Atomic Theory

Name Date Period

Station 1: It's All Greek to Me

Circa 460 BC Understanding: Greek philosopher Empedocles developed a model explaining that all things in the universe consist of 4 elements: earth, water, air, and fire (Aristotle also supported these ideas during his lifetime, 384-322 BC). These elements are characterized by the following qualities: earth is cold and dry, water is cold and moist, air is hot and moist, and fire is hot and dry. Additionally, emotions such as love and hate are interconnected with these elements.
Each substance is a combination of these 4 elements. The elements themselves never exist in a pure form, although they aspire to take their proper place in the universe. The proper place for earth is the Earth itself. As water floats on earth, its proper place is above the Earth. Air rises higher than water, so air is above the water. Fire rises highest of all.

Do the activity. What happened?

Given your circa 460 BC understanding, explain what happened.

WAIT! DON'T ANSWER YET! Given your modern understanding, explain what happened.

Station 2: It's (Still) All Greek to Me

Circa 415 BC – early 19th century Understanding: Greek philosopher Democritus created the moniker "atoms" to describe the small, indivisible things that make up all matter (Our modern word "atom" comes from the Greek *atomos*, meaning "indivisible"). Elements are substances composed of only one type of atom, and observations can be explained by the exchange of atoms among substances. Contrary to the theory of Empedocles, who thought that "pure" elements did not exist in the real world, Democritus tells us it is now possible to have *pure* elements that are composed of only one kind of atom. Like the theory of Empedocles, however, explanations amount to figuring out how much of each element is contained in a substance, how much might be added, and how much might be subtracted.

In 1803, John Dalton revived and supported this atomic theory, contending that atoms are indivisible and indestructible and combine in simple whole-number ratios to form compounds.

Do the activity. What happened?

Given your circa 415 BC – early 19th century understanding, explain what happened.

WAIT! DON'T ME ANSWER YET! Given your modern understanding, explain what happened.

Station 3: Time for Dessert

1890s Understanding: A cathode ray tube is a glass tube with much of the air removed by a vacuum. When electricity is run through the tube, a beam runs through the glass tube. The beam is registered by a fluorescent screen at the end of the tube.

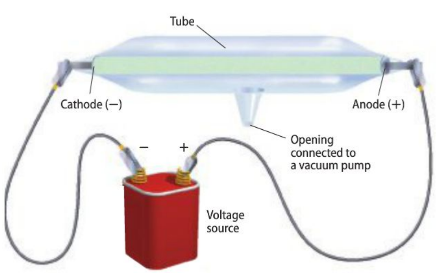
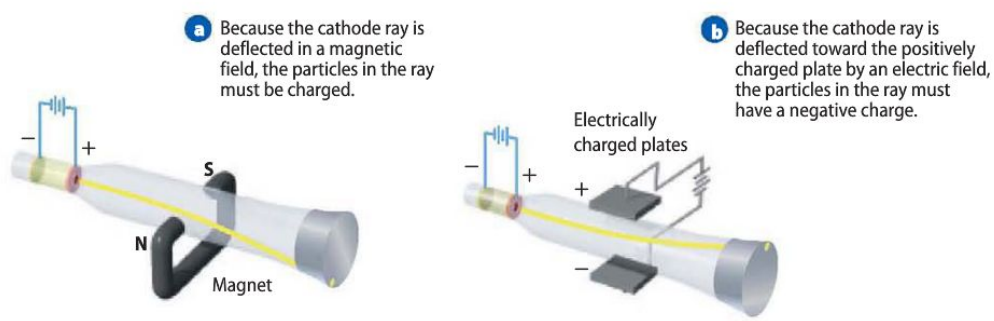


Figure 6 A cathode-ray tube is a tube with an anode at one end and a cathode at the other end. When a voltage is applied, electricity travels from the cathode to the anode.

When the two ends of a magnet or electrically charged plates are placed around the tube, the beam bends toward the positive end of the magnet or charged plate.

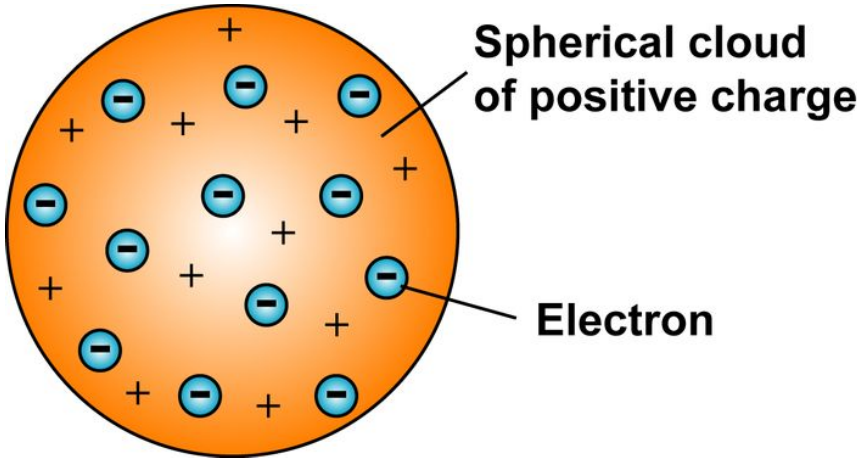
Figure 7 A tiny hole located in the center of the anode produces a thin beam of electrons. A phosphor coating allows the position of the beam to be determined as it strikes the end of the tube.



By the end of the 1800s, from the cathode ray tube experiments, scientists were fairly convinced that cathode rays were streams of charged particles and that these particles were negatively charged. English physicist J.J. Thompson was the first scientist to measure the mass-to-charge ratio of the charged particles in the cathode ray, discovering that these particles were much less massive than the hydrogen atom. This was groundbreaking! Thompson discovered that particles smaller than the smallest atom existed (he received the 1906 Nobel Prize for this breakthrough)!

Unfortunately, this amazing discovery presented some problems. If all matter is neutral (you know this; you do not receive an electric shock when you touch something, except in peculiar conditions), then how can it contain negative charges? To reconcile these ideas, Thomson proposed a *plum pudding model* as a description of the atom. Plum pudding is an English dessert, a cake packed with fruit and nuts and such.

Thomson imagined that the cake (aka matter) was itself positively charged with negatively charged particles (the fruit and nuts and the like inside the cake) floating within.



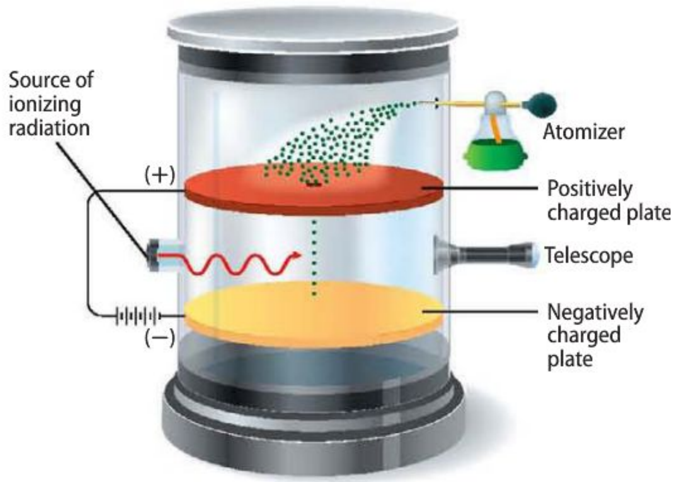
Do the activity. What happened?

Given your 1890s understanding, explain what happened.

WAIT! DON'T ANSWER YET! Given your modern understanding, explain what happened.

Station 4: Electronic Maneuvering

1910s Understanding: American physicist Robert Millikan brilliantly designed an experiment to determine the charge of the electron. Millikan sprayed oil into the space above two charged plates. The oil droplets then fell through a small hole in the top plate, into the space between the plates.



Using ionizing radiation (specifically, x-rays) in the space between the charged plates, Millikan was able to knock out electrons from the particles in the air onto the oil droplets. The oil droplets, therefore, became negatively charged. Millikan was then able to vary the rate of fall of the droplets by varying the intensity of the electric field created by the charged plates. He then determined that the magnitude of the charge on each drop increased in discrete amounts and determined that the smallest common denominator was 1.602×10^{-19} coulombs - the charge of an electron (This charge is now equated to a single unit of negative electron charge, 1-). After Millikan calculation of the charge of the electron, using Thomson's discovered mass-to-charge ratio of the electron, the mass of the electron was deduced (9.1×10^{-28} g, $1/1840^{th}$ of a hydrogen atom).
If electrons are so, so tiny, what composes the rest of the mass of atoms? Is the answer in Thomson's *plum pudding model*?

Do the activity. What happened?

Given your 1910s understanding, explain what happened.

WAIT! DON'T ANSWER YET! Given your modern understanding, explain what happened.

Station 5: The Tissue Paper Deflected The Cannon

1911 Understanding: New Zealand-born British physicist, Ernest Rutherford began to work with alpha particles (large, heavy radioactive particles with a 2+ charge). Rutherford, a student of Thomson, sought to support Thomson's *plum pudding model* through an experiment with alpha particles. Rutherford shot alpha particles at a thin sheet of gold foil (composed of gold atoms, of course). According to Thomson's *plum pudding model*, the alpha particles should move directly through the gold foil, as the super tiny electrons would only minorly alter the path of the alpha particles.

Do the activity. What happened?

Given your 1911 understanding, explain what happened.

WAIT! DON'T ANSWER YET! Given your modern understanding, explain what happened.

Ahhhh! Something caused the particles to bounce back! What was it?!