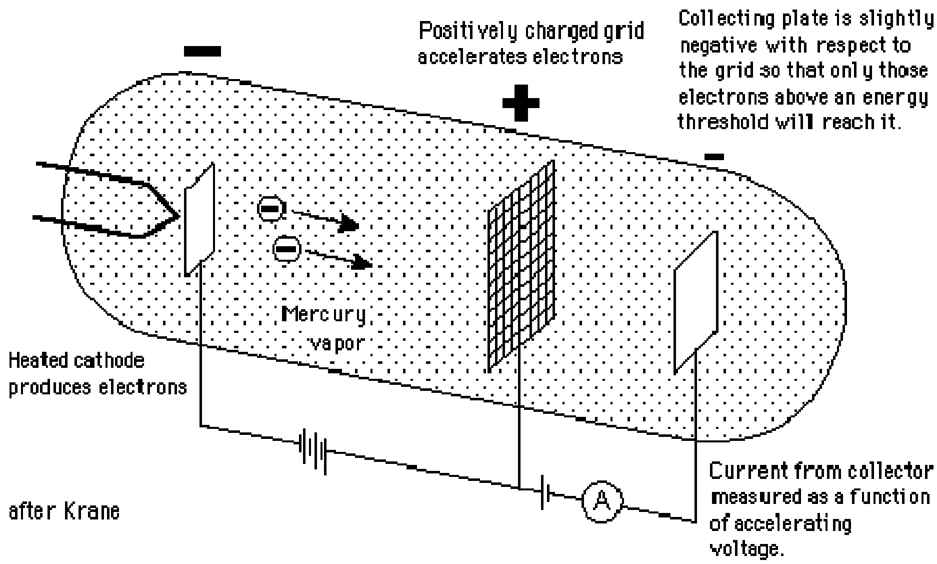
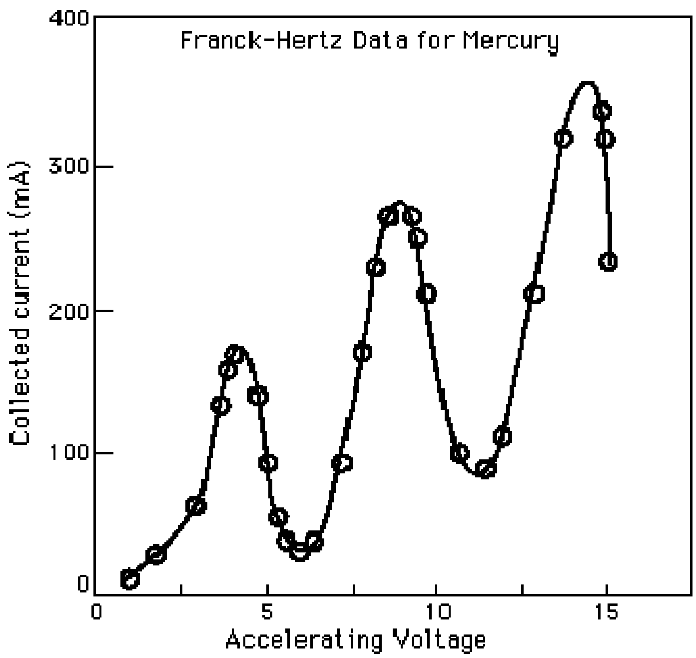
Introdcution:

The Franck Hertz experiment was performed in 1914 in order to provide direct evidence of atomic energy levels. The key idea was to consider what happens when a free electrons strikes an atom. If the free electron has insufficient energy to excite the atom to next energy level, then it scatters in an elastic collision. However, if it has sufficient energy it will excite the atom to the next energy level and will lose a corresponding amount of energy, equal to the first excitation energy of that atom. Franck and Hertz devised a way to measure the energy of electrons after colliding with atoms of Mercury in an evacuated chamber.

The main piece of apparatus was a cathode ray tube, which emits a stream of electrons from a heated cathode and accelerates them towards a positively charged anode using an accelerating potential *V*ac. In the Franck-Hertz experiment, the anode is a positively charged grid, which some of the electrons pass through. If these electrons have enough energy they are able to continue until collide with a collection plate which is held at a slightly negative potential. The result is a small current in the wire that connects the collecting plate back past the anode toward the cathode. The more electrons that make it to the plate, the higher the current, I.



As the accelerating potential is increased the energy of the electrons at the anode grid gets larger and the number of electrons that go on to reach the collecting plate increases. The current increases correspondingly. However, at some point the electrons have enough energy to excite the mercury atoms, and so the average energy of the accelerated electrons drops. Fewer of them reach the collecting plate and the current drops. However, if the accelerating potential is increases further, the current rises again, until the electrons have enough residual energy to cause a second mercury atom to excite. Thus the current drops again. Thus the current rises and falls then rises and falls again as the accelerating potential is increased. The pattern can continue for many cycles. A graph of Fracnk-Hertz's data is shown below:



The shape of the graph provides clear evidence of atomic energy levels. In addition the distance between the peaks give the first excitation energy in electron volts. In this lab you will repeat the Franck-Hertz experiment using a cathode ray tube containing argon instead of mercury.

Procedure:

1. Switch on the power to the Franck-Hertz apparatus. Make sure the Manual-Auto switch is set to Manual. Set the filament voltage to 3.5 V. This provides power to heat the cathode.
2. Now turn the voltage stepping switch to the 1.3-5 V range and adjust the corresponding knob until the meter reads 2.5 volts. This voltage removes charged ions from the tube that may interfere with the cathode rays.
3. Now turn the voltage setting switch to the 1.3-15 V range and adjust the corresponding knob until the meter reads 4.5 volts. This voltage is called the retarding potential, which provides the negative potential to slow down electrons after they pass the anode grid
4. Now turn the voltage stepping switch to the 1-100 V range. Adjusting the corresponding knob will now change the accelerating potential. Increase the potential from 0 to 2 volts and record the corresponding current. You will need to adjust the current multiplier to a suitable setting in order detect the current. Keep increasing in the voltage in 2 volt increments until you reach 50 volts. Record the current for each new voltage. (Warning: Don't go above 60 volts as this may damage the tube).
5. Once you have collected this data, go back and locate the voltage and current for the peaks and troughs more accurately.
6. Finally, set the accelerating potential to zero, and then turn all other potentials to zero, and turn the power off.
7. Plot your data and measure the voltage difference between each pair of peaks and each pair of troughs. Find the average and standard deviation and hence determine the first excitation energy of argon with uncertainty. Compare your result with the expected answer of 11.55 volts.