电子科技大学
格拉斯哥学院
Glasgow College, UESTC

# Physics Experiments II

## Experimental Examination



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|---|---|
| Experiment Title: | The Photoelectric Effect |
| Your Chinese Name: | 郑长刚 |
| Student Number: | 2016200302027 |
| Paper Number: | 3 |
| Instructor: | Jing Wu |
| Date Performed: | December 21th 2017 |
| Total Mark: | |

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**Abstract** (About 50 words, 4 points)

By understanding the experiment and how the photoelectric could happened and the meaning of the cut off frequency as well as the maximum kinetic energy, we could have a deeper understanding the quantum property of the light. Also, we should try to calculate the magnitude of the Planck's constant.

From this experiment, I could get that $h = 6.5168\times10^{-34} j\cdot s$ $relative\ error = -1.648\%$

From the experiment, I understand that the frequency of the photon could influence the energy of a photon and the intensity of the light could influence the energy of the light ($E = hv$). More than that, I understand that the light could show its quantum property， as only one photon increasing to an enough high level (f is higher than the cut-off frequency) it could be absorb and generate the photoelectric effect.

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**Calculations and Results** (Calculations, data tables and figures, 26 points)

Data Table 1. The stopping potential for different lights.

| Wavelength, $\lambda$ (nm) | 365 | 405 | 436 | 546 | 577 |
|---|---|---|---|---|---|
| Frequency, f ($v$) ($\times10^{14}$Hz) | 8.219 | 7.407 | 6.881 | 5.495 | 5.199 |
| Stopping potential, U0(V) | -1.810 | -1.420 | -1.250 | -0.670 | -0.570 |

(Note: Show the sample calculation of frequency, 1 point)

**1.** $$C = f\lambda$$

$$v = \frac{c}{\lambda} = \frac{3\times10^{8} m/s}{365\times10^{-9} m} = 8.219\times10^{14} Hz$$

**2.** By applying the last-square fitting method:

$$\Delta V_s = \frac{h}{e}v - \frac{w}{e}$$

$$\mathrm{y} = \Delta V_s$$

$$x = v$$

$$a = -\frac{w}{e}$$

$$b = \frac{h}{e}$$

$$y = a + bx$$

$$\bar{x} = (8.219 + 7.407 + 6.881 + 5.495 + 5.199) \div 5 = 6.6402\ (\times 10^{14} Hz)$$

$$\bar{y} = (-1.81 - 1.41 - 1.25 - 0.67 - 0.57) \div 5 = -1.144V$$

$$\overline{xy} = [8.219\times(-1.81) + 7.407\times(-1.41) + 6.881(-1.25) + 5.495\times(-0.67) + 5.199(-0.57)] \div 5$$

$$= (-14.88 - 10.52 - 8.61 - 3.682 - 2.963) \div 5$$

$$= -8.128$$

$$\overline{x^2} = [8.219\times8.219 + 7.407\times7.407 + 6.881\times7.407 + 5.495\times5.495 + 5.199\times5.199] \div 5$$

$$= (67.55 + 54.86 + 47.35 + 30.20 + 27.03) \div 5 = 45.398$$

$$a = \frac{\bar{x}\cdot\overline{xy} - \bar{y}\cdot\overline{x^2}}{\bar{x}^2 - \overline{x^2}} = \frac{6.6402\times(-8.128) - (-1.144)\times45.398}{44.092 - 45.398} = 1.5608$$

$$b = \frac{\bar{x}\cdot\bar{y} - \overline{xy}}{\bar{x}^2 - \overline{x^2}} = \frac{6.6402\times(-1.144) - (-8.128)}{44.092 - 45.398} = -0.4073$$

$$y = -0.4073x + 1.5608$$

we can finally get: (I just add the unit to the last step)

$$h = e\times b\times\frac{1}{10^{14}} = -1.6\times10^{-19}\times(-0.4073)\frac{1}{10^{14}} = 6.5168\times10^{-34} j\cdot s$$

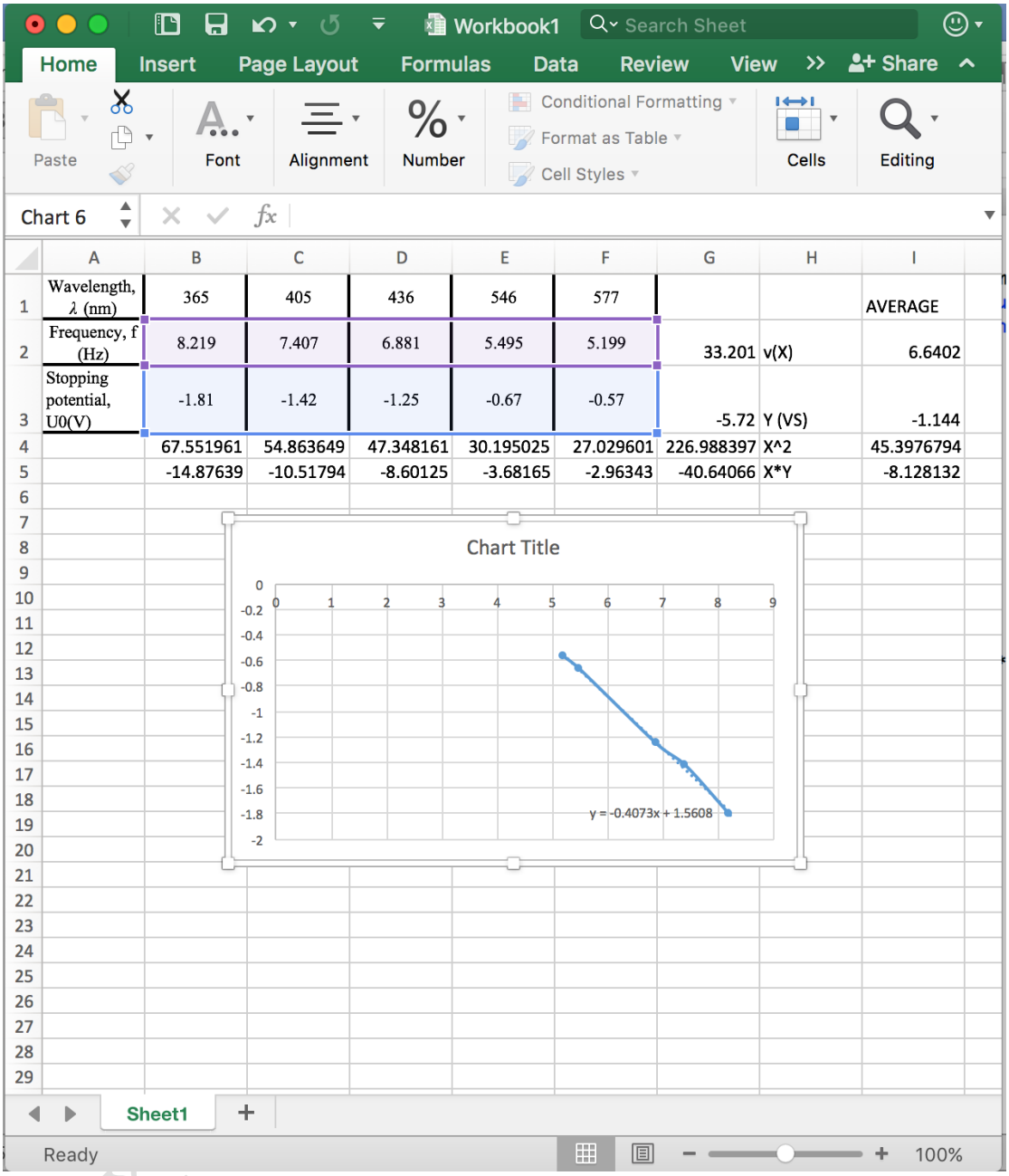
**3.**

$$Error_{absolute} = result\ of\ measurement - true\ value$$
$$= 6.5168\times10^{-34} - 6.626\times10^{-34} = -0.1092\times10^{-34} j\cdot s$$

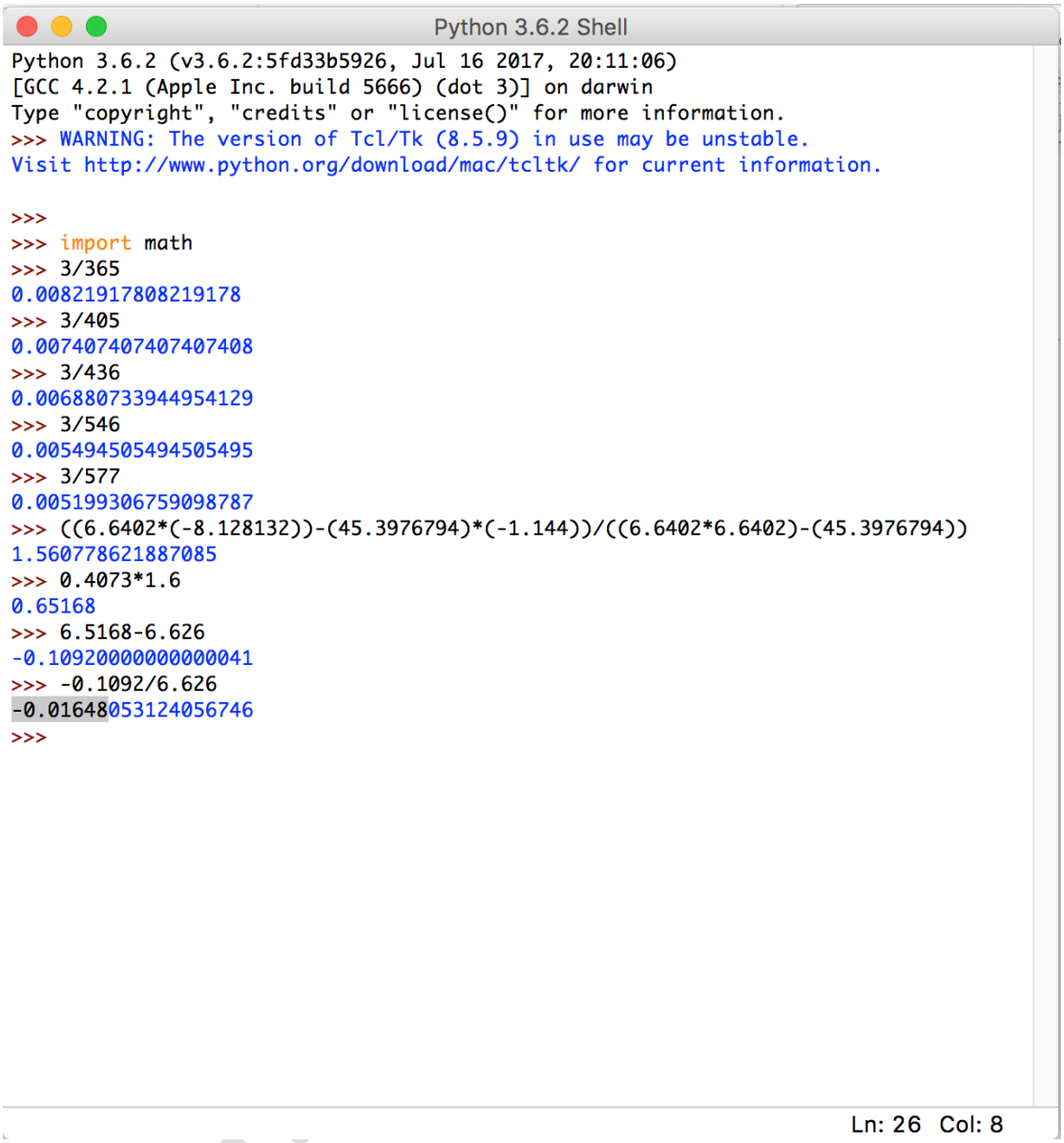
$$relative\ error = \frac{Error_{absolute}}{real\ value} = \frac{-0.1092\times10^{-34} j\cdot s}{6.626\times10^{-34} j\cdot s}\times100\%$$

$$= -0.01648\times100\% = -1.648\%$$

## Calculation steps: (By applying some advanced apps)




| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Wavelength, λ (nm) | 365 | 405 | 436 | 546 | 577 | | | AVERAGE |
| 2 | Frequency, f (Hz) | 8.219 | 7.407 | 6.881 | 5.495 | 5.199 | 33.201 | v(X) | 6.6402 |
| 3 | Stopping potential, U0(V) | -1.81 | -1.42 | -1.25 | -0.67 | -0.57 | -5.72 | Y (VS) | -1.144 |
| 4 | | 67.551961 | 54.863649 | 47.348161 | 30.195025 | 27.029601 | 226.988397 | X^2 | 45.3976794 |
| 5 | | -14.87639 | -10.51794 | -8.60125 | -3.68165 | -2.96343 | -40.64066 | X*Y | -8.128132 |


Python 3.6.2 Shell
Python 3.6.2 (v3.6.2:5fd33b5926, Jul 16 2017, 20:11:06)
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwin
Type "copyright", "credits" or "license()" for more information.
>>> WARNING: The version of Tcl/Tk (8.5.9) in use may be unstable.
Visit http://www.python.org/download/mac/tcltk/ for current information.
>>>
>>> import math
>>> 3/365
0.00821917808219178
>>> 3/405
0.007407407407407408
>>> 3/436
0.006880733944954129
>>> 3/546
0.005494505494505495
>>> 3/577
0.005199306759098787
>>> ((6.6402*(-8.128132))-(45.3976794)*(-1.144))/((6.6402*6.6402)-(45.3976794))
1.560778621887085
>>> 0.4073*1.6
0.65168
>>> 6.5168-6.626
-0.10920000000000041
>>> -0.1092/6.626
-0.016480531240567 46
>>>
Ln: 26 Col: 8

**Examination Paper Number: 3**

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**Answers to Questions** (ONLY write the answers, 10 points)

**1** D

**2** D

**3** **(a)** w is the work function

$$E_{Kmax} = e\Delta V_s = hv - w$$

when $\Delta V_s = 1.68V \times 1e = 1.68eV$

$$v = \frac{c}{\lambda} = \frac{3\times10^{8}m/s}{365\times10^{-9}m} = 0.8219\times10^{15}Hz$$

$$hv = 6.626\times10^{-34}\times0.8219\times10^{15} = 5.446\times10^{-19}j = 3.398eV$$

$$w = hv - e\Delta V_s = 3.398\text{-}1.68 = 1.72eV$$

**(b)** Same material, so the w would be the same magnitude

$$w = hv\text{-}e\Delta V_s$$

$$v = \frac{w + e\Delta V_s}{h} = \frac{(1.72 \div 6.24\times10^{18}) + (-1.6\times10^{-19})1.11}{6.626\times10^{-34}} = 1.48\times10^{14}Hz$$