Name of the Student:_____
Max. Marks : 23 Marks **Time : 23 Minutes**

Mark Schemes

Q1.

(a) Filament / metal is heated due to the current through it ✔

OR

Temperature of the filament rises due to the current through it

(Free / conduction) electrons gain sufficient/enough (kinetic) energy to leave (the metal surface)

OR

Work function (defines work function) ≤ energy supplied to an electron/electron energy ✔

Thermionic emission ✔

Not
Electrons are heated
Not heated due to the pd across it
Allow
By electrical power or electrically heated
Not allowed
Reference to electrons leaving <u>atoms</u> or ionisation
Allow
Energy supplied sufficient to overcome the work function

3

(b) Use one of $\frac{1}{2}mv^2 = eV$ and $r = \frac{mv}{Be}$ or $\frac{mv^2}{r} = Bev$

To arrive at

$\frac{Ber}{m} = v$ or $v = \sqrt{\frac{2eV}{m}}$ or $v^2 = \frac{2eV}{m}$

or $\frac{e}{m} = \frac{v}{Br}$ or $\frac{e}{m} = \frac{v^2}{2V}$ ✔

Substitution in the other equation and manipulates <u>correctly</u> and clearly to give $\frac{e}{m} = \frac{2V}{B^2r^2}$ ✔

Condone q for e
Substitution in other equation and correct manipulation
NB this is a show that so mark is not simply for stating the equation

given

I presented such that v (velocity) and V (voltage) are indistinguishable in manipulation then award only first mark

2

(c) Correct substitution $\frac{e}{m} = \frac{2 \times 320}{(1.5 \times 10^{-3})^2 \times 0.040^2}$

And answer 1.8×10^{11} ✔

Answer to 2 sig figs ✔

Allow for incorrect answer following incorrect substitution in equation

As answer is on the data sheet must see correct substitution with all correct powers of ten

2

(d) The specific charge of the cathode rays/the particles was(much) larger/greater than the hydrogen ion/proton ✔

This provided evidence that cathode rays were composed of electrons/particles which have a (very) small mass / have a high (negative) charge

OR

Mass (much) smaller than the mass of a hydrogen (ion)/proton ✔

Not higher

If mark 1 not given then 0 for the question

Not lightest as substitute for mass

2

[9]

Q2.

(a) Pattern shows:

Maximum at start and shows minimum of zero (never negative) ✔

Correct periodicity zeros/maxima 180° apart ✔

(ie angles in right places)

Curvature rather than spikes ie 

(The graph should fall to zero – (NB First and last parts should ideally be curved not as illustrated here)

If negative then can get second mark only

Assume that bottom of graph grid is zero unless otherwise stated

Must be numbers on x-axis

Ignore if graph shows what happens beyond 360

If only one minimum shown then loses this mark

Allow if shown starting at zero

Freehand sketch so allow if clear attempt to show curvature in most of sketch or arches

3

(b) Correct substitution leading to a calculation of the speed of electromagnetic wave

$\frac{1}{\sqrt{(4\pi\times10^{-7})(8.85\times10^{-12})}}$ = 3.0 (2.9986) × 10^8 m s^{-1}

1

Comment that this speed agrees with the measured speed of light

Or speed determined from experiments

Or similar to Fizeau's result

1

[5]

Q3.

(a) Converts 6.2 eV, 0.5 eV or 6.7 eV to J
eg 6.2 × 1.6 × 10^{-19} J or 9.9(2) × 10^{-19} seen
for 0.5 eV 8.0 × 10^{-20} seen
for 6.7eV 1.07 × 10^{-18} seen ✔

$\lambda = \frac{hc}{E}$ or substitution $E = \frac{6.63\times10^{-34}\times3\times10^{8}}{\lambda}$

With one of the above values included for energy✔

190 (185,186 or 187) nm ✔

NB use of λ=h/mv is a PE and scores 0

May use $f = \frac{E}{h}$ *and then* $\lambda = \frac{c}{f}$

Treat incorrect E in the same way

Guidance

Use of 0.5 eV gives 4.0 × 10^{-25}

6.2 eV 3.2 × 10^{-26}

6.7 eV 3.0 × 10^{-26}

These will score 1

8.0 × 10^{-20} gives 2500 nm

9.9(2) × 10^{-19} 200 nm

These will score 2

1 sf answers are not allowed so correct working with answer 186 nm rounded to 200 nm will also score 2

1
1
1

(b) **Classical Wave Model**

Wave model predicts an increase in the photocurrent
Plus one from

- As energy transferred into each electron increases (over time) /energy of the emitted electrons increases
- Electrons can gain sufficient KE to reach T
- Electrons can leave the surface with greater KE✔

Photon Model

The photon model predicts no change in the photocurrent
Or photocurrent remains at zero ✔

One from

- The energy of a photon depends on the frequency not the intensity
- Energy of each incident photon remains the same
- KE of electrons leaving the surface does not change
- Electrons released are still unable to reach T✔

NB The response has to discuss the effect of each theory on the maximum KE of the electrons when they leave the surface

Discussions that relate to threshold frequency or delay before emission are not relevant

3

(c) Fewer electrons will have sufficient energy to move away from the surface/or to reach T/anode
Or
Electrons need more energy to cross the gap
Or
Some of the electrons released were more tightly bound to the surface
Or
Electrons have a range of energies(when emitted from surface)
or
Some electrons use more of the photon energy to escape from the surface (this is related to the energy of the photoelectrons). ✔

Fewer electrons per second have sufficient kinetic energy to reach T scores 2

1

Fewer electrons per second/rate at which electrons reach T will reach terminal T/cross the gap (the per second part captures what is going on in terms of the current)✔

Do not allow

Fewer photoelectrons per second flowing through the circuit

1

(d) A > B > C ✔

1

[9]