Photo Electric Effect

Planck's Constant

AP2341-002 Dual LCD Meters, Lamp & Filters, Experiments 1 & 2

Description:

Kit Contents:

- 1 pce. Photo-Electric Effect instrument. Runs from 9V transistor battery.
- 1 pce. 9V battery, type #216
- 1 pce. Lamp as light source, 12Volt, 25 Watt. Mounts on rear of unit.
  Spare lamp is Cat: PA2043-004 2pin, QI, 12V, 25W.
- 1 set of 5x Colour filters. Calibrated in nanometres wavelength.
- 1 set. 4x Apertures to set the quantity of light from the light source.
  Aperture orifices: 7mm, 10mm, 14mm, and 20mm diameters
  One test sheet and Experiment Sheets for using the instrument are included.

Features of this model:

- Dual meters permit the "backing voltage" and the photo-cell current to be viewed together without requiring the switching from one to the other.
- Removal of two selection switches makes readings quicker and less confusing.
- This model includes selection of nanoamps or microamps as the current range for some of the experiments.

Length: 272mm	Width: 160mm	Height: 110mm	Weight: 1.3kg

The 'IEC' Photo-Electric Unit: description

A bench mounting instrument with 2 digital meters to simultaneously indicate both the current through the internal photo-cell and the backing voltage applied to the cell.

This model requires a 9V battery in the holder on the rear panel.

The image above shows the lamp mounted and the filters and apertures on the bench. They are normally stored in the container mounted to the panel. A small label lists the shortest wavelength (highest frequency) of light that can pass through each filter.

On the underside panel, an instruction label provides basic assistance to the user in the operation of the instrument to avoid unnecessary reference to the full set of instruction sheets.

Also the EXPT.1) is divided into several sections and each section is explained on the large information label.

Part of the study is to prove the discovery that the energy of photons depends on the wavelength of the light and not the amount or brightness

To avoid the use and possible loss of colour filters, IEC makes another model of the "Photo Electric" instrument AP2342-001 that uses LEDs of specific wavelengths as the light sources.

Principle of Operation:

Experiments can be performed in the following areas:

a) Photo Electric Effect … that light can create an electric current.
b) Illumination / Current relationship ... that current changes with luminous intensity.
c) Energy of a Photon … that a photon can drive an electron from a surface.
d) Planck's Constant … the amazing relationship between energy and wavelength.
e) Energy Distribution … where the energy is expended

The experiment sheets form a separate document, so in this small document we mention only the "Planck's Constant" experiment. Explanation is below:

When light falls on the cathode of the photo-cell, providing the energy level of the photon is high enough, the photon drives an electron from the metallic surface of the cathode. This electron has the energy imparted to it from the photon, therefore the higher energy of the photon, the higher energy of the electrons driven from the surface.

These electrons pass across the vacuum space in the cell to the Anode pin inside the cell. When a voltage is applied to the Anode in a direction to repel the electrons from the anode, the current flow completely stops as the last electrons of the highest energy levels cannot quite reach the anode. This voltage applied to the cell to stop the electron flow through the cell is called the "backing voltage". Therefore, the backing voltage that JUST causes this current to become exactly zero is a measurement of the energy level of the MOST energised electrons caused by the wavelength of the light applied to the cell.

It can be proven that the AMOUNT of light does not alter the energy level of the electrons, but, amazingly, the various wavelengths of the light alter the energy levels of the electrons. The graphing of the backing voltage against the frequency of the light for each of the 5 filter wavelengths creates a straight line proving a linear relationship between frequency of the radiation and the energy of its photons. The slope of this straight line multiplied by 'e' (charge on an electron) is the value of "Planck's Constant" ('h').

The Experiment:

- Slide the lamp housing into the slots on the rear face of the instrument and connect the 4mm banana plugs to a 12V AC or DC power source. Insert the blue filter.
- Select Experiment 1 using nanoamps (nA) and turn ON the front panel switch so that the displays will show values.
- Set the FINE control to about 'half' position. Using the COARSE control, adjust the BACKING VOLTS until the NANOAMPS reading is very close to zero. Then use the FINE control to achieve exactly zero nanoamps. Wait several seconds to be sure it is exactly zero. Take note of the BACKING VOLTS reading for the colour filter being used in front of the light source. Repeat the measurement to get an average.
- Repeat the above for each colour filter in turn and note the backing volts in each case. Each time, repeat the measurement once or twice to obtain average volts.
- Graph the results with the 'X' axis scaled as frequency of the colour in Hz $x10^{14}$ and the "Y" axis as backing volts in volts, then plot each relationship. Draw a straight line graph of best fit through the 5 points.
- Planck's Constant ('h') is the SLOPE of this line (dV/df) x the charge on an electron ($1.6x10^{-19}$ coulombs). Theoretically, this value of 'h' = $6.626x10^{-34}$

Front Panel Controls:

On/Off Switch: When ON, the digital displays will show digits.

'Wavelength' of the Colour Filters:

The unit for wavelength is 'nanometres' = Metres $x10^{-9}$. Abbreviation: 'nm'.

Frequency is: (3,000 / nm) $x10^{14}$ Unit: Hertz (Hz)

- Blue: 432 nm wavelength (or 6.944 $x10^{14}$ Hz frequency)
- Green: 477 nm wavelength (or 6.289 $x10^{14}$ Hz frequency)
- Yellow: 501 nm wavelength (or 5.988 $x10^{14}$ Hz frequency)
- Orange: 522 nm wavelength (or 5.747 $x10^{14}$ Hz frequency)
- Red: 582 nm wavelength (or 5.155 $x10^{14}$ Hz frequency)

'Backing Volts"– Coarse / Fine Rotary Controls:

Adjusts the DC volts applied to the anode and cathode of the photo cell attempting to completely stop the flow of electrons from the cathode to the anode.

The value of this voltage is a measurement of the energy level of the electrons that relate to the selected wavelength of the light. The "coarse" control adjusts the voltage rapidly.

The "fine" control adjusts the voltage more slowly to determine exactly zero current flow (zero electrons reaching the anode).

'Volts" and "Nanoamps" Meters:

The VOLT meter displays the value of the backing voltage required to bring the photo-cell current to exactly zero. This voltage value is graphed against the frequency of the light to determine Planck's Constant.

The NANOAMPS meter displays the small current passing through the photo-cell down to 0.1 nanoamps (amps $x10^{-10}$). 1 nanoamp = $1/1000^{th}$ of 1 microamp.

Experiment Selection 1 or 2:

Exp.1 permits 1a, 1b, 1c, 1d and 1e. Some require nA and others require uA measurements and this can be selected. EXPT.1) experiments relate to Photo Electric and Planck's Constant. EXPT.2) is for Characteristic curve of Photo Tube.

Brightness of the Light:

To adjusts the brightness or intensity of the light coming from the light source, take an aperture and slide it into the slot in front of the filter to change the orifice.

The change of light intensity is to prove the proposal that it is not the amount of light that governs the energy levels of the electrons driven from the cathode of the photo-cell by the photons, but it is the wavelength of the light.

The energy level will be found to be close to the same at both high and low light intensity levels.

Note: IEC produces an "Experiment Sheet" outlining the use of the equipment and the experiments to be performed.

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