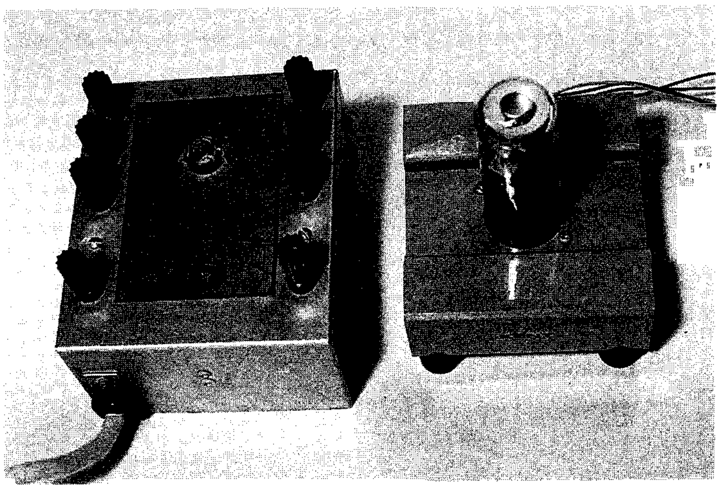
MASS OF THE ELECTRON KIT



This kit is used to calculate the charge-to-mass **(q/m)** ratio of an electron and ultimately the mass of the electron itself. It consists of a special *valve* mounted in a socket, fitted to a base. The valve is **a** vacuum tube with a central cathode surrounded by a bowl-shaped anode. The anode is coated with a fluorescent material which emits flashes of light when electrons impinge on it.

The electron path is observed to curve when the valve is placed in the uniform magnetic field from a solenoid. (*See figure* 2).

The radius (R) of this curve is measured and used, with the magnetic field strength **(B)** and the accelerating voltage **(V)** of the electrons, to calculate the mass-to-charge ratio **(q/m).**

SAFETY PRECAUTIONS

- When using the high voltage power supply be careful to secure the connections safely.
- Do not touch the connections when the power is turned on - *work always with one hand behind your buck* to avoid getting an electric shock.
- Do not touch the glass tube when the power is on, as low energy X-rays may be produced when the electrons are stopped suddenly in the glass.

SETTING UP AND USING THE MASS OF THE ELECTRON KIT

C **It is worth checking the following items before an experiment is set up**

- Ensure that you have an appropriate high voltage power supply (0-200V). An especially designed power source was originally available with the kit (see *above photograph).* If this is no longer available, the power source supplied with some cloud chambers will also work effectively.
- Calculate the magnetic field strength **(B)** at the centre of the solenoid for a given current **(I). This** value can be determined from a calibration graph for the solenoid of **B** against **I** drawn up using the current balance kit. *(See page 21).*

  An alternative method for determining the value of **B** is to use the formula

  $$B = \frac{4 \times 10^{-7} NI}{\sqrt{l^2 + d^2}}$$

  where **I =** the current in the solenoid,
  d = the average diameter of the solenoid.
  N **=** number of turns in the solenoid
  ***l* =** length of the solenoid

X **Extra equipment for the suggested learning experience includes:**

- an air-core solenoid from the current balance kit
- a special high voltage power supply (0-200V)
- 2 power packs
- an ammeter
- 1 rheostat or variable resistor
- 4 leads
- cork borers of varying sizes to use as templates
- vernier callipers

Setting up the Mass of Electron Kit

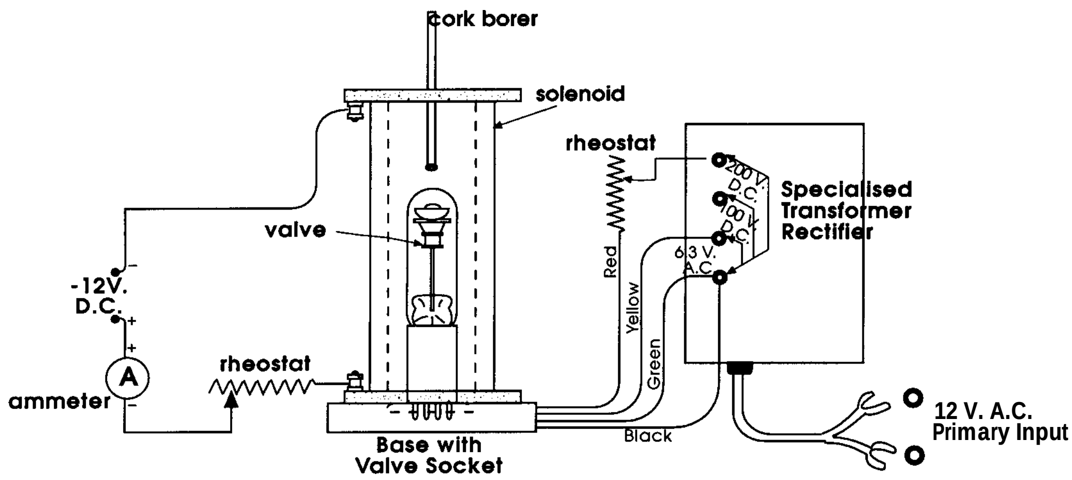


figure 1

- Set up the equipment in two separate circuits, as shown in figure 1.

  One circuit, which consists of the rheostat, ammeter andpowerpack, is used to supply a uniform magnetic field in the centre of the solenoid.

  The other circuit consists of the valve and its power supply, set up in the following way:
  - Connect the green and yellow wires from the valve across the 6.3 volt terminals of the power supply. These are used to heat the filament of the cathode.
  - Connect the red and black leads across the 200 volt terminals of the power supply -the red is connected to the anode and goes to the positive terminal, while the black is connected to the earth or negative terminal. This supplies the accelerating voltage (V) to the electrons.
- Place the solenoid in a vertical position over the top of the valve.

HANDY HINTS

- After the valve is turned on several minutes are required for the filament to heat up.
- Use the vernier callipers to measure the inside and outside diameters of the solenoid and then calculate its average diameter (d). See *Yr 12 Senior Physics Lab Manual p61.*

SUGGESTED LEARNING EXPERIENCE

Calculate the mass of an electron using the following expression

$$m = \frac{B^2 q R^2}{2 v}$$

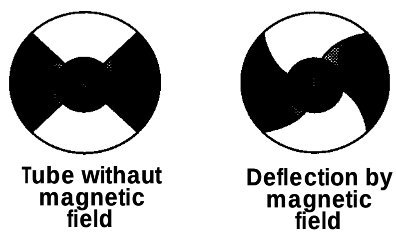


figure **2**

where **R =** the radius of curvature of the electron path (see ***method below),***

B = the magnetic field strength at the centre of the solenoid

V = the accelerating voltage

q = 1.6×10^{-19}C (the known value for the charge on an electron)

This expression has been derived from equating the two equations for the magnetic force on the electrons $F = BqV$ and $F = mV^2/R$.

An easy method for measuring R

In order to measure the radius of curvature (R) use a cork borer as a template. Select a large cork borer and, looking through the borer to the top of the valve, adjust the current flowing through the wire loop so that the electron path exactly fits the curvature of the selected cork borer. Measure the diameter of the cork borer with the vernier callipers and calculate the radius of curvature of the electron path. Figure 2 shows the top view of the valve when the magnetic field is turned off and when it is turned on. See ***the PSSC Lab Manual page 79 for further details.***