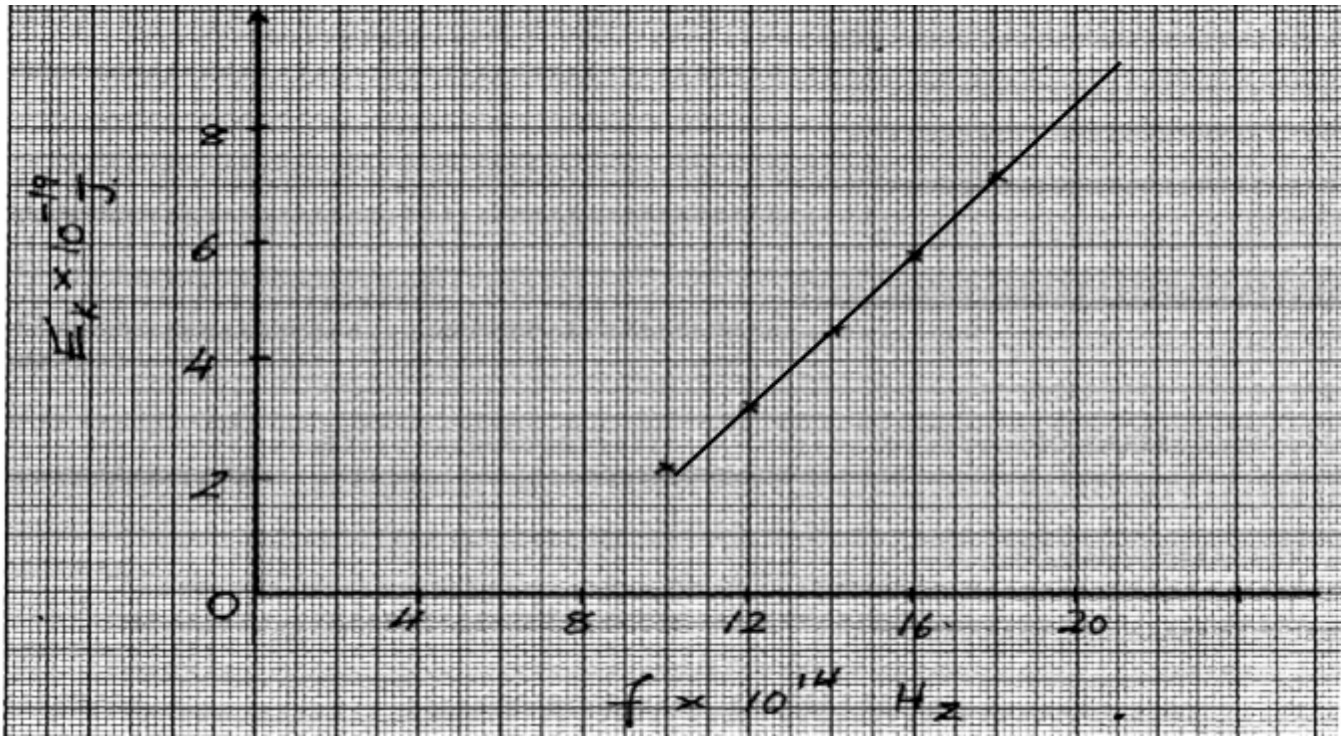
Photoelectric effect

1. (a) Define the following:

(i) Photoelectric effect

(ii) threshold wavelength

(b) The variation of frequency f with the maximum kinetic energy E_k of the emitted electrons is shown on the graph below:



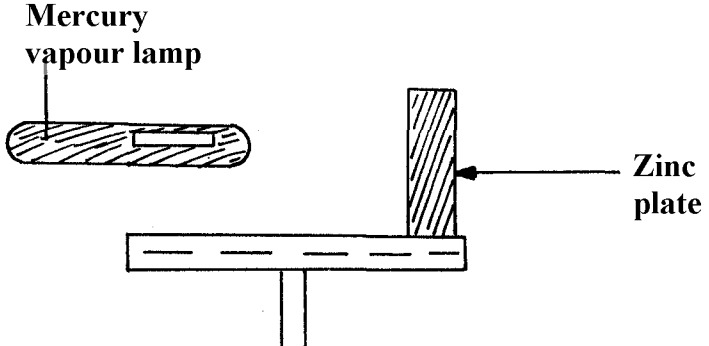
(ii) the value of the Planck's constant h

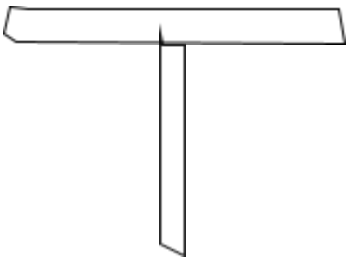
(iii) the work function, W_o

(c) On the same graph in **(b)** above, draw a line to show the variation of frequency, f, with the maximum kinetic energy, E_k, of the emitted electrons from a second metal which has a lower work function that used in **(b)**

2. ***Figure 8*** below shows a mercury vapour lamp, which emits ultraviolet light held over a negatively charged electroscope:

figure 8





(i) What happens to the leaf after the lamp is switched on?

(ii) Explain why it happens

(iii) If the experiment is repeated with equally bright red light held the same distance from the
plate in place of the mercury vapour lamp, what effect would this have on the leaf?
Give a reason

(iv) What does photoelectric effect suggest about the nature of light?

3. Calculate the wavelength of Green light whose energy is 3.37×10^{-19} J .
($h = 6.63 \times 10^{-34}$JS, $C = 3.0 \times 10^{8}$m/s)

4. a) Define the term *work function*

b) Name **one** factor that determines the velocity of photoelectrons produced on a metal surface
when light shine on it

c) In a photoelectric effect experiment, a certain surface was illuminated with radiations of
different wavelengths and stopping potential determined for each wavelength. The table
below shows the results obtained.

Stopping potential , Vs	1.35	1.15	0.93	0.62	0.36
Wave length, ($x10^{-7}$m)	3.77	4.04	4.36	4.92	5.46

i) On the grid provided plot a graph of stopping potential (Y –axis) against frequency

ii) From your graph determine:

a) The threshold frequency

b) The plank's constant, h

(e = 1.6 x 10^{-19} Coulomb, C = 3.0 x 10^{8} m/s)

5. a) State the role of the Grid in a cathode ray tube

b) Explain why a magnetic field is used in the TV deflection system instead of an electric field

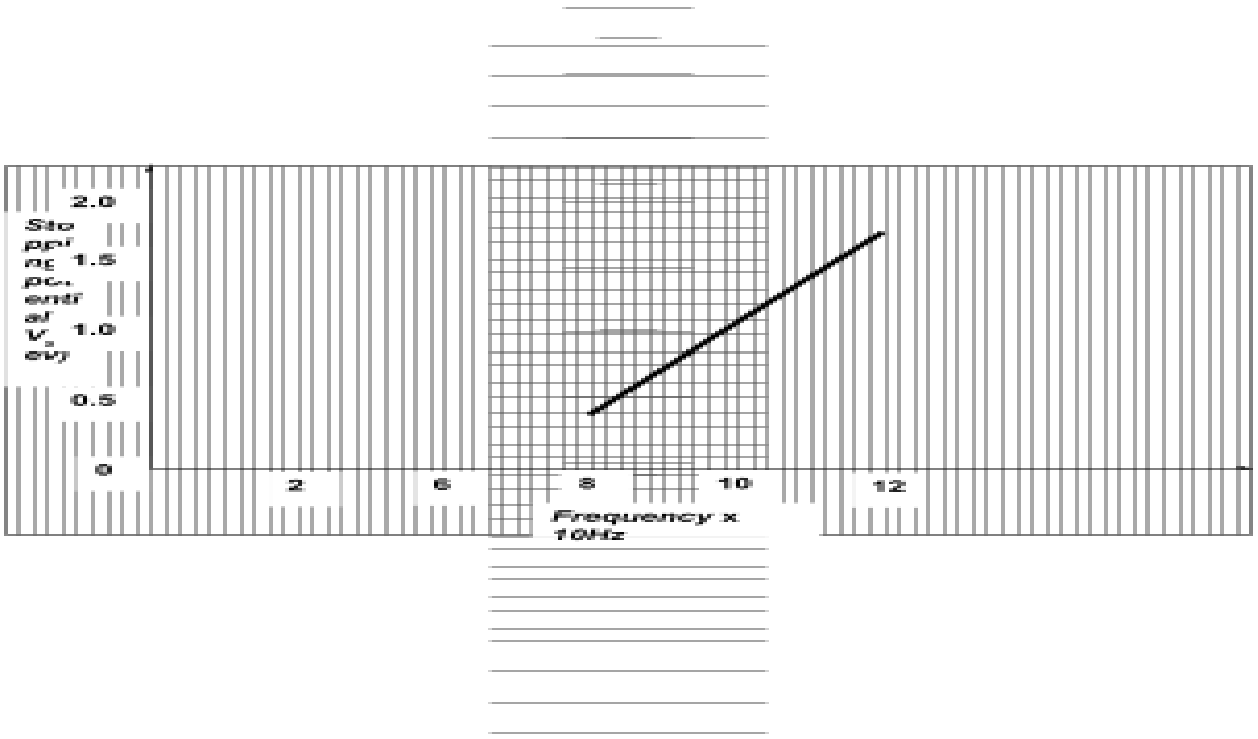
c) The time base of a CRO is 25ms/div while its gain is 2.5V/div. Use this information to

answer the questions that follow:

i) Calculate the frequency of the signal

ii) What is the peak voltage of the signal

6. The graph below shows the relation between the stopping potential, Vs and the frequency of radiation when a certain surface is illuminated with light of different frequencies



From the graph determine:-

(i) The threshold frequency

(ii) The value of plank's constant (e = 1.6 x 10^{-19}C)

(III) The work function of the material

7 a) State **one** reason why a C.R.O is a more accurate voltmeter than a moving coil voltmeter

(b)The diagram below represents a cathode ray oscilloscope (CRO)

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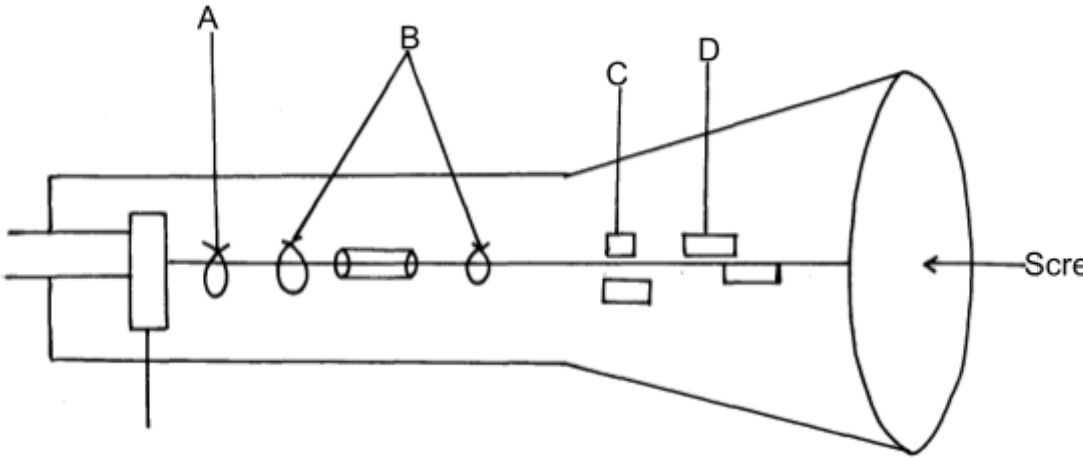


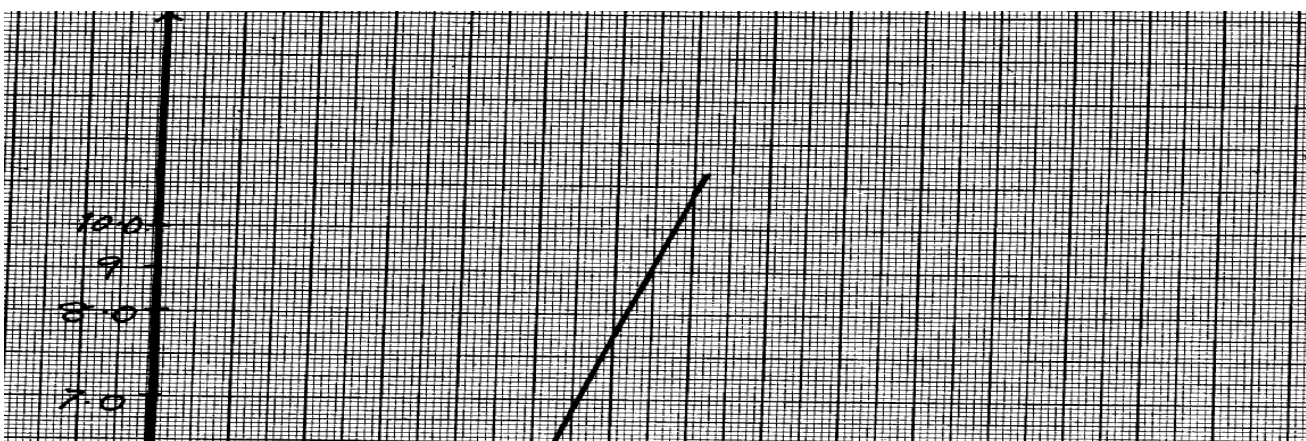
i) Name the parts labeled **A** and **B**

ii) What are the functions of **C** and **D**?

iii) State how electrons are produced

8. a) What is meant by the term photo electric effect

b) In an experiment using a photo cell, ultra violet light of varying frequency strikes a metal surface. The maximum Kinetic energy (KE max) of the frequency **F** is measured. The graph below shows how the maximum kinetic energy varies with frequency **F**



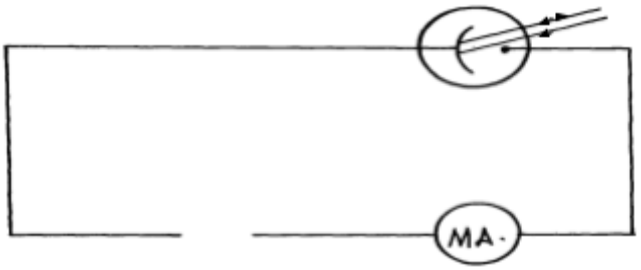
K.E max (
X 10^{-19}kJ)

Use the graph to determine:-
i) Threshold frequency **F**

ii) The plank's constant, **h**

iii) Work function of the metal

9. (a) The diagram fig 9 below shows a photo cell; connected in a circuit:-
fig. 9



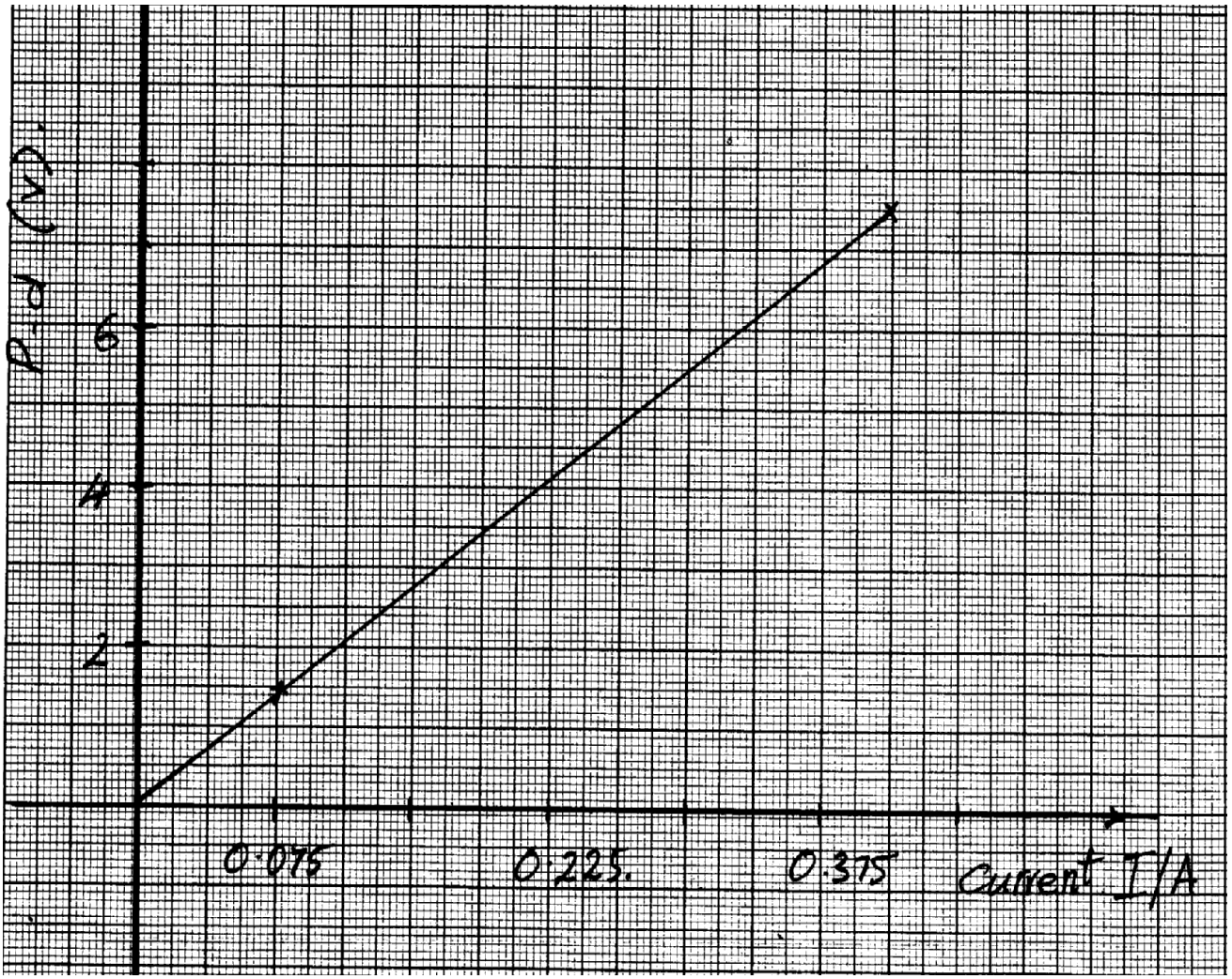
(i) Complete the diagram by indicating the correct polarities in the gap for current to flow in
the circuit

(ii) State and explain the effect of using light of different wave lengths on the amount of
current flowing in the circuit given that the distance of the source of light remains the same

(b) Two fixed resistors one of 100Ω and the other of unknown resistance are connected in parallel.

The combination is placed in a circuit and current passing through the combination was

measured for various p.d. The graph in figure 10 below drawn to scale shows the results:-



(i) From the graph, calculate the total resistance of the combination

(ii) Determine the value of the unknown resistance

(c) (i) Explain the cause of eddy currents and how they are minimized in a transformer

(ii) A transformer with 4200 turns in the primary coil operates a 240V mains supply and gives an output of 8.0V. Determine the number of turns in the secondary coil (assuming it is 10% efficient)

10. State **one** factor that affects photoelectric effect

11. a) i) What is photoelectric effect?

ii) You are provided with the following; a photo cell; a source of UV light, a rheostat, a source of e.m.f, a millimeter, a voltmeter and connecting wires. Draw a circuit diagram to show how photoelectric effect may be demonstrated in the laboratory

b) In a photoelectric effect experiment, a certain surface was illuminated with radiation of different frequencies and stopping potential determined for each frequency. The following results were obtained:

Frequency (f) (x 10^{14} H_z)	7.95	7.41	6.88	6.10	5.49
Stopping potential, (V_s), (V)	1.35	1.15	0.93	0.62	0.36

i) Plot a graph of stopping potential (Y-axis) against frequency

ii) Determine plank's constant, h and the work function of the surface given that

$EV_s = hf - hf_o$, where $hf_o = Q_e = 1.6 \times 10^{-19}$ C

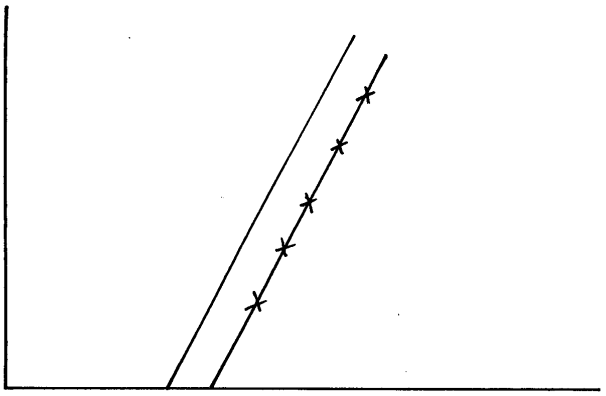
c) A surface whose work function Q = 6.4 x 10^{-19} J is illuminated with light of frequency 3.0 x10^{15} H_z. Find the minimum K.E of the emitted photo electrons (use value of h obtained in **b(ii)** above)

Photoelectric effect

1. a) i) – The emission of electrons from metal surface when radiation of unstable wave length falls on it √

ii) The maximum wavelength beyond which no photoelectric effect occurs √

b)



i) $f = 6.4 \times 10^{14} H$ √

ii) $EK = hf - W$

h = gradient√

$= (6.2 - 22) \times 10^{-19}$√

$(16 - 10) \times 10^{14}$

$= 6.667 \times 10^{-34} Js$√

iii) $W_o = hf_o$

$= 6.667 \times 6.4 \times 10^{14} \times 10^{-34}$√

$= 4.267 \times 10^{-19} J$√

2. (a) (i) X – Intercept = $4.5 \times 10^{14} Hz$

(ii) Slope = $\frac{h}{e}$ – $h = e \times$ slope

$= e \times \frac{6.6 - 0)V}{(6\text{-}4.5) \times 10^{14\ s\text{-}1}}$

$= 1.610^{-19} \times 4 \times 10\text{-}15$

$= 6.4 \times 10^{-34} Js$

(iii) $W_0 = hf_0$

$= 6.4 \times 10\text{-}34\ Js \times 4.5 \times 1014s\text{-}1$

$= 2.88 \times 10\text{-}^{19} J$

(b) (i) The leaf falls 1 Collapses 1

(ii) The electrons are repelled causing the leaf potential to decrease 1

(iii) NO effect on the leaf. Light emitted by red light doesn't have enough energy to cause

photoelectric effect. 1

(iv) Light is a wave, it carries energy in small packets (protons). 1

3. Calculate the wavelength of Green light whose energy is 3.37 x 10-19 J .
(h = 6.63 x 10-34JS, C = 3.0 x 108m/s)

$\lambda = v$ | $f = 3.37 \times 10\text{-}19j$ | $\lambda = 3.0 \times 10\ 8m/s$

f | $6.63 \times 10\text{-}34$ | $5.083 \times 1014HZ$

| $= 5.08\ 3X10\ 14HZ$ | $= 5.902 \times 10\text{-}7m$

$f = E$

h

4. a) This is the least radiation energy required to just dislodge an electron from a metal surface.

b)The energy of the radiation. The higher the energy the higher the velocity of photo electrons

Frequency X 1014 Hz 7.959 7.43 6.88 6.10 5.49

i) On the grid provided plot a graph of stopping potential (Y –axis) against frequency

Graph (diagram)

ii) From your graph determine:

The threshold frequency

$fo = 4.5 \times 10^{14} HZ$

b) The plank's constant, h

(e = 1.6 x 10-19 Coulomb, C = 3.0 x 108 m/s)

$eVs = hf - hfo$ | gradient = 1.15 – 0.93

$Vs = h \quad f - h\,fo$ | (7.43 -6.98) X 10^{14}

| $= 0.22 \times 10^{-14}$

gradient = h | 0.55

e | $= 0.4\ X10^{-14}$

$= 0.4 \times 10^{-14} \times 1.602 \times 10^{-19}$ | $h = 6.408 \times 10\text{-}34js$

5. a) It controls the intensity of electron leaving the electron gun controlling the brightness of the spot on the screen.

b) The magnetic field deflection system make electrons span the whole screen unlike the electric field deflection system.

c) i) Calculate the frequency of the signal

$T = 25ms/div \times 2\ div$
$= 50\ ms$

$f = \frac{1}{50/1000}$

$F = \frac{I}{T}$

$= 20HZ$

ii) What is the peak voltage of the signal

- peak voltage $= 21 \times 2.5v|d.v$
$= 5\ Volts$

6. (i) Graph is extrapolated to meet x-axis

$f_0 = 7 \times 1014Hz$ 1 1

(ii) Gradient $= \frac{\Delta Vs}{\Delta f}$

$= \frac{1.75 - 0}{12 - 7}$ 1

$= \frac{1.75}{5 \times 10^{14}} = 0.35 \times 10^{-14} = 3.5 \times 10^{-15}$ 1

$h = Gradient \times e$
$= 3.5 \times 10\text{-}15 \times 1.6 \times 10\text{-}19$
$= 5.6 \times 10\text{-}34Js$
1 1

(iii) $W = hf_o$ 1
$= 5.6 \times 10^{-34} \times 7 \times 10^{14}$
$= 3.92 \times 10^{-19}\ J$ 1

7. a) – Has infinite resistance/ does not take up any current
- Sensitive/ does not require heating time

b) i) A – Grid
B- Electron gun

ii) C – Vertical deflection of the beam
D- Horizontal deflection of the beam

iii) – By thermionic emission as heating the filament

8. a) Electrons being ejected from metal surfaces by use of electromagnetic waves

b) i) X – intercept $= 1.0 \times 10^{15}$

ii) From $K.E = hf$

Planks constant (h) = gradient of graph

$$= \frac{(8.2 - 0) \times 10^{-19}}{(2.5 - 1.0) \times 10^{15}}$$

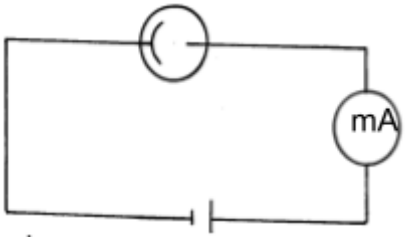
$$= \frac{8.2 \times 10^{-19}}{1.5 \times 10^{15}}$$

$H = 5.5 \times 10^{-34}$ *JS*

iii) Work function, $W_0 = 5.5 \times 10^{-34} \times 1.0 \times 10$

$= 5.5 \times 10^{-19}$ *J*

9. *(a) (i)*



Correct polarity

(ii) No change in the amount of photo current. Change in wavelength/frequency of the radiation does not affect the amount of photo electrons produced. It is the number of photo electrons that determines the photocurrent.

(b) (i) Total resistance = gradient

$$= \frac{7.5 - 0}{0.375 - 0} = 20\Omega$$

(ii) Combine d resistance = $\frac{100R}{100 + R}$

$$\frac{100R}{100 + R} = 20$$

$100R = 20R + 2000$

$80R = 2000$ $R = 25\Omega$

(c) (i) Alternating magnetic flux in the coil induces current in the core of the same coil causing eddy currents.

- Eddy currents are minimized by lamination of the core

(ii) $\frac{Vs}{Xp} = \frac{Ns}{Np} = \frac{8}{240} = \frac{Ns}{4200}$ $Ns = \frac{4200 \times 8}{240}$

10 *- Intensity of the radiation*

- Energy of the radiation

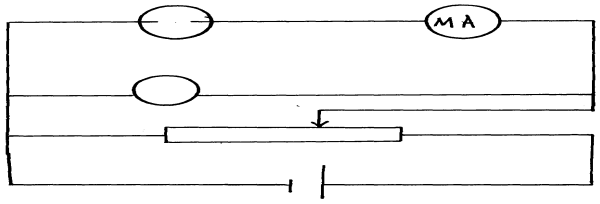
- *Type of the metal*

Ns = 140turns

11. a)i) Emission of electrons from metal surface by electromagnetic radiation falling on the surface

b) ii) $M = \frac{u}{e} = \frac{0.56 - 0}{(6\text{-}4.6) \times 10^{14}} = \frac{0.56}{1.4 \times 10^{14}} = 40 \times 10^{-15}$

$h = 4.0 \times 10^{-15} \times 1.6 \times 10^{-19} = 6.4 \times 10^{-34}$ *Jl*



c) $hf = Q + K.E$

$6.4 \times 10^{-34} \times 3.0 \times 10^{15} = 6.4 \times 10^{-19} + K.E$

$K.E = 19.2 \times 10^{-19} - 6.4 \times 10^{-19}$

$= (19.2 - 6.4) \times 10^{-19}$

$= 12.8 \times 10^{-19}$

$= 1.28 \times 10^{-18}$ *J*