电子科技大学
格拉斯哥学院
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Score

Physical Experiment Ⅱ

Physics Lab Report 14

Experiment Title: The Photoelectric Effect

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Lab Date: 2018.12.06

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Abstract (About 100 words, 10 points)

The main purpose of this experiment is to test the photoelectric effect, and determine the values of Planck' s constant. In this experiment, we measured the stopping potential and the current-voltage characteristics of the photoelectric tube. After that, we determined the value of the Planck' s constant (about $6.288\times10^{-34}\mathrm{j}\cdot\mathrm{s}$) and the work function of the mental in the photoelectric tube (about 1.701eV) by calculating the data and using the lest-squares fitting method. From this experiment, I understand the quantum property of the light deeply, and find that the light could show its quantum property and generate the photoelectric effect, when f is higher than the cut-off frequency.

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Calculations and Results (Calculations, data tables and figures; 15 points)

Calculations

(1) Use the following formula to compute the frequencies of the five lights. Show one sample calculation and put the data in Data Table 3.14-1.

$$v = \frac{c}{\lambda} \tag{3.14-6}$$

Where c is the speed of light (c=3.00×10^8 m/s), and λ is the wavelength of light.

$$v = \frac{c}{\lambda} = \frac{3\times10^8 m/s}{365\mathrm{nm}} = 8.219\times10^{14} Hz$$

(2) Suppose that the frequency v and the stopping potential ΔV_s satisfy the relationship $\Delta V_s = kv + b$. Use the data in Data Table 7-1 and the least-square fitting method to find out the values of the Planck's constant and the work function of the metal in photoelectric tube.

$$\bar{x} = \frac{8.219\times10^{14} + 7.407\times10^{14} + 6.881\times10^{14} + 5.495\times10^{14} + 5.199\times10^{14}}{5} = 6.649\times10^{14}\mathrm{Hz}$$

$$\bar{y} = \frac{(-1.498) + (-1.227) + (-0.914) + (-0.614) + (-0.313)}{5} = -0.913$$

$\overline{xy}$

$$= \frac{8.219\times10^{14}\times(-1.498) + 7.407\times10^{14}\times(-1.227) + 6.881\times10^{14}\times(-0.914) + 5.495\times10^{14}\times(-0.614) + 5.199\times10^{14}\times(-0.313)}{5}$$

$$= -6.538\times10^{14}$$

$$\overline{x^2} = \frac{(8.219\times10^{14})^2 + (7.407\times10^{14})^2 + (6.881\times10^{14})^2 + (5.495\times10^{14})^2 + (5.199\times10^{14})^2}{5} = 45.398\times10^{28}$$

$$a = \frac{\bar{x}\cdot\overline{xy} - \bar{y}\cdot\overline{x^2}}{\bar{x}^2 - \overline{x^2}} = \frac{-43.471\times10^{28} - (-0.913)\times45.398\times10^{28}}{(6.649\times10^{14})^2 - 45.398\times10^{28}} = \frac{-2.023}{-1.189} = 1.701$$

$$b = \frac{\bar{x}\cdot\bar{y} - \overline{xy}}{\bar{x}^2 - \overline{x^2}} = \frac{-6.071\times10^{14} - (-6.538\times10^{14})}{-1.189\times10^{28}} = -0.393\times10^{-14}$$

$y = (-0.393\times10^{-14})x + 1.701$

W=1.701eV

$h = e\cdot b = (-1.6\times10^{-19})\times(-0.393\times10^{-14}) = 6.288\times10^{-34} j\cdot s$

$$\gamma = \frac{\sum_i^5 (x_i-\bar{x})(y_i-\bar{y})}{\sum_i^5 (x_i-\bar{x})^2 (y_i-\bar{y})^2} = -0.984$$

Data Tables

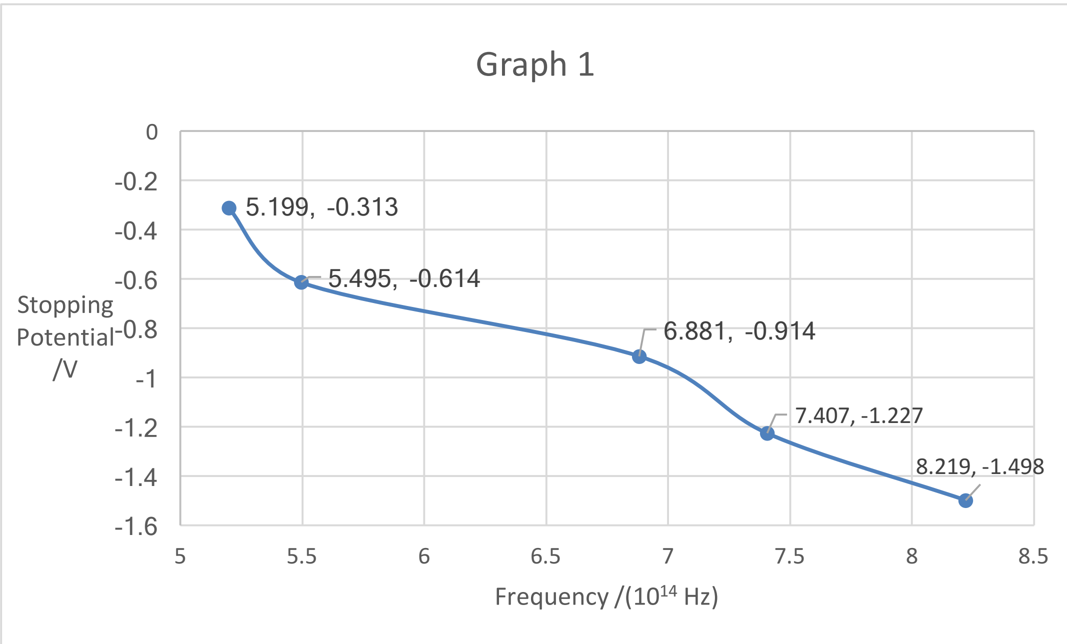
DATA TABLE 3.14-1 (*purpose*: to measure the stopping potentials for different lights)

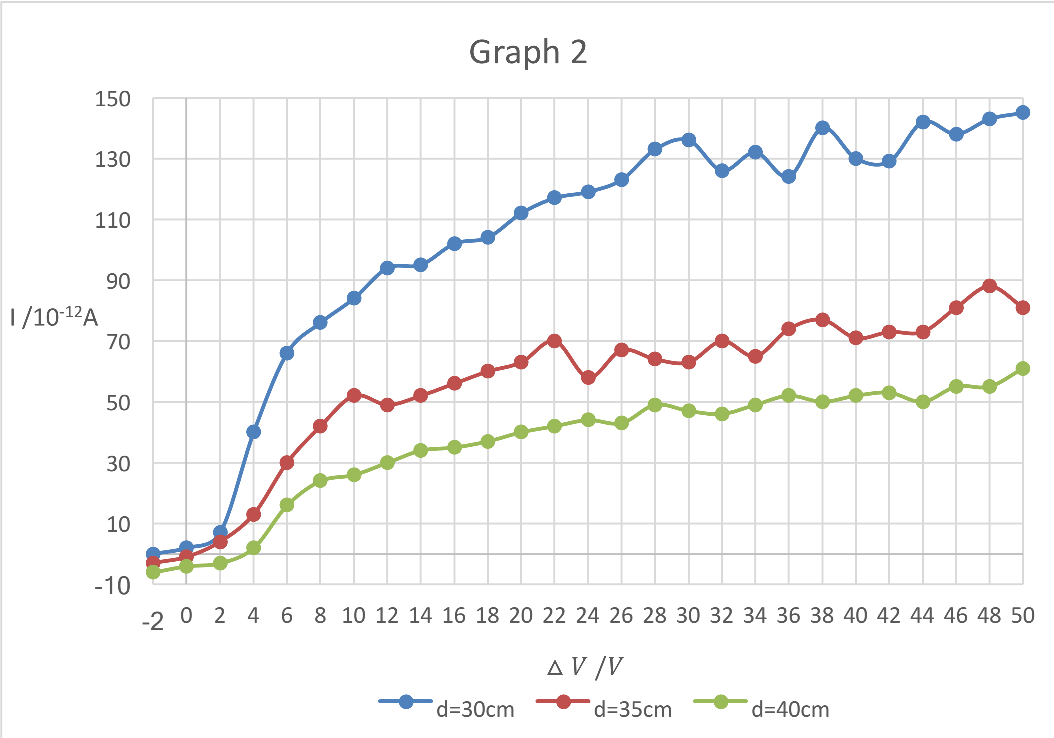
Wavelength (nm)	Frequency (Hz)	Stopping potential (V)
365	8.219×10^{14}	-1.498
405	7.407×10^{14}	-1.227
436	6.881×10^{14}	-0.914
546	5.495×10^{14}	-0.614
577	5.199×10^{14}	-0.313

DATA TABLE 3.14-2 (*purpose*: to measure current-voltage characteristics of the photoelectric tube)

ΔV / V	-2.0	0.0	2.0	4.0	6.0	8.0	10.0	12.0
d=30cm, I / 10^{-12}A	0	2	7	40	66	76	84	94
d=35cm, I / 10^{-12}A	-3	-1	4	13	30	42	52	49
d=40cm, I / 10^{-12}A	-6	-4	-3	2	16	24	26	30
ΔV / V	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0
d=30cm, I / 10^{-12}A	95	102	104	112	117	119	123	133
d=35cm, I / 10^{-12}A	52	56	60	63	70	58	67	64
d=40cm, I / 10^{-12}A	34	35	37	40	42	44	43	49
ΔV / V	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0
d=30cm, I / 10^{-12}A	136	126	132	124	140	130	129	142
d=35cm, I / 10^{-12}A	63	70	65	74	77	71	73	73
d=40cm, I / 10^{-12}A	47	46	49	52	50	52	53	50
ΔV / V	46.0	48.0	50.0					
d=30cm, I / 10^{-12}A	138	143	145					
d=35cm, I / 10^{-12}A	81	88	81					
d=40cm, I / 10^{-12}A	55	55	61					

Graphs





Score

Conclusions (About 100 words, 5 points)

After measuring the stopping potential and the current-voltage characteristics of the photoelectric tube in this experiment, and determining the values of Planck' s constant and the work function of the mental, I have a deeper understanding about the quantum property of the light and how the photoelectric effect generated. In this experiment, with some calculations, we obtained that the value of the Planck' s constant is about $6.288\times10^{-34}\mathrm{j\cdot s}$, the work function of the mental in the photoelectric tube is about $1.701\mathrm{eV}$, and the relation coefficient is -0.984, whose absolute value is close to 1, which means the data fits the line well.

Score

Answers to Questions (10 points)

(1) Because if the light intensity is not changing, the maximum amount of the electron per time which can arrive the polar plate is not changing, so the current will increase first then reach the saturation.

(2) The particle property of light is demonstrated by photoelectric effect.

(3) As there exists the cut-off frequency, which means that if the frequency is higher than it, there will be current. As a result, a work function that the electron run out of the polar plate can be verified.

Appendix

(Scanned data sheets)

3.14.5 Experimental Data

Data table 3.14-1 *Purpose*: To measure the stopping potentials for different lights

Wavelength /nm	Frequency /Hz	Stopping potential /V
365	8.219×10^{14}	−1.498
405	7.407×10^{14}	−1.227
436	6.88[illegible]$ \times 10^{14}$	−0.914
546	5.495×10^{14}	−0.614
577	5.1[illegible]9×10^{14}	−0.313

Data Table 3.14-2 *Purpose*: To measure current-voltage characteristics of the photoelectric tube

ΔV/V	−2.0	0.0	2.0	4.0	6.0	8.0	10.0	12.0
d = 30cm, $I/\times10^{-12}$A	0	2	7	40	66	76	84	94
d = 35cm, $I/\times10^{-12}$A	−3	−1	4	13	30	42	52	49
d = 40cm, $I/\times10^{-12}$A	−6	−4	−3	2	16	24	26	30
ΔV/V	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0
d = 30cm, $I/\times10^{-12}$A	95	102	104	112	117	119	123	133
d = 35cm, $I/\times10^{-12}$A	52	56	60	63	70	58	67	64
d = 40cm, $I/\times10^{-12}$A	34	35	37	40	42	44	43	49
ΔV/V	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0
d = 30cm, $I/\times10^{-12}$A	136	126	132	124	140	130	129	142
d = 35cm, $I/\times10^{-12}$A	63	70	65	74	77	71	73	73
d = 40cm, $I/\times10^{-12}$A	47	46	49	52	50	52	53	50
ΔV/V	46.0	48.0	50.0					
d = 30cm, $I/\times10^{-12}$A	138	143	145					
d = 35cm, $I/\times10^{-12}$A	81	88	81					
d = 40cm, $I/\times10^{-12}$A	55	55	61					

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