Course Contents:

List of Experiments:

1. Determination of Planck"s constant using light emitting diodes (LEDs).
2. Determination of particle size using LASER diffraction halos method.
3. Determination of Rydberg constant of Hydrogen spectra using gas discharge tube.
4. Measuring the ionization potential of mercury gas.
5. Determination of e/m of an electron using a bar magnet (Thomson effect).
6. Verification of inverse square law for gamma-rays.
7. Measurement of half-life period of a radioactive source (K 40).
8. Measuring the absorption coefficient of gamma-rays.
9. Study the characteristics of GM-tube.
10. Determination of Planck"s constant using color filters.

Experiment No.:- 01 **Date:**

DETERMINATION OF PLANCK'S CONSTANT USING LED METHOD

Aim: To determine Planck's constant.

Apparatus: Planck's constant apparatus set up, patch cards.

Formula:

$$\text{Theoretically } h = \frac{e\,(\lambda V_k)\text{ mean}}{C} \text{ Js}$$

$$\text{Graphically } h = \frac{e \times (slope)}{C} \text{ Js}$$

where ,
h - Planck's constant by calculation.
e - Charge of the electron, $e = 1.6 \times 10^{-19}$C.
V- knee voltage applied across the LED terminals that makes it emit light (V).
λ - Wavelength of the light emitted (m).
C - Velocity of light (ms^{-1}) $= 3 \times 10^8 ms^{-1}$.

Procedure:

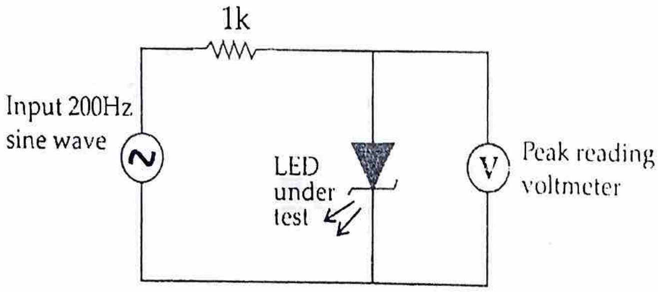
1. The circuit connections are made as shown in the diagram.
2. Insert LEDs one by one, note down the respective knee voltages (Vk) in the tabular column.
3. Plot the graph of knee voltage (Vk) versus (1/wavelength) (1/λ) of different colors.
4. Calculate Planck's constant using the above formula and also from graph.

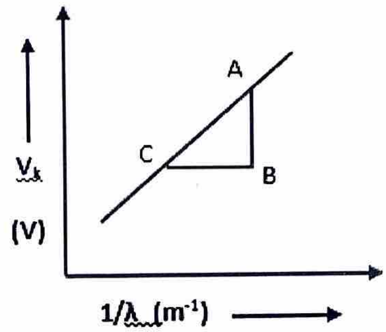
Result: i) The Plank's constant by calculation method h = _______________Js

ii) from graph = _____________________Js

Experiment No.:- 01

Circuit diagram:





Tabular column:

Colour of LED	Wavelength λ ($\times 10^{-9}$m)	Knee voltage, Vk (volt)			Vk λ (10^{-9} m)	1/ λ (m^{-1})
		Trial 1	Trial 2	Mean Vk		
Red						
Yellow						
Green						
Blue						
				mean =		

Experiment : Rydberg Constant

Aim: Determination of Rydberg constant.

Apparatus: Hydrogen discharge tube, high voltage power supply, spectrometer and grating.

Formula:

The wavelength of Hydrogen Spectral line is given by

$$\lambda = \frac{sin\theta}{Nn}$$

Where, θ=angle of diffraction.

n = order of spectrum (n=1).

N = Grating constant ($5x10^5$).

The Rydberg constant is given by,

$$R_n = \frac{1}{\lambda_d}\left[\frac{n_1^2 - n_2^1}{n_2^1 - n_1^2}\right]$$

Where; n_1 is lower orbit, n_2 is higher orbit

Procedure:

The preliminary adjustments of the spectrometer.

1) Focus the telescope of the spectrometer is towards a white wall and the piece is focused towards a white wall. Push or pull the piece so that the cross wire is distinctly seen; the vertical cross wire is made straight.
2) The spectrometer telescope is now adjusted to a distance object and the inverted image of the object at distance L is observed by adjusting the rack and pinion movement on the telescope tube. The image is made very clear with the adjustments. Telescope is set to receive parallel rays hence the settings should not be disturbed throughout the expt.
3) The spectrometer is now placed in front of the hydrogen light with the objective of the spectrometer close to the light slit is opened about 1nm and the slight image is viewed through the telescope. The slit image is made sharpened by adjusting the rack and pinion arrangements on the collimator tube.
4) The direct reading of the spectrometer is taken by coinciding the slit image with the vertical cross wire. The telescope is now rotated exactly go from the direct ray reading and fixed at the position.

5) A grating is taken, it grating constant is noted. It is mounted on a grating holder fitted to prism table.
6) The telescope of the spectrometer is now rolled to the right side of same lines are the other side again by coinciding the red and cyan lines with vertical cross wire. Spectrometer reading is recorded. The difference in the two reading for the lines are calculated and presented in table wavelength of red and cyan lines are calculated using relation; $\lambda = \frac{\sin\theta}{Nn}$

Observation Table:

Spectral lines	Reading of diffracted ray				$\theta = \frac{\theta_1 - \theta_2}{\alpha}$	Wavelength λ (nm)
	left vernier		right vernier			
	msr	Lvd	msr	lvd		
H_α						
H_β						

Result:

From the Experiment Rydberg constant was found to be

Theoretical=

Experimental=

Experiment : **Date :**

CHARACTERISTICS OF A GM COUNTER

Aim : To study the characteristics of a Geiger Muller (GM) counter and hence determine it's operating voltage.

Apparatus : GM counter ,GM tube , Radioactive sources.

Principle :

When a gamma ray enters the gas filled GM tube , it ionizes the gas inside it and the electric field applied between the electrodes drift the electron towards the anode . The electrons thus collected at the anode are counted for various applied voltage versus corrected counts , and hence the operating voltage is determined from the graph .

Formula :

Corrected count rate , $C = \frac{N-N_B}{t}$

Where ,

N is the count for t sec with radioactive source.

N_b is the count for t sec with out the source.

Operating voltage , $V_0 = \frac{V_1+V_2}{2}$

Plateau Voltage, $V_{PL} = V_2 - V_1$

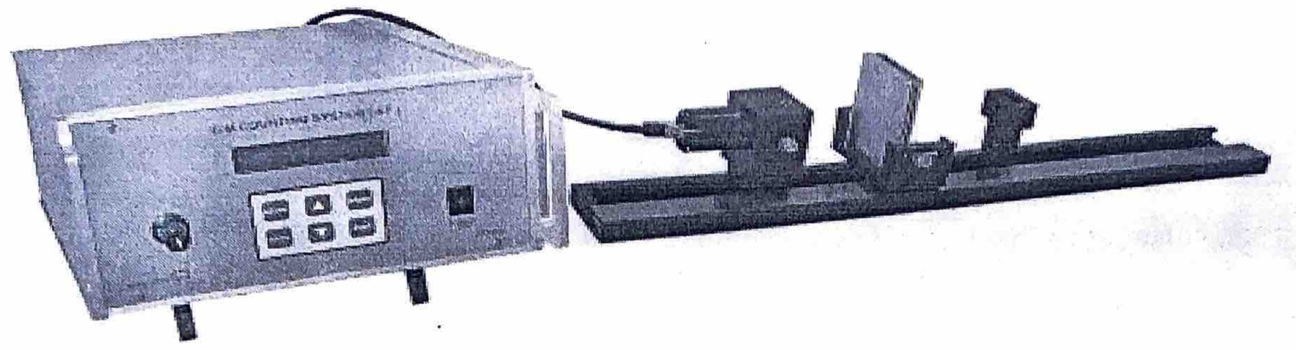
Slope of the plateau $= \frac{(C_2-C_1)\times 100}{C_1\times(V_2-V_1)}$

Where,

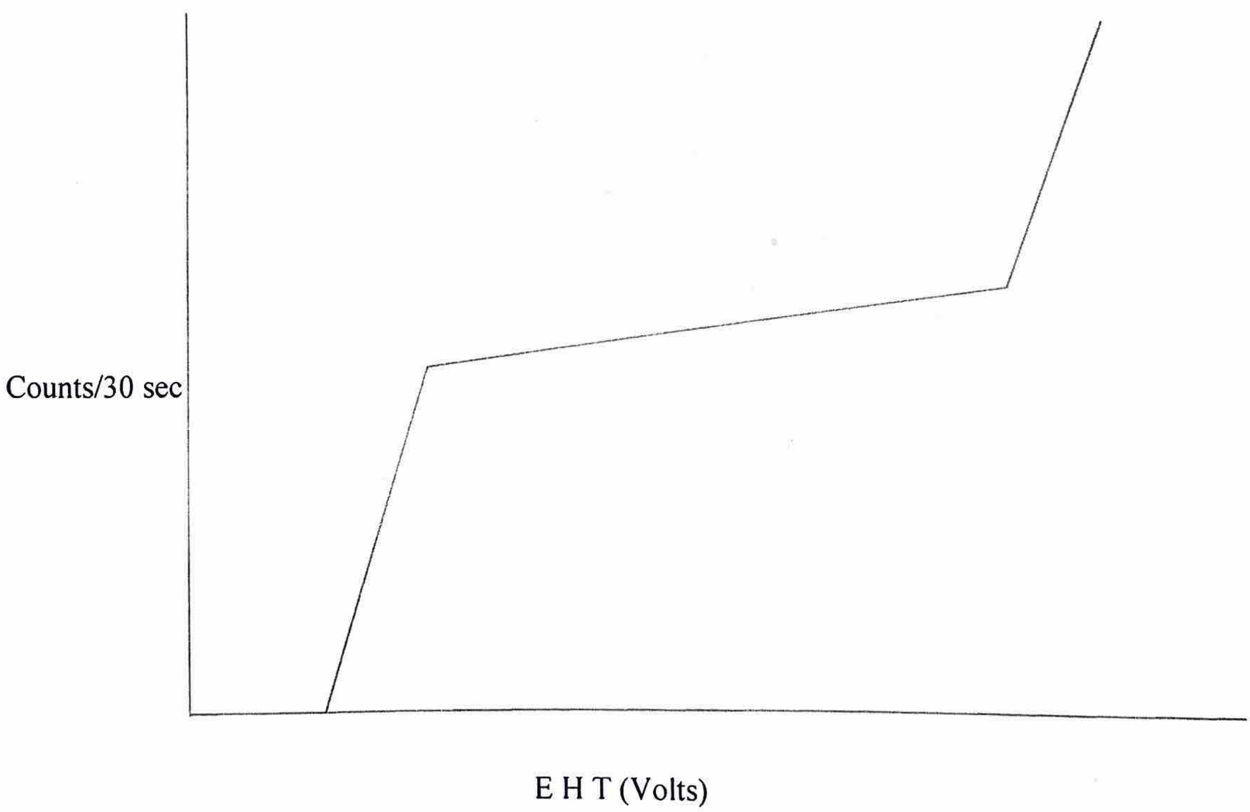
C_1 and C_2 are the count rates at the lower and the upper limit of the plateau.

V_1 and V_2 are the corresponding voltages.

(NOTE : if the slope is less than 10 % then the tube is good)



Expected Graph:



Procedure:

1. Connect the Geiger counting system to the G.M tube .
2. Ensure that EHT knob is in anticlock wise direction completely , before switching on the apparatus
3. (V=0).
4. Preset time to 30(or)60 seconds .
5. Note the average background count N_B for 0 to 900V in steps of 15V.
6. Place the radioactive source at a distance of about 2cm from the tube.
7. Increase the ETH (V) insteps of 15V(or)30V and Note the counts N for each voltage upto 900V.
8. Calculate the corrected count rate , $C = \frac{N-N_B}{60}$.
9. Plot C versus V. Make the threshold voltage V_{TH} and the limits V_1 and V_2 at the Geiger Plateau .
10. Note V_1 and V_2 and calculate the Operating voltage ,

$$V_0 = \frac{V_1+V_2}{2}$$

Observations :

Trail no	Applied Voltage V(volt)	Background countsfor30(or) 60s (Without source)	Countsfor30(or) 60s N (with source)	Corrected count rate $C = \frac{N-N_B}{60}$ in s^{-1}
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				

Calculation :

Operating voltage , $V_0 = \frac{V_1+V_2}{2}$ =....... V,

Plateau Length , $V_{PL} = V_2 - V_2$ =......V,

Slope of the plateau = $\frac{(C_2-C_1)\times 100}{C_1\times(V_2-V_1)}$ =

V_{TH} = ...V

Background:

The most important sources of background count are:

1. Gamma radiation from the environment and from cosmic radiation.
2. Mesons from cosmic radiation .
3. Beta particle from contamination and impurities of the materials from which the detector itself is made.
4. Spontaneous discharge or pulses in the detector and the counting circuit that do not originate from radiation(Electronic noise).

Result :

1. Threshold Voltage , V_{TH} = ...V
2. Operating Voltage =...........V
3. Plateau length =.........V
4. Slope of the Plateau =..........%

Experiment 8 : **Date :**

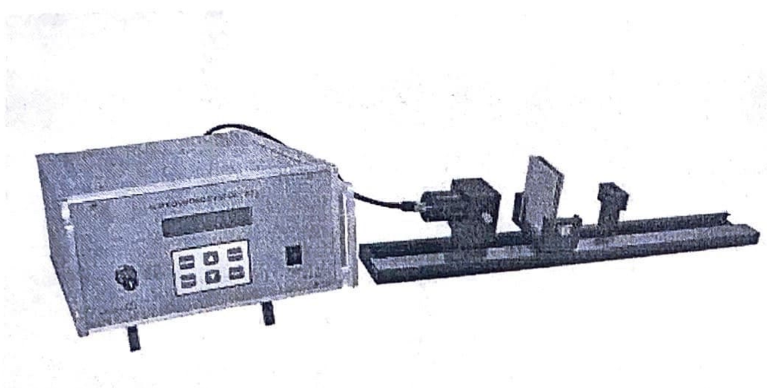
INVERSE SQUARE LAW

Aim : To verifyed the inverse square law of a gamma rays

Apparatus :

GM counter ,GM Detector , Source holder bench , Radioactive sources

DIAGRAM :



Procedure :

1) Make detector –source arrangements and power on the unit.

2) without source make few (about 5 readings) background measurements and take an average of them for a preset time of say 60 sec.compute average back ground counts in 60 sec

Ba= (b1+b2+b3+b4+b5) / 5 compute back ground rate = Ba/t

3) Place a gamma source in the source holder and adjust the distance (d) from the detector end window to be at 2 cm away from the centre of source holder .

4) keep the source holder in source stand and keep the distance 2 cm

5) set HV to operating voltage (500V) program preset time 60 sec and record the data count by pressing START button .

6) Increase the Distance (d) in steps of 0.5 cm and for each step record the observations and tabulate the data as given below till you reach a distance of 8 to 10 cms from the detector face .

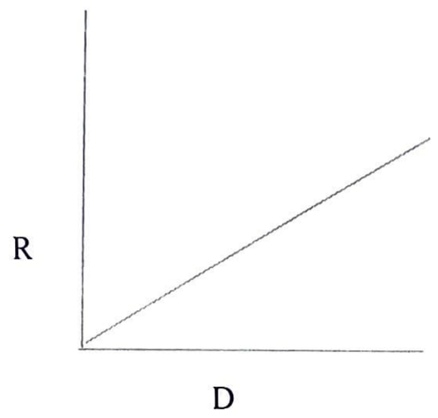
7) subtract the back ground counts from the recorded counts which results in corrected counts (N) in 60 sec .from this obtain net count rate (R) per sec

Compute and tabulate net count rate , (R) distance ,(d) product of ($C=R.d^2$).

Transformation ($1/d^2$)ete.as shown in the table(2)

Plot a graph of net count rate (R) vs ,distance (d) in cm

Model graph :



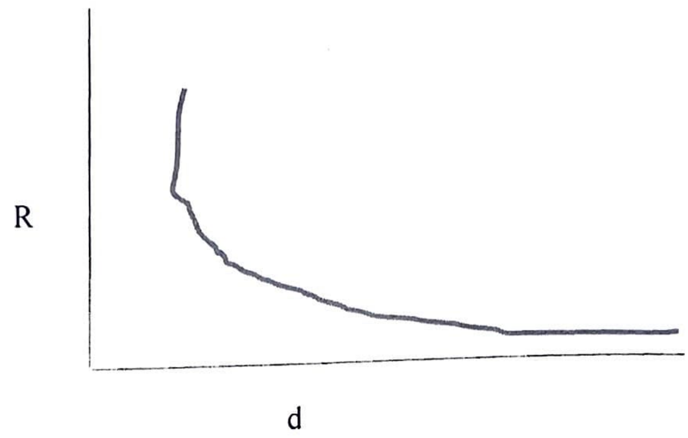


Table : Data for Inverse Square Law Experiment

S.no	Distance(d) in cm	Corrected counts (N) in 60 sec	Net count rate R in 1/s	Product $C=R.\ d^2$ In cm^2/s	Transformation $1/\ d^2$ in $1/m^2$
1	2.0				
2	2.5				
3	3.0				
4	3.5				
5	4.0				
6	4.5				
7	5.0				
8	5.5				
9	6.0				
10	6.5				
11	7.0				

If the count rate obeys the inverse square law .it can easily be shown that the product $(R.d^2)$ is a constant .The results of the product $(R.d^2)$ are shown in the table above: allowing for statistical fluctuations, the result obey this law, with a mean value of $c=904\ cm^2/sec$.The observed net count rate as a function of distance is given by

$$R_d=904/\ d^2\ \mathbf{cm^2}\ /sec$$

An alternative analysis method involves transforming the data so that the results lie on a straight line for this purpose net count rate (R) vs reciprocal of the distance square ($1/d^2$) are plotted this will be a straight line passing through the origin (0,0)as this po
a source ,detector distance of infinity .

Gradient can be estimated easily from the net count rate (R) corresponding to a value of ($1/d^2$) of 400 m^2

In this example C= 886 cm^2 /sec which is in agreement with the results of the previous method.

At 5 cms,

$C=34.41 s^{-1}/400\ m^2 = 0.0886\ m^2/sec = 886\ cm^2/sec$

Result: Hence inverse square law is verified

Measurement of e/m ratio by Thomson's bar magnet method.

AIM : To determine e/m of an electron by Thomson's method.

Apparatus : Cathode Ray tube (CRT) with power supply unit, one pair of bar magnets, deflection magnetometer with U-shaped stand

Formula : $$e/m = \frac{Vy}{L \cdot l \cdot d \; B^2}$$

$V \rightarrow$ Y-deflection voltage

$y \rightarrow$ distance moved by the spot.

$L \rightarrow$ The distance between Y-deflecting plates & the screen

$d \rightarrow$ width of the Y-plate

$l \rightarrow$ Length of the X-plate.

$B \rightarrow$ Magnetic field strength at the centre of the compass due to the bar magnet.

$B = B_H \tan\theta$, where B_H is earth's magnetic field, $B_H = 3.81 \times 10^{-5}$ T at Bangalore

Theory: The mass of the electron cannot be measured directly. Thomson suggested one method to determine e/m of an electron. This involves the motion of an electron in a cathode ray tube

If an electric field 'E' is applied between the two plates perpendicular to the direction of electron beam passing through the space between the plates, the force acting on the electron in the direction of motion is given by

$F = eE$ $\quad$ $e \rightarrow$ charge of electron
$E \rightarrow$ applied electric field.

Because of applied electric field, electrons travel in a semicircular path.

In stead of electric field, if the magnetic field is applied, deflection of the beam takesplace. The force acting on the electron beam is given by

$$Bev = \frac{mv^2}{r}, \quad e/m = \frac{v}{Br}$$

when the magnetic force is equal to the electric force, the beam comes back to the original position

$$Bev = eE, \quad e/m = \frac{E}{B^2 r} \qquad r = \frac{Ll}{y}, \quad E = \frac{V}{d}$$

$$v = \frac{E}{B}$$

$$\boxed{e/m = \frac{Vy}{Ll \cdot d B^2}}$$

Experimental Procedure

1. The magnetic meridian, giving the direction of earth's North-south magnetic field is marked on the center of the study table.

2. The U-shaped stand is placed on the table and its two arms are made perpendicular to the magnetic meridian.

3. The CRT is now placed in the arms of U-shaped stand. In this position the axis of the CRT is parallel to the earth's magnetic field.

4. The CRT is now connected to the power supply and is switched on. The brightness and focus knobs are adjusted to get a bright spot on the CRT screen. With X & Y deflection voltage knobs turned to the minimum position, the position of the spot on the screen is noted. (zero cm)

5. The Y-deflection voltage is now applied so that the spot moves up (or down) by 1 cm, 2 cm. The corresponding voltage is noted for different deflection of the spot along Y-direction.

6. The bar magnets are placed on either side with opposite poles & at equal distances from the tube so that the spot comes back to zero position. Note down the distance 'D' & is read from the scale for each deflection of the spot.

7. The same is repeated for reverse applied voltage. The polarity of the deflecting voltage is also reversed by turning the switch to the reverse position.

8. The CRT is now removed without disturbing the arms and a compass is placed in its place along the magnetic meridian

9. The bar magnets are placed at the same distances 'D' for each trial on both the arms and deflection in the compass is noted. 'θ'.

10. Specific charge e/m is calculated using ~~for each~~ the formula given for each trial.

Tabular column

~~Deflecting~~ voltage (V)	~~spot~~ deflection 'y'	Vy	~~deflection~~ θ	B $= B_H \tan\theta$	e/m

Tabular column

Trial no.	Deflecting voltage V	Spot deflection 'y'	Vy	deflection 'θ'	$B = B_H \tan\theta$	$e/m = \frac{Vy}{B^2 \cdot L l d}$

Result: e/m of the electron is found to be = ... ~~kg~~ Coulomb/kg e/m constant values

$$B_H = 3.81 \times 10^{-5}\ T$$

$$L = 12.3 \times 10^{-2}\ m$$

$$l = 3.1 \times 10^{-2}\ m$$

$$d = 2.8 \times 10^{-2}\ m$$

$$B = B_H \tan \theta$$

$$e/m = \frac{Vy}{B^2 \cdot L \cdot l \cdot d}$$

Experiment Determination of Planck's constant and work function of metals using Photoelectric Effect.

Aim: To determine planck's constant 'h' from the stopping voltages measured at different frequencies of light.

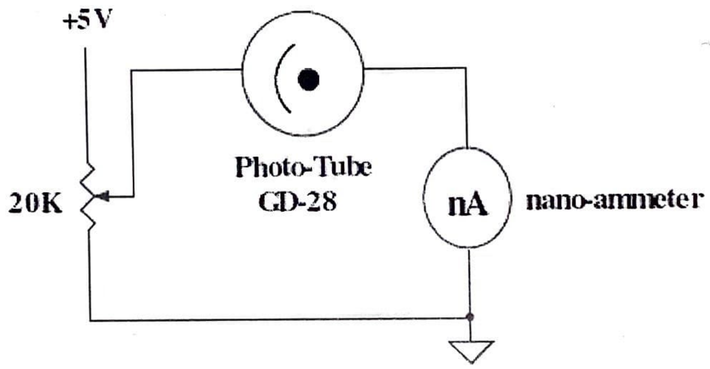
Apparatus: A vaccum phototube, light source, Color filters, regulated power supply, Ammeter and Voltmeter.

Formula:

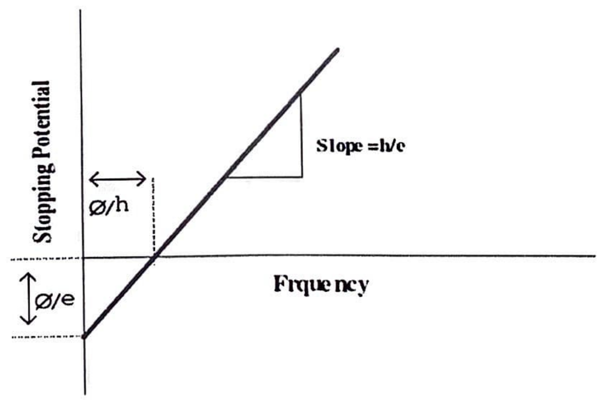
$$\frac{h}{e} = \text{slope}$$

Planck's constant, $h = e * \text{slope}$

Diagram:



Graph:



Procedure:

1. The photo tube is connected to the experimental set-up. The nanometer and retarding potential voltmeter are connected as shown in Figure-3. The cathode voltage is set to 0V.
2. The blue filter is placed in front of the photo tube so that only blue light (λ=461nm) falls on the photo tube cathode. Photo current is noticed in the digital nano-ammeter.
3. Retarding potential is now applied by adjusting the knob of the retarding potential power supply. As the retarding potential is increased, the current in the Nano ammeter correspondingly decreases.
4. Retarding potential is increased until the photo current becomes zero and the Nano ammeter.
5. Trial is repeated 2 to 3 times so that at zero current; consistent retarding potential is obtained in the voltmeter. The retarding potential is noted in Table-1.VS= 1.123V for blue filter
6. Experiment is repeated by bringing the retarding potential back to zero volt and another color filter is placed in front of the photo tube. The retarding potential obtained is tabulated in Table-1. This is continued for all the filters provided along with the experimental set-up.
7. A graph showing the variation of frequency and retarding potential is drawn as shown in figure. From the graph, the X-intercept, Y-intercept and slope are determined.

Tabular Column:

Colour/Filter	Wavelength(nm)	Frequency(10^{14}Hz)	Stopping potential (V).
Red			
Orange			
Yellow			
Green			
Blue			

Result:

The Planck's constant by photoelectric effect is found to be, h=

Experiment # : Ionization potential of xenon gas

Mercury

Aim: Determination of ionization potential of Xenon gas.

Apparatus: Xenon gas filled tube, variable power supply, ammeter, voltmeter, connecting wires.

Theory:

Bohr's Theory of the structure of the atom is that the nucleus is surrounded by orbiting electrons which can have certain energy levels.

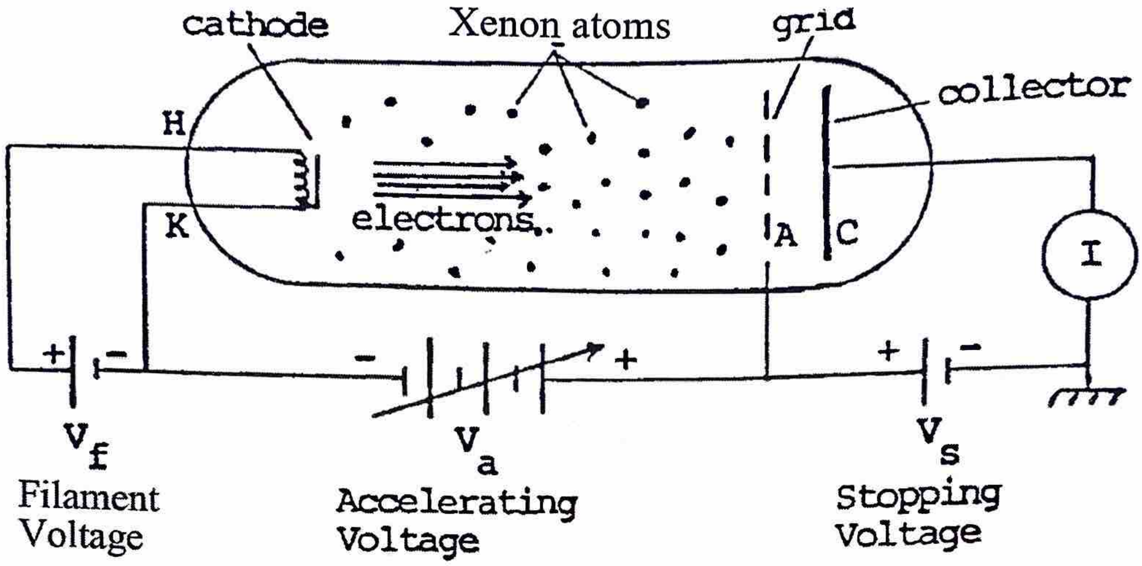
If the atom is bombarded by particles of sufficiently high energy, or if energy is added to the atom by electromagnetic radiation (X-ray bombardment), it is possible that one or more of the outer orbital (or valence) electrons may become completely detached from the atom with the result that the atom is no longer electrically neutral, but (because it has lost a negatively charged electron) it is now positively charged and has now become a positive ION. We can then say that the material 'has been Ionized'.

Ionization potential is defined as the minimum amount of energy required in (ev) electron - volts to just remove an electron from an atom.

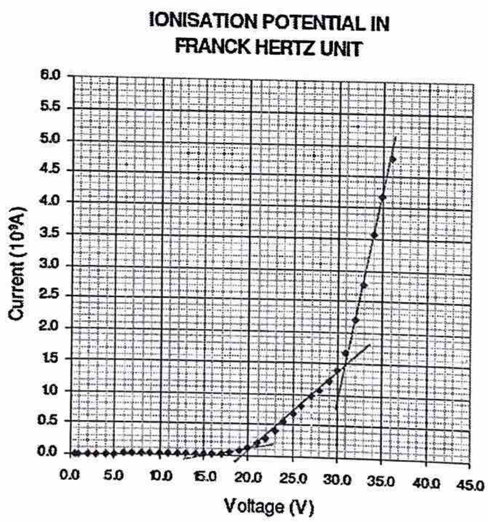
Working principle:

When a positive potential is applied to the plate and it is increased slowly, plate current also increases slowly. But when plate potential increases beyond a value, plate current increases more rapidly. This is because the electrons arriving at the anode gain enough energy to knock out electrons from the atoms of the gas close to anode. These electrons are also attracted by plate and hence causing increase in plate and current. The positive ions so produced neutralize the space charge which further helps in increasing the kinetic energy of thermal electrons. This value of plate potential at which plate current shows large increase is known as ionization potential of the gas.

Diagram:



Expected Graph:



Procedure:

1. Make connections as in the figure and switch on power supply.
2. Vary plate voltage, V = 1 - 20 V and take reading of plate current, I, for each one.
3. Draw graph between applied voltage versus current.
4. Draw a straight line between last few points. This line intersects with X-axis that will gives the value of observed ionization potential of xenon gas.

Tabular Column:

Sr. No.	Plate voltage in volts	Plate current in mA

Result:

The ionization potential of xenon is ....Volts