Thomson’s Atomic Model

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You probably know that the wires strung between these high towers carry electricity. But do you know what electricity is? It actually consists of a constant stream of tiny particles called electrons. Electrons are negatively charged fundamental particles inside atoms. Atoms were discovered around 1800, but almost 100 years went by before electrons were discovered.

Thomson Discovers Electrons

John Dalton discovered atoms in 1804. He thought they were the smallest particles of matter, which could not be broken down into smaller particles. He envisioned them as solid, hard spheres. It wasn’t until 1897 that a scientist named Joseph John (J. J.) Thomson discovered that there are smaller particles within the atom. Thomson was born in England and studied at Cambridge University, where he later became a professor. In 1906, he won the Nobel Prize in physics for his research on how gases conduct electricity. This research also led to his discovery of the electron. You can see a picture of Thomson 1.1.

Thomson’s Experiments

In his research, Thomson passed current through a cathode ray tube, similar to the one seen in the Figure 1.2. A cathode ray tube is a glass tube from which virtually all of the air has been removed. It contains a piece of metal called an electrode at each end. One electrode is negatively charged and known as a cathode. The other electrode is positively charged and known as an anode. When high-voltage electric current is applied to the end plates, a cathode ray travels from the cathode to the anode.
What is a cathode ray? That’s what Thomson wanted to know. Is it just a ray of energy that travels in waves like a ray of light? That was one popular hypothesis at the time. Or was a cathode ray a stream of moving particles? That was the other popular hypothesis. Thomson tested these ideas by placing negative and positive plates along the sides of the cathode ray tube to see how the cathode ray would be affected. The cathode ray appeared to be repelled by the negative plate and attracted by the positive plate. This meant that the ray was negative in charge and that it must consist of particles that have mass. He called the particles “corpuscles,” but they were later renamed electrons.

Thomson also measured the mass of the particles he had identified. He did this by determining how much the cathode rays were bent when he varied the voltage. He found that the mass of the particles was 2000 times smaller than the mass of the smallest atom, the hydrogen atom. In short, Thomson had discovered the existence of particles smaller than atoms. This disproved Dalton’s claim that atoms are the smallest particles of matter. From his discovery, Thomson also inferred that electrons are fundamental particles within atoms.

**Q:** Atoms are neutral in electric charge. How can they be neutral if they contain negatively charged electrons?

**A:** Atoms also contain positively charged particles that cancel out the negative charge of the electrons. However,
these positive particles weren’t discovered until a couple of decades after Thomson discovered electrons.

**The Plum Pudding Model**

Thomson also knew that atoms are neutral in electric charge, so he asked the same question: How can atoms contain negative particles and still be neutral? He hypothesized that the rest of the atom must be positively charged in order to cancel out the negative charge of the electrons. He envisioned the atom as being similar to a plum pudding, like the one pictured in the Figure 1.3—mostly positive in charge (the pudding) with negative electrons (the plums) scattered through it.

![Figure 1.3](image)

**Q:** How is our modern understanding of atomic structure different from Thomson’s plum pudding model?

**A:** Today we know that all of the positive charge in an atom is concentrated in a tiny central area called the nucleus, with the electrons swirling through empty space around it, as in the Figure 1.4. The nucleus was discovered just a few years after Thomson discovered the electron, so the plum pudding model was soon rejected.

**Summary**

- In 1897, J. J. Thomson discovered the first subatomic particle, the electron, while researching cathode rays.
- To explain the neutrality of atoms, Thomson proposed a model of the atom in which negative electrons are scattered throughout a sphere of positive charge. He called his atom the plum pudding model.

**Review**

1. Who was J. J. Thomson?
2. Explain how Thomson discovered negatively charged particles smaller than atoms.
3. Thomson compared his idea of atomic structure to a plum pudding. Invent an original analogy for Thomson’s plum pudding model of the atom.
4. Why was Thomson’s model soon rejected?
Explore More

Watch this detailed presentation about J. J. Thomson’s discovery of the electron, and then answer the question below.

1. Thomson not only discovered that a cathode ray consists of flowing negatively charged particles that are smaller than atoms. He also made the logical leap that these particles help make up atoms. What reasoning did Thomson use to make this inference?

References

2. Zachary Wilson. Cathode ray tube used in Thomson’s experiment . CC BY-NC 3.0
3. Plum pudding: Lachlan Hardy; Model: User:Fastfission/Wikimedia Commons. Plum pudding and Thomson’s plum pudding model . Plum pudding: CC BY 2.0; Model: Public Domain
4. Laura Guerin. Model of an atom . CC BY-NC 3.0