EXPERIMENT-2

AIM:

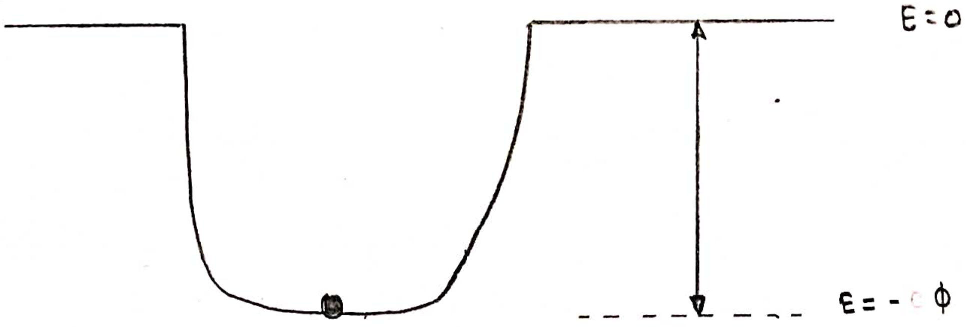
I. To determine Planck's constant 'h'
II. To determine the work function 'ϕ' of metals.

APPARATUS USED:

Vaccum phototube, Tungsten halogen lamp, votmeter, ammeter

THEORY AND FORMULA USED:

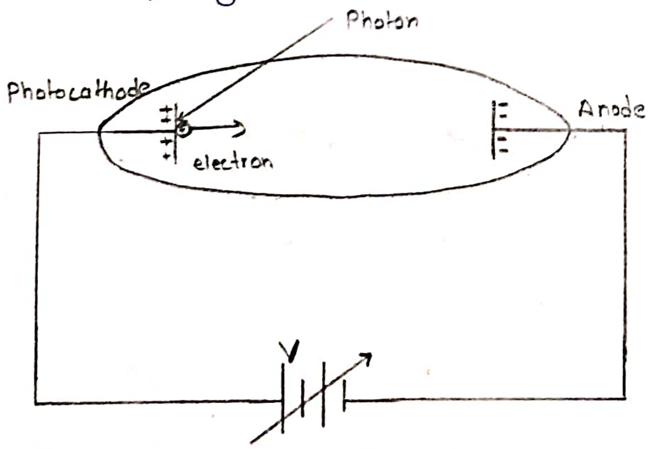
An electron in metal cap be modelled as a particle in an average potential well due to net attraction and repulsion of protons and electrons. The minimum depth that an electron is located in the potential well is called the workfunction of the metal ϕ. It is a measure of the amount of work that must be done on the electrons (located in the well) to make it free from the metal. Since different metal atoms have different number of protons and different values of electrical properties, the work function ϕ depends on the metal.

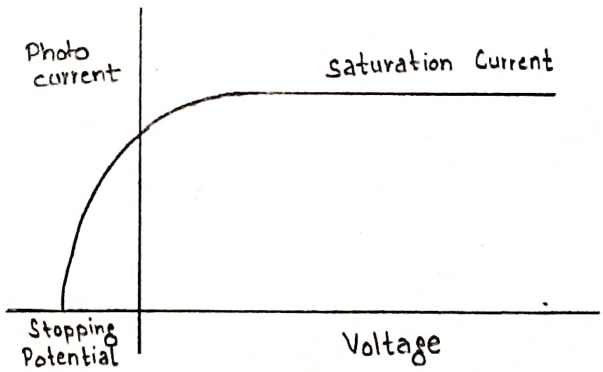


When a photon with frequency 'ν' strikes the surface of a metal, it impats all of its energy to a conduction electron near the surface of a metal, it imparts all of its energy to a conduction electron near the surface of the metal. If the energy of the photon ($h\nu$) is greater than the work function (ϕ), the electron may be ejected from the metal. By conservation of energy, the maximum kinetic energy ~~wl~~ with which the electron could be emitted from the metal surface T_{max}, is related to the the energy of the absorbed photon $h\nu$, and the work function ϕ, by the relation.

$$T_{max} = \frac{1}{2} m v_{max}^2 = h\nu - \phi$$

Now, if we consider the case of electrons being emitted by a photocathode in a vacuum tube, all the emitted are slowed down as they approach the ~~cathode~~ anode. If the voltage just stops the electrons (with maximum kinetic energy T_{max}) from reaching the anode. The voltage required to do this is called the "stopping potential" (V_0).





$$T_{max} = \frac{1}{2} m v_{max}^2 = h\nu - \phi$$

$$eV_0 = h\nu - \phi$$

$$\boxed{V_0 = \frac{h}{e}\nu - \frac{\phi}{e}}$$

PROCEDURE :

1. Choose the material from control panel.
2. Choose a suitable wavelength.
3. Fix area and intensity at a reasonable value. You should not change these values while taking data.
4. Voltage should be maximum (i.e.,0)
5. Record data for current.
6. Vary the voltage and record the current till the value of current becomes zero
7. Record data for current for each voltage
8. Plot I-V graph from the data recorded for the wavelength.
9. Repeat for atleast 5 frequencies.

OBSERVATION :

METAL: Copper I: 25 W/m² Area: 0.2cm²

Colors and corresponding wavelengths :

Colour	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wavelength λ(nm)	100	120	140	160	180

Table 1: For I-V characteristics

λ= 100 nm

Voltage (V)	0	-0.1	-1.4	-2.1	-2.8	-3.5	-4.2	-4.9	-5.6	-7.8
Current (μA)	38.58	38.08	31.58	28.08	24.58	21.08	17.58	14.08	10.58	0

λ= 120 nm

Voltage (V)	0	-0.5	-1	-1.5	-2	-2.5	-3	-3.5	-4.5	-5.7
Current (μA)	28.23	25.73	23.23	20.73	18.23	15.73	13.23	10.73	5.73	0

λ= 140 nm

Voltage (V)	0	-0.4	-0.9	-1.3	-1.8	-2.2	-2.7	-3.4	-3.8	-4.2
Current (μA)	20.84	18.84	16.34	14.34	11.84	9.84	7.34	3.84	1.84	0

$\lambda = 160$ nm

Voltage (V)	0	-0.3	-0.6	-0.9	-1.2	-1.6	-2	-2.4	-2.8	-3.1
Current (μA)	15.30	13.80	12.30	10.80	9.30	7.30	5.30	3.3	1.3	0

$\lambda = 180$ nm

Voltage (V)	0	-0.2	-0.4	-0.6	-0.8	-1	-1.2	-1.6	-2	-2.2
Current (μA)	10.99	9.99	8.99	7.99	6.99	5.99	4.99	2.99	0.99	0

Table 2: Data for potential (Stopping Potential) – Wavelength

Stopping Potential	-7.8	-5.7	-4.2	-3.1	-2.2
Wavelength (nm)	100	120	140	160	180
frequency (10^{14} Hz)	30	25	21.42	18.75	16.66

METAL: Platinum   I – 25 W/m² Area – 0.2 cm²

Colours and corresponding wavelengths:

Colour	–	–	–	–	–
Wavelength λ (nm)	100	120	140	160	180

Table 1: For I-V characteristics

$\lambda = 100$ nm

Voltage (V)	0	-0.6	-1.2	-1.8	-2.4	-3	-3.6	-4.8	-5.4	-6.10
Current (μA)	30.33	27.33	24.33	21.33	18.33	15.33	12.33	6.33	3.33	0

$\lambda = 120$ nm

Voltage (V)	0	-0.4	-0.8	-1.2	-1.6	-2	-2.4	-2.8	-3.6	-4
Current (μA)	19.98	17.98	15.98	13.98	11.98	9.98	7.98	5.98	1.98	0

$\lambda = 140$ nm

Voltage (V)	0	-0.2	-0.4	-0.8	-1	-1.2	-1.6	-1.8	-2.2	-2.6
Current (μA)	12.59	11.59	10.59	8.59	7.59	6.59	4.59	3.59	1.59	0

$\lambda = 160$ nm

Voltage (V)	0	-0.2	-0.4	-0.6	-0.8	-1	-1.2	-1.3	-1.4	-1.5
Current (μA)	7.05	6.05	5.05	4.05	3.05	2.05	1.05	0.55	0.05	0

$\lambda = 180$ nm

Voltage (V)	0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6			
Current (μA)	2.74	2.24	1.74	1.24	0.74	0.24	0			

Table 2: Data for stopping potential - Wavelength

Stopping Potential	-6.10	-4	-2.6	-1.5	-0.6
Wavelength (nm)	100	120	140	160	180
frequency (10^{14} Hz)	30	25	21.42	18.75	16.66

GRAPH:

1. Plot I-V characteristics for different wavelengths.
2. Plot stopping potential - frequency for two metals.

CALCULATION;

Value of 'h' copper $= \frac{5.7}{14} \times \frac{1.6 \times 10^{-19}}{10^{14}} = 6.51 \times 10^{-34}$ Js

Value of 'h' for platinum $= \frac{4}{9.75} \times \frac{1.6 \times 10^{-19}}{10^{14}} = 6.56 \times 10^{-34}$ Js

Average value of h $= \frac{(6.56 + 6.51) \times 10^{-34}}{2} = 6.535 \times 10^{-34}$ Js

RESULT :

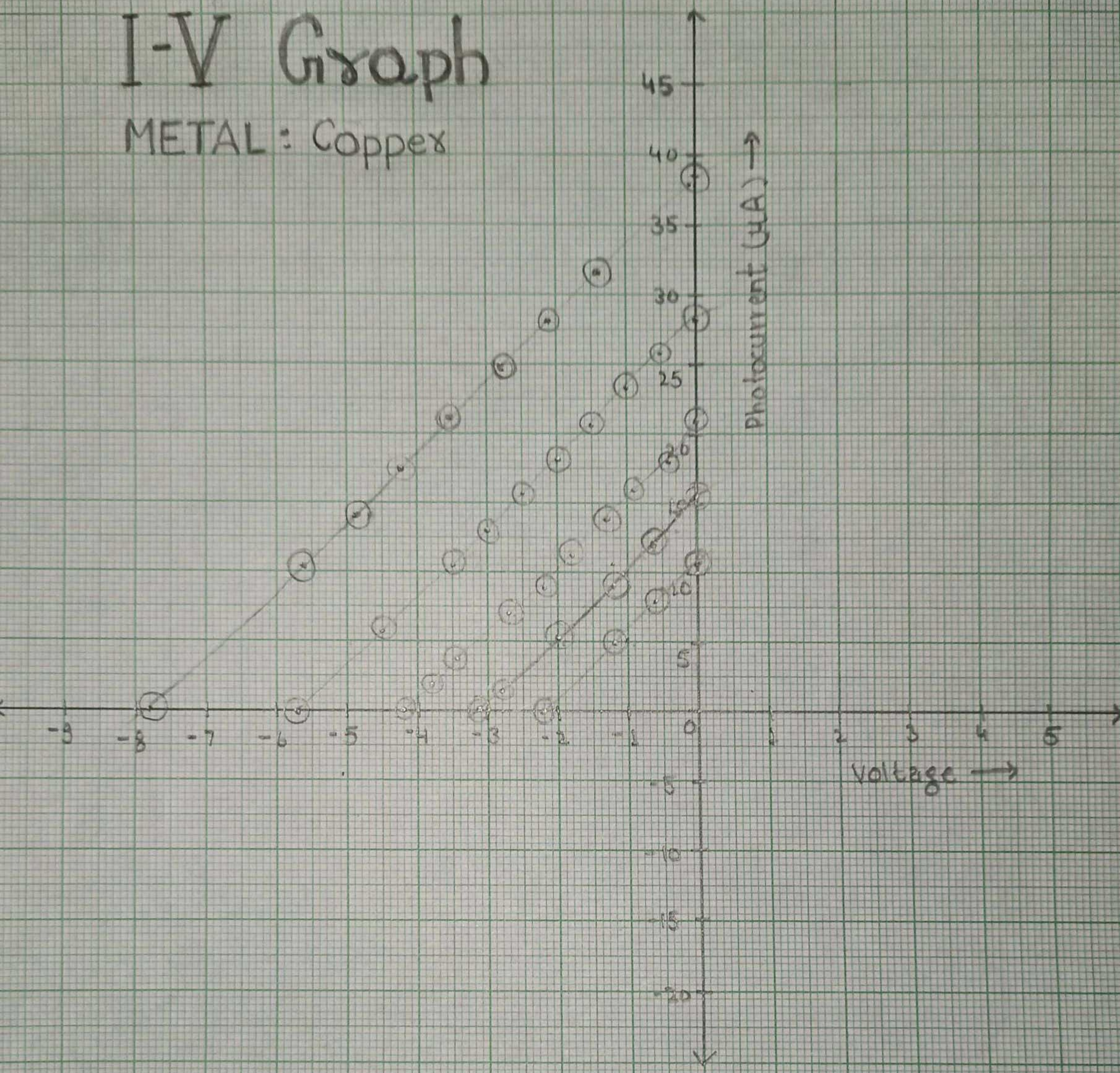
Slope $= \frac{\frac{5.7}{14} + \frac{4}{9.75}}{2} = \frac{0.407 + 0.410}{2} = 0.408$

Intercept for copper = -4.6

Intercept for platinum = -6.3

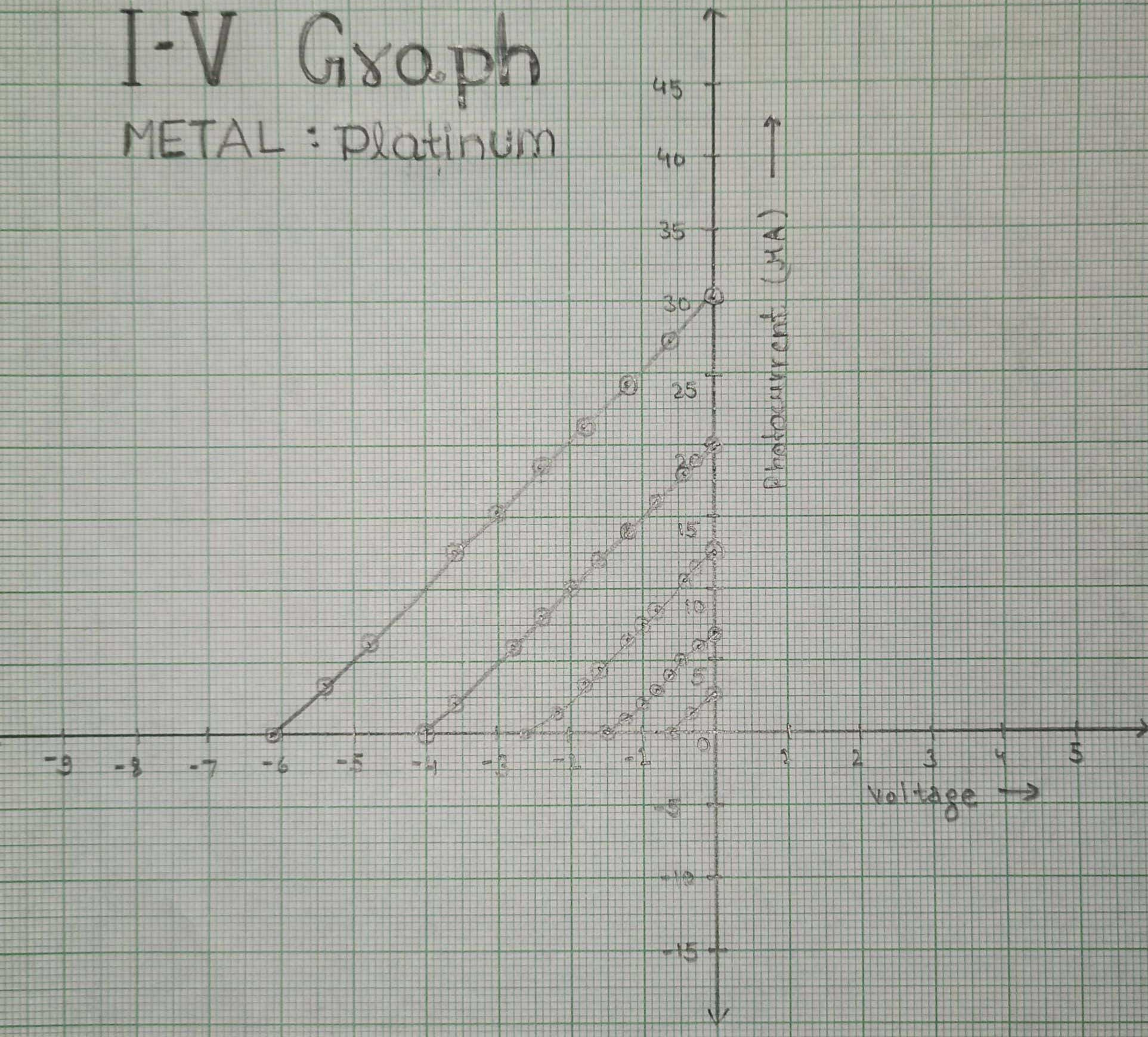
I-V Graph

METAL : Copper

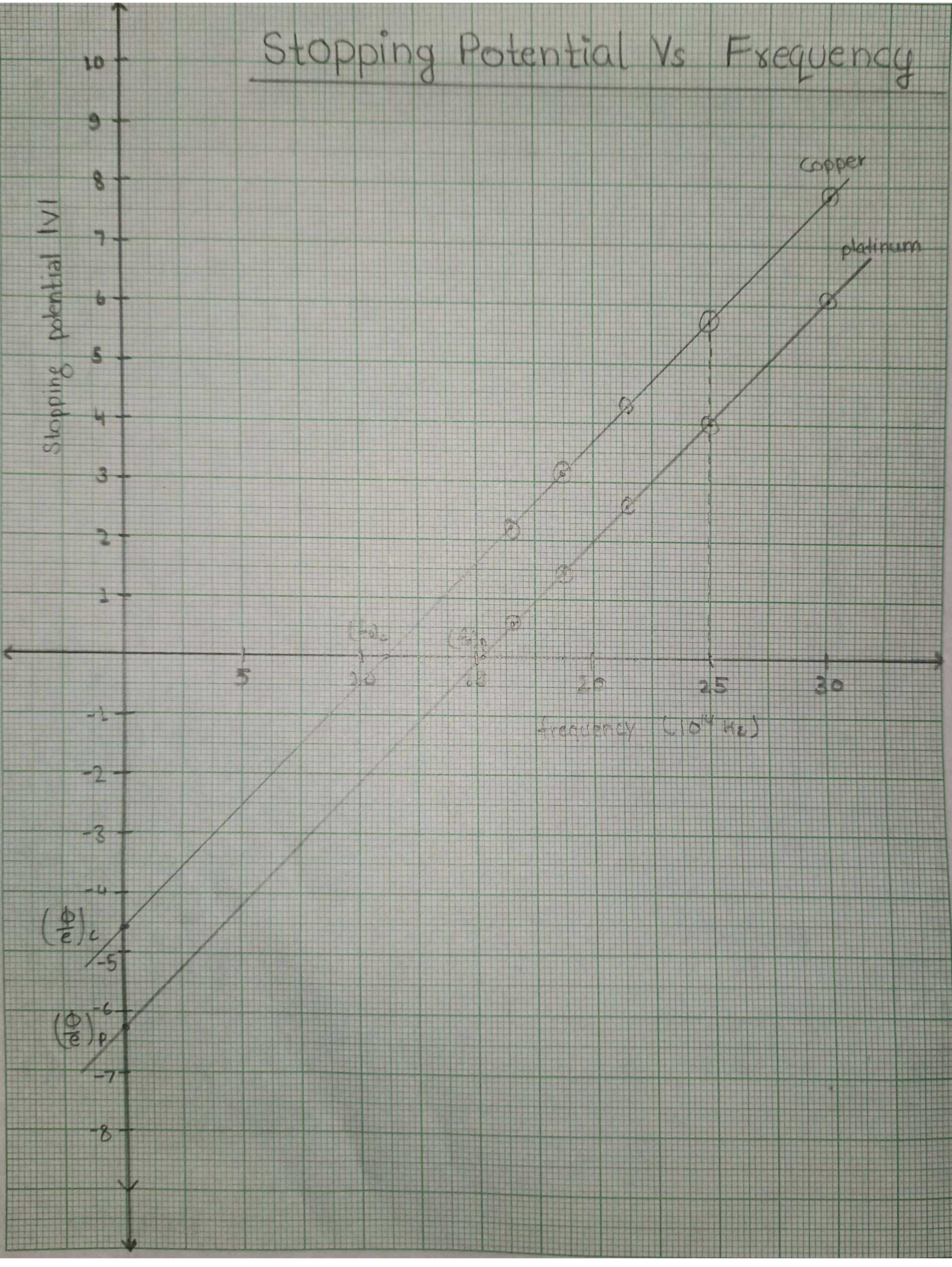


I-V Graph

METAL : Platinum



Stopping Potential Vs Frequency



PRECAUTIONS:

1. Do not use a voltage in excess of the operating voltage range.
2. Do not short circuit the load.
3. Do not reverse power supply polarity
4. Be sure to insert a load when connecting the power supply.

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