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Experiment No - 5

Planck's Constant using Photoelectric Effect

Aim -

Measurement of Planck's constant using photoelectric effect and to determine the work function and threshold frequency of the cathode material.

Formula Used -

1. $E = h\nu = \frac{hc}{\lambda}$

where E is Photon's energy
h is Planck's constant
c is Speed of light
λ is Wavelength of light

2. $\nu = \frac{c}{\lambda}$

where ν is frequency of incident radiation
c is speed of light
λ is wavelength of light

3. $h\nu = \frac{1}{2} m v^2 + e\phi$

where h is Planck's constant
ν is frequency of incident radiation
v is the velocity of electron
ϕ is the work function of cathode material

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Observations-

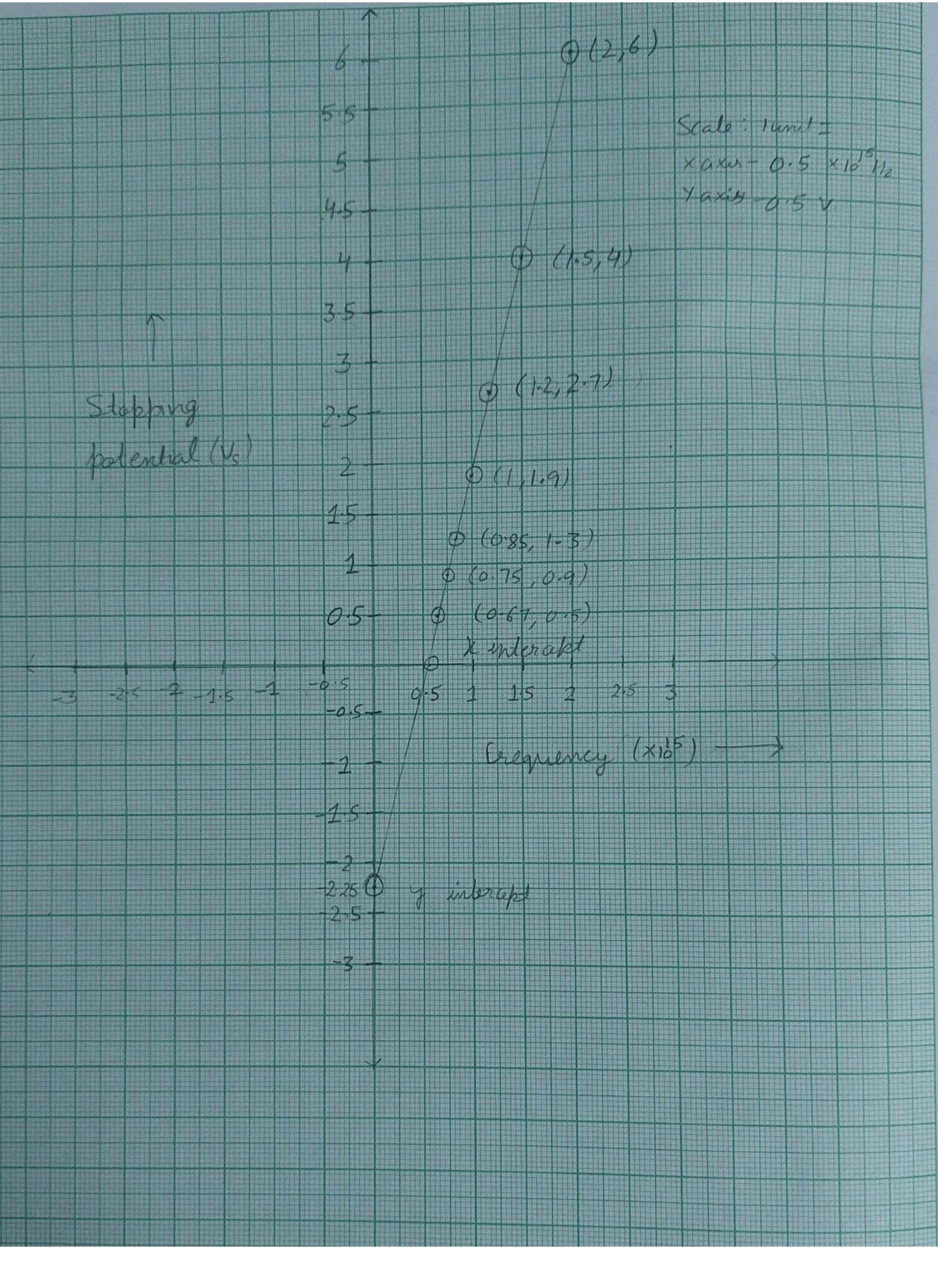
Material of plate (cathode) used for photoelectric emission: Sodium

Area of plate: $0.3\ cm^2$

Intensity of light: $15\ W/m^2$

Table 1. Stopping potential versus frequency of incident light

S. No.	Wavelength, λ (nm)	Frequency, $\nu = c/\lambda$ (10^{15} Hz)	Magnitude of stopping potential, V_s (Volt)
1	150	2	6
2	200	1.5	4
3	250	1.2	2.7
4	300	1	1.9
5	350	0.85	1.3
6	400	0.75	0.9
7	450	0.67	0.5


Scale: 1 unit =
x axis - 0.5 $\times 10^{15}$ Hz
y axis - 0.5 V
Stopping potential (V_s)
(2, 6)
(1.5, 4)
(1.2, 2.7)
(1, 1.9)
(0.85, 1.3)
(0.75, 0.9)
(0.67, 0.5)
x intercept
y intercept
Frequency ($\times 10^{15}$)

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4. $h\nu = eV_s + e\phi$

$V_s = \frac{h\nu}{e} - \phi$

where V_s is stopping potential
h is Planck's constant
ν is frequency of incident radiation
e is charge of electron (1.6×10^{-19} C)
ϕ is work function of cathode material

Calculations-

Actual values-
Planck's constt. (h) - 6.63×10^{-34} J.s
Work function (ϕ) for sodium = 2.3 eV.

1. Slope = $\frac{y_2 - y_1}{x_2 - x_1} = \frac{6 - 0.5}{2 - 0.67} = 4.135 \times 10^{-15}$

Points used (2, 6) ; (0.67, 0.5)

2. Planck's Constant (h) = $4.135 \times 10^{-15} \times 1.6 \times 10^{-19}$
$= 6.6163 \times 10^{-34}$ J.s

% error in h = $\frac{|6.626 - 6.616|}{6.63} \times 100$
$= 0.211\%$

3. y intercept (Work function (ϕ)) = 2.25 eV

4. x intercept (Threshold frequency (ν_0)) = 0.505×10^{15}

% error in work function $= \frac{|2.3 - 2.25|}{2.3} \times 100$

$= \frac{0.05}{2.3} \times 100$

$= 2.17\%$

Result & Conclusion -

Planck's constant, $(h) = 6.616 \times 10^{-34}$ Js.

% Error = 0.211 %

Work function, $(\phi) = 2.25$ eV

% Error = 2.17 %

Threshold frequency of sodium, $(\nu_0) = 0.505 \times 10^{15}$ Hz