Related topics
External photoelectric effect, work function, absorption, photon energy, anode, cathode.

Principle and task
A potassium photo-cell is illuminated with light of different wavelengths. Planck’s quantum of action, or Planck’s constant \((h)\), is determined from the photoelectric voltages measured.

Equipment
- Photocell, for h-det., w. housing 06778.00 1
- Interference filters, set of 3 08461.00 1
- Interference filters, set of 2 08463.00 1
- Experiment lamp 6 11615.05 1
- Spectral lamp Hg 100, pico 9 base 08120.14 1
- Power supply for spectral lamps 13662.93 1
- Mounting plate R, 32 cm × 21 cm 13001.00 1
- Universal measuring amplifier 13626.93 1
- Digital multimeter 07134.00 1
- Screened cable, BNC, l 300 mm 07542.10 1
- Connecting cord, 250 mm, red 07360.01 1
- Connecting cord, 250 mm, blue 07360.04 1

Problems
To determine Planck’s quantum of action from the photoelectric voltages measured at different wavelengths.

Set-up and procedure
The experimental set-up is as shown in Fig. 1. The interference filters are fitted one after the other to the light entrance of the photo-cell.

The measuring amplifier is used in the following way
- Electrometer \(R_0 ≥ 10^{13} \Omega\)
- Amplification: 100
- Time constant: 0
- Voltmeter: DC 2 V

The high-impedance input of the measuring amplifier is discharged via the 'zero' button between measurements.

Theory and evaluation
Half of the inside of the high-vacuum photo-cell is a metal-coated cathode. The anular anode is opposite the cathode.

Fig. 1: Experimental set-up for determining Planck’s quantum of action.
If a photon of frequency \( f \) strikes the cathode, then an electron can be ejected from the metal (external photoelectric effect) if there is sufficient energy.

Some of the electrons thus ejected reach the (unilluminated) anode so that a voltage is set up between anode and cathode, which reaches the limiting value \( U \) after a short (charging) time. The electrons can only run counter to the electric field set up by the voltage \( U \) if they have the maximum kinetic energy, determined by the light frequency,

\[
hf - A = \frac{m}{2} v^2 \quad \text{(Einstein equation),}
\]

where \( A = \) work function from the cathode surface, \( v = \) electron velocity, \( m = \) rest mass of the electron.

Electrons will thus only reach the anode as long as their energy in the electric field is equal to the kinetic energy:

\[
eU = \frac{m}{2} v^2
\]

with \( e = \) electron charge = \( 1.602 \cdot 10^{-19} \text{ As} \)

An additional contact potential \( \phi \) occurs because the surfaces of the anode and cathode are different:

\[
eU + \phi = \frac{m}{2} v^2
\]

If we assume that \( A \) and \( \phi \) are independent of the frequency, then a linear relationship exists between the voltage \( U \) (to be measured at high impedance) and the light frequency \( f \):

\[
U = -\frac{A + \phi}{e} + \frac{hf}{e} f
\]

If we assume \( U = a + bf \) to the values measured in Fig. 2 we obtain:

\[
h = 6.7 \pm 0.3 \cdot 10^{-34} \text{ Js}
\]

Literature value: \( h = 6.62 \cdot 10^{-34} \text{ Js} \).