ charges, and therefore that the negative charges could be removed from the bulk of the atoms. He then developed a model of the atom in which little electrons were stuck in a big positive goo called the \_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_ model. He just assumed the positive charge was one big mass.

4. Click on: [Rutherford Scattering](http://phet.colorado.edu/simulations/rutherford-scattering/rutherford-scattering.jnlp) simulation or use video provided. Turn the “gun” on for 10 seconds and observe the pattern of particles in relation to the central mass.

a. RECORD your observation of how the moving particles behave near the central mass:

b. This simulation gives a microscopic picture of Rutherford’s famous experiment in which he shot \_\_\_\_\_\_\_\_\_\_\_ particles at a thin foil of \_\_\_\_\_\_\_. Change the number of protons to “20” at the right side of the screen. Turn the gun on again and record your observations:

c. Slide the “number of protons” bar to the right little by little and observe the “particles” as they approach the central mass. Record how the deflection of the particles changes as one adds more protons:

d. Based on Rutherford’s finding, what inference did he make about the distribution of positive charge in the atom (*where is it concentrated*)?

e. Just for comparison, click on the “Plum Pudding Atom” simulation (next to Rutherford’s simulation) and see how this compares to what Rutherford ACTUALLY found:

5. Return to the [Models of the Hydrogen Atom](http://phet.colorado.edu/simulations/hydrogen-atom/hydrogen-atom.jnlp) simulation or video provided. Click on “Prediction” and “Classical Solar System” mode. Rutherford developed a “solar system” model of the atom based on a positive nucleus and a negative electron orbiting that nucleus. Run the simulation several times and explain why Rutherford was NOT correct:

6. Bohr made a simple observation that atoms are stable and do not collapse in on themselves. Click on the “Bohr” simulation. Draw a sketch to the right of the atom that Bohr developed.

a. In the upper right corner of the simulation, click on “Show electron energy diagram.” What does “**n**” refer to in the Bohr simulation? How many are present?

b. As “**n**” gets larger, do the **orbits** get closer together or farther apart? Why?

c. As “**n**” gets larger, do the **energy levels** get closer together or farther apart? Why?

d. Turn the gun on and allow it to run for about a minute. Observe closely what happens to the blue “electron” in the simulation as light particles strike it. Where does it go when struck? Observe the diagram to the right of the simulator (*electron* *energy levels*) as well.

e. When an electron changes energy levels (*when struck by the light*), we say the atom is in the \_\_\_\_\_\_\_\_\_\_\_\_\_ state. A stable atom (*before getting excited*) is in the \_\_\_\_\_\_\_\_\_ state.

7. Click on the “deBroglie” simulator and observe for 30 seconds.

8. Click on the “Schrodinger” simulator. Change the speed at the bottom of the screen to “fast” and observe this simulation for one minute. Click on pause as a pattern develops and then play it again. Observe the electron energy level diagram to the right as well.

# ANSWER KEY

1. Click on “Prediction” in the upper left corner of the simulation. The simulation should be on “Billiard Ball.” Otherwise click on that button.

2. Click the “O” just above the “light control” box. Allow the “light beam” to pass for about 10 seconds and click again, observing what happens to the center particle and the light particles.

a. RECORD your observations: ***particles bounce off the center particle***

b. Who stated that all matter is made up of indivisible particles? ***Democritis.***

3. Return to the Hydrogen Atom simulation and click on “Plum Pudding” prediction mode. Allow the “light beam” to pass for about 10 seconds, observing what happens to the center particle and the light particles and then stop the light beam.

a. RECORD your observation of the “blue sphere” within the red blob:

***The blue sphere gets hit by particles and moves back and forth within the red blob.***

b. Do the light particles “bounce” off the blob as the billiard balls in the previous simulation? What happens instead?

***The light particles pass through the red blob rather than bounce off.***

c. ***JJ Thompson*** (*scientist*) made the inference that atoms could be separated into a negative part and a positive part. He made the inference that ***cathode*** rays were made of ***negative*** charges, and therefore that the negative charges could be removed from the bulk of the atoms. He then developed a model of the atom in which little electrons were stuck in a big positive goo called the ***plum pudding*** model. He just assumed the positive charge was one big mass.

4. Click on: [Rutherford Scattering](http://phet.colorado.edu/simulations/rutherford-scattering/rutherford-scattering.jnlp) simulation or use video provided. Turn the “gun” on for 10 seconds and observe the pattern of particles in relation to the central mass.

a. RECORD your observation of how the moving particles behave near the central mass:

***The particles approach the central mass and are deflected.***

b. This simulation gives a microscopic picture of Rutherford’s famous experiment in which he shot ***alpha*** particles at a thin foil of ***gold***. Change the number of protons to “20” at the right side of the screen. Turn the gun on again and record your observations:

***The particles get much closer to the central mass before they are deflected.***

c. Slide the “number of protons” bar to the right little by little and observe the “particles” as they approach the central mass. Record how the deflection of the particles changes as one adds more protons:

***The more the protons, the more the deflection away from the central mass.***

d. Based on Rutherford’s finding, what inference did he make about the distribution of positive charge in the atom (*where is it concentrated*)?

***The central mass (nucleus) contains all the positive charge in the atom.***

e. Just for comparison, click on the “Plum Pudding Atom” simulation (next to Rutherford’s simulation) and see how this compares to what Rutherford ACTUALLY found:

***Rutherford’s model has the electrons outside the nucleus (central mass containing the positive charges) while Thompson’s plum pudding model has the positive charges as a “pudding” and the negative charges moving within/inside the pudding.***

5. Return to the [Models of the Hydrogen Atom](http://phet.colorado.edu/simulations/hydrogen-atom/hydrogen-atom.jnlp) simulation or video provided. Click on “Prediction” and “Classical Solar System” mode. Rutherford developed a “solar system” model of the atom based on a positive nucleus and a negative electron orbiting that nucleus. Run the simulation several times and explain why Rutherford was NOT correct:

***Rutherford’s model did not account for the electron (negative charge) outside the nucleus colliding/spinning into the nucleus.***

**e**

6. Bohr made a simple observation that atoms are stable and do not collapse in on themselves. Click on the “Bohr” simulation. Draw a sketch to the right of the atom that Bohr developed.

**+**

a. In the upper right corner of the simulation, click on “Show electron energy diagram.” What does “**n**” refer to in the Bohr simulation? How many are present?

***Energy levels where the electrons exist in “orbits”***

b. As “**n**” gets larger, do the **orbits** get closer together or farther apart? Why?

***The orbits get farther apart (showing they are higher energy levels)***

c. As “**n**” gets larger, do the **energy levels** get closer together or farther apart? Why?

***The energy levels get farther apart (showing they are higher energy levels). “Orbits” are the energy levels.***

d. Turn the gun on and allow it to run for about a minute. Observe closely what happens to the blue “electron” in the simulation as light particles strike it. Where does it go when struck? Observe the diagram to the right of the simulator (*electron* *energy levels*) as well.

***The electron orbits in the same energy UNTIL it gets hit by a photon. Then, it jumps to a higher energy level. It also returns to the original energy level (orbit).***

e. When an electron changes energy levels (*when struck by the light*), we say the atom is in the ***excited*** state. A stable atom (*before getting excited*) is in the ***ground*** state.

7. Click on the “deBroglie” simulator and observe for 30 seconds.

***Debroglie included the concept of wavelength in the atomic structure model.***

8. Click on the “Schrodinger” simulator. Change the speed at the bottom of the screen to “fast” and observe this simulation for one minute. Click on pause as a pattern develops and then play it again. Observe the electron energy level diagram to the right as well.

***Schroedinger included the concept of electron clouds in the atomic structure model.***