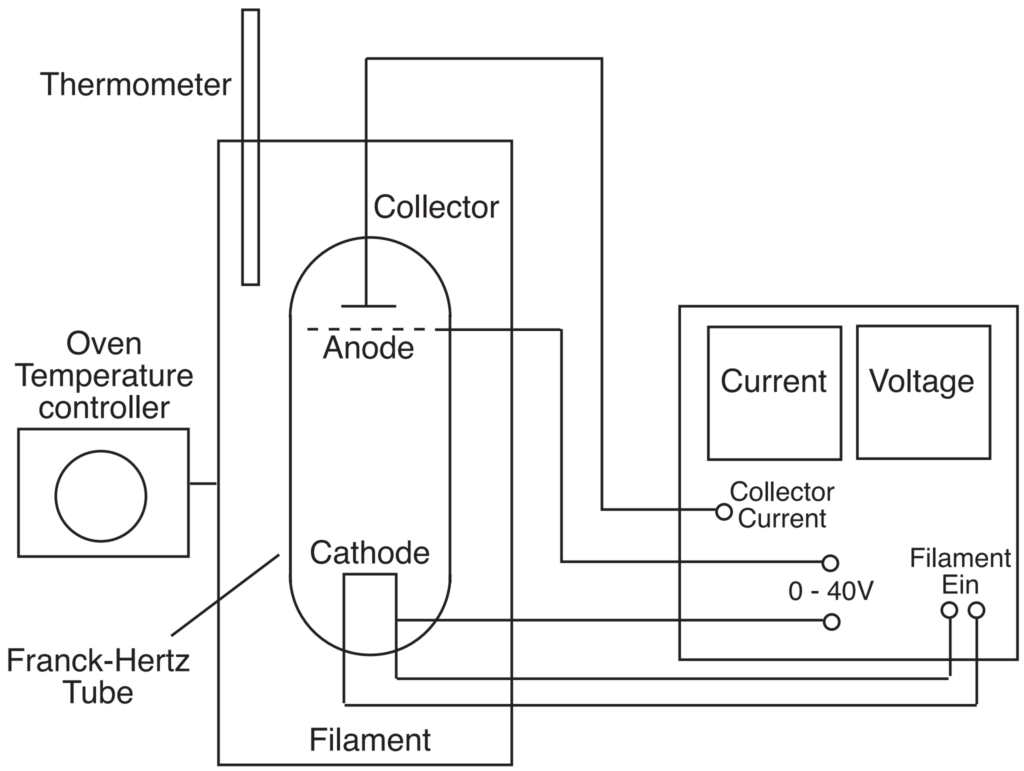
Franck - Hertz Praktikum

Aim:
To verify that atomic systems have discrete energy levels by bombarding vapour phase mercury atoms with electrons and observing the decrease of current through the vapour due to discrete absorption.

Introduction:
In 1914, James Franck and Gustav Hertz (Nephew of Heinrich Hertz) first attempted to verify that the atomic systems have discrete energy levels which can be excited by collisions with bombarding electrons. This experiment examines the effect of bombarding atoms of mercury with electrons. Since atoms are believed to have discrete energy levels one would expect that in collisions with electrons, the transfer of energy to the atom should occur in discrete amounts. One possible mechanism would be inelastic scattering in which a discrete amount of the incident electron energy is absorbed by the whole atom which is thus raised to an excited state.



Equipment:
A diagram of equipment to be used is shown above. It consists of a Franck-Hertz tube with a cathode, an anode and a third electrode which is called the collector. The tube also contains a small amount of mercury. The whole tube is heated up to 200°C to maintain a mercury vapour pressure in the tube. The pressure is, of course, temperature dependent and the amount of pressure is critical to the experiment. If the vapour density is too low, there may be too few mercury atoms to produce observable effects. At too high a pressure the reduction in the mean free path and thermal agitation becomes troublesome.

The anode is connected to a variable voltage source (0 to +50 Volts) with respect to the cathode. The counter electrode is maintained at -1.5 Volts with respect to the anode.

The presence of the mercury vapour modifies the behaviour of the system. Electrons accelerated from the cathode to the anode will collide with the mercury atoms. When the electrons acquire sufficient energy to inelastically excite a mercury atom, the electron can lose most of its energy. It then may have insufficient energy to overcome the -1.5 Volts required of it to reach the counter electrode. Therefore, as one increases the anode voltage, one should see a sharp dip in the counter current at the energy at which such collisions can occur. At higher voltages the counter current starts to rise again but eventually the electrons gain sufficient energy to suffer two or more inelastic collisions. Thus, the observed current-voltage curve should be steadily rising with a superimposed series of dips; the separation of two dips will correspond to the difference in energy of the ground state and first excited state in the mercury atoms.

The procedure for the experiment is as follows: Measure the current between the cathode and anode as a function of applied voltage. Ensure that a sufficient number of points are measured to enable an accurate determination of the peak value. A voltmeter may be used to measure the applied voltage. Repeat the measurement at two different temperatures, in the range 170 - 200 ^{o}C as measured by the mercury thermometer. NB After use, ensure the filament and heater are switched off.

Analysis:

To average over all your single-temperature data at once, assign an integer number (1, 2, 3,...) to each peak in order. Now plot your data as x=1, y=14.3V, etc. Explain why you would expect this to yield a straight line, and what the slope would represent. Calculate the slope at each temperature and the associated error. Draw conclusions about whether the slope (and whatever it represents) changes with temperature, and whether the current in the tube changes with temperature. Try to explain why the current should behave in the way you observe.

Report:

The report should be approximately five word processed pages long, not including appendices. All diagrams and graphs should be included in the body of text, not as separate pages. It should be written in scientific english. Scientific reports are written in the 3rd person or the third person plural, for example: “the temperature was measured” or “we measured the temperature” NEVER: “I measured the temperature” (even though this may be true!) Avoid using long sentences, and make every word count. HOWEVER, don’t worry, the standard of english will not be considered, only the scientific content and layout. The report should consist the following sections:

1. Abstract

About 50 words briefly describing the main features of the report, such as type of apparatus used, temperature at which results were taken and finally the final value with errors.

2. Introduction

This should explain the historical background of the experiment and the reason for doing it.

3. Theory
This section explains all the relevant theory. An energy level diagram of mercury should be included and explained. Equations can be included using microsoft equation editor in Word or a similar editor.

4. Experimental Procedure
Start with a diagram, correctly annotated. The diagram can be drawn in Word or imported into word as an image file. Following the diagram should be an explanation of the apparatus and the procedure used.

5. Results
This section should only include results that have been processed, in this case, it means results in graph form. Excel can be used for the graphs and then imported into the word document. Do not include tables of raw values, these can be included as an appendix at the end of the report.

6. Discussion and Conclusion (sometimes these can be separate sections)
The sections draws the conclusion of the experiment. It should quote the value found in the experiment for the energy level, including errors. This value should be compared to the commonly accepted “literature value” on the energy level diagram. Any differences between the two values should be explained.

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