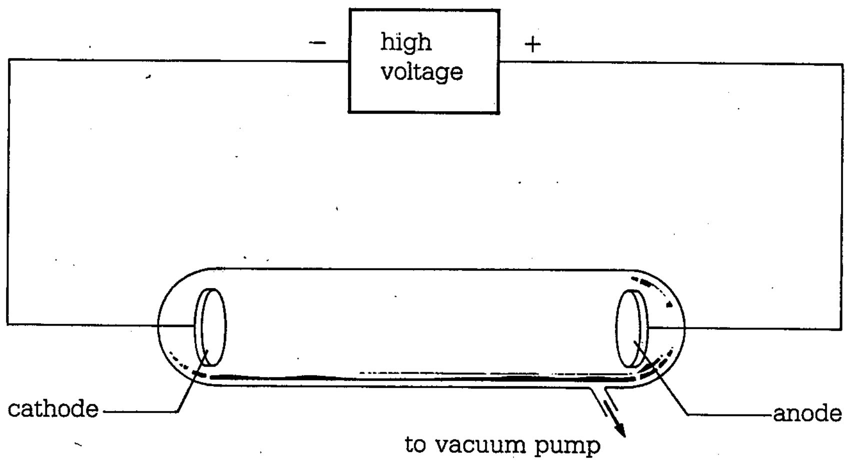
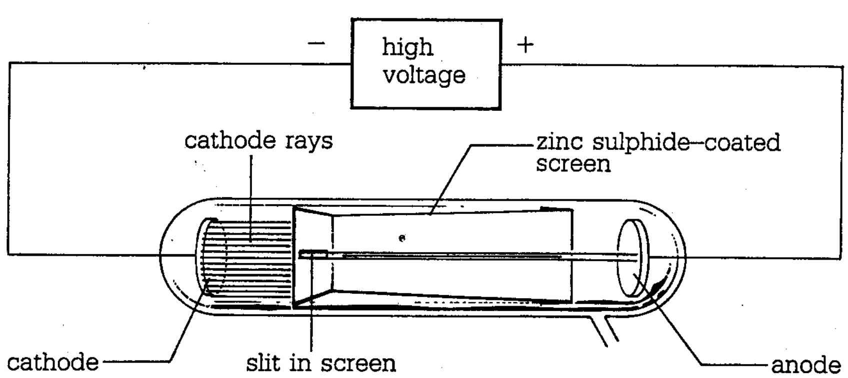
Discovering the Electron

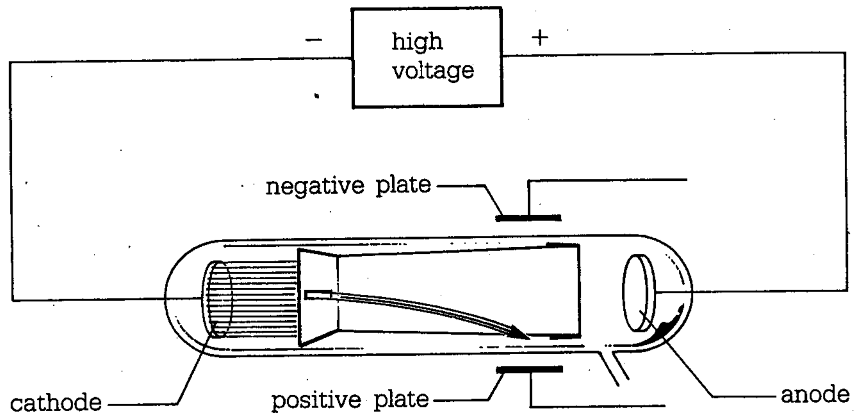
During the 1860s, many scientists experimented with discharge tubes. A **discharge tube** is a glass tube which is sealed at both ends. A metal plate is sealed into the tube at each end. These plates, called **electrodes**, are connected to a source of high voltage, usually between 10 kV and 20 kV. The tube is also connected to a vacuum pump to remove the gas inside it. (See Figure 2.6.) Discharge tubes are often known as Crookes tubes, after Sir William Crookes, the English scientist who did much of the early work with them. (See Figure 2.7.)



Experiments showed that when some of the air in the discharge tube was removed, and a very high voltage applied to the electrodes, electricity flowed through the tube and the air remaining in the tube glowed. Experiments also showed that different gases in the tube produced different colours. Air gave a pink glow, neon red, and mercury green. If almost all of the gas in the tube was removed, the electricity continued to flow, but the coloured glow disappeared. In its place, a faint, green glow appeared on the walls of the tube. The glow could be made more visible if the inside of the tube was coated with the compound zinc sulphide. When a screen with a slit in it, and coated with zinc sulphide, was placed in the discharge tube as shown in Figure 2.8, it was seen that the glow originated from the negative electrode, called the **cathode**, and not from the positive electrode, called the **anode**.



Scientists concluded that the glow was caused by invisible rays coming from the cathode. The rays were named **cathode rays.** Further experiments showed that cathode rays were attracted toward a positively charged plate held outside the tube. (See Figure 2.9.) This showed that they carried a negative charge. Scientists further discovered that cathode rays consisted of tiny, negatively charged particles. These particles were named **electrons.**



In 1897, J.J. Thomson (see Figure 2.10), an English physicist, carried out quantitative experiments on the nature of cathode rays. Thomson constructed a discharge tube similar to the one shown in Figure 2.11. Although he was unable to measure the charge or the mass of an electron, he was able to determine the charge-to-mass ratio of the particles. Thomson found that in all cathode ray experiments the same charge-to-mass ratio was obtained, regardless of the gas in the tube or the material which made up the cathode. He concluded that electrons were part of all matter.

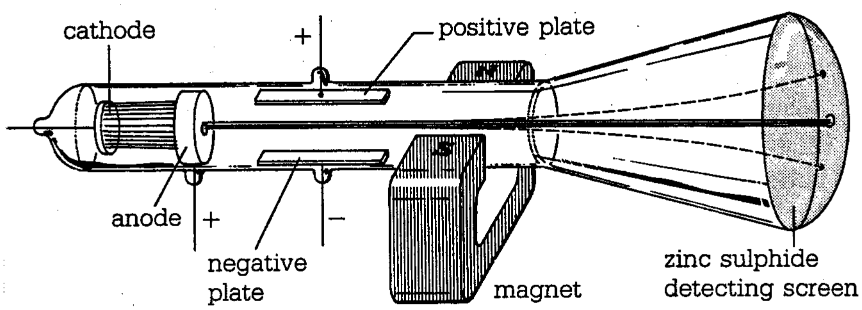


Figure 2.11
Thomson carried out quantitative experiments with cathode rays. He investigated the deflection of the rays by electrical and magnetic fields. The electrons that made up the rays were deflected in one direction by the electrical field, and in the opposite direction by the magnetic field. The amount of deflection varied directly as the charge on the electron (the greater the charge, the greater the deflection). The amount of deflection also varied inversely as the mass of the electron (the greater the mass, the smaller the deflection). Thomson determined the size of the electrical field that was needed to exactly balance the effect of a known magnetic field. From this he was able to calculate the charge to mass ratio for the electron. Neither the charge nor the mass of the electron could be determined separately by this method.