J.J. Thomson Discovers the Electron

1. Cathode ray bends toward positive electrical pole Why? Ray is negative in charge.

2. Cathode ray bends under magnet. Why? Electricity and magnetism are two forms of the same force. A moving electrical charge creates a magnetic field. (This point is developed in physics, not chemistry.) The two magnetic fields interact and since the lines of force are curved, the beam bends.

3. Evidence that cathode rays were particles, not electromagnetic radiation
   a. they had a charge, i.e. deflected by electric or magnetic fields
   b. had a detectable mass
   c. traveled at less than the speed of light

4. What did Thomson measure?
   a. velocity of beam
   b. displacement of beam
   c. electric field strength
   d. magnetic field strength
   e. amount of time spent in fields

5. When he solved his equations, he determined the charge-to-mass ratio (symbol e/m). He could not determine e or m independently with a cathode ray. The best determination of e was done by Robert A. Millikan in 1914 in the oil-drop experiment (p. 227 in the text). A clear and lucid explanation of the equations Thomson used and his reasoning is found in The Discovery of Subatomic Particles (1983). Steven Weinberg. W.H Freeman: New York.

6. Thomson determined that the e/m ratio was the same for every combination of gas present in the tube and metal used as cathode and anode. In other words, suppose you measured the e/m ratio found in every possible combination of these gases: hydrogen, chlorine, nitrogen, neon and these metal electrodes: gold, silver, copper, platnium. The value was ALWAYS the same.

7. Why do We Remember Thomson as the Discoverer of the Electron?
To put it into his own words,

"...we have in the cathode rays matter in a new state, a state in which the subdivision of matter is carried very much farther than in the ordinary gaseous state: a state in which all matter–that is, matter derived from different sources such as hydrogen, oxygen, etc.–is of one and the same kind; this matter being the substance from which the chemical elements are built up."

He had leaped to the conclusion that the particles in the cathode ray (which we now call electrons) were a fundamental part of all matter. This was reaching quite far beyond what he had actually discovered. As he was to recall much later,

"At first there were very few who believed in the existence of these bodies smaller than atoms. I was even told long afterwards by a distinguished physicist who had been present at my [1897] lecture at the Royal Institution that he thought I had been 'pulling their legs.' "

Other people had measured the e/m ratio or suggested that the cathode rays were composed of particles, but Thomson was the first to say that the cathode ray was a building block of the atom. It was a risky thing, but he was proved right and for his courage he is remembered as the discoverer of the electron.