Candidate evidence

Q10(a)(i)(A) **Maximum mark: 3**

Response 1 **Marks**

$F = qvB \quad = (2 \times 1 \cdot 6 \times 10^{-19}) \times (5 \times 10^{6}) \times 1 \cdot 7$

$= \underline{\underline{2 \cdot 72 \times 10^{-12} N}}$

Response 2

$F = qvB$

$F = 3 \cdot 2 \times 10^{-19} \times 5 \times 10^{6} \times 1 \cdot 7$

$F = 2 \cdot 72 \times 10^{-12} N C^{-1}$

Response 3

$F = qvB$

$= (3 \cdot 2 \times 10^{-19})(5 \times 10^{6})(1 \cdot 7)$

$= \underline{\underline{2 \cdot 7}} \times 10^{-2} N$

Q10(a)(i)(B) **Maximum mark: 3**

Response 1 **Marks**

The candidate's final answer for Q10(a)(i)(A) was 2·72 × 10^{-12} N.

$$F = \frac{mv^2}{r}$$

$$r = \frac{mv^2}{F}$$

$$= \frac{(6.645\times10^{-27})(5\times10^6)^2}{2.72\times10^{-12}}$$

$$= \underline{6.11\times10^{-2}\,m}$$

Response 2

The candidate's final answer for Q10(a)(i)(A) was 2·72 × 10^{-12} N.

$$F_{magnetic} = F_{centripetal}$$

$$Bqv = \frac{mv^2}{r} \qquad r = \frac{mv}{Bq}$$

$$Bq = \frac{mv}{r} \qquad r = \frac{(6.645\times10^{-27})(5.0\times10^6)}{1.7(3.2\times10^{-19})}$$

$$r = \underline{0.061\,m}$$

Response 3

The candidate's final answer for Q10(a)(i)(A) was 2·72 × 10^{-12} N.

$$F = \frac{mv^2}{r}$$

$$r = \frac{mv^2}{F}$$

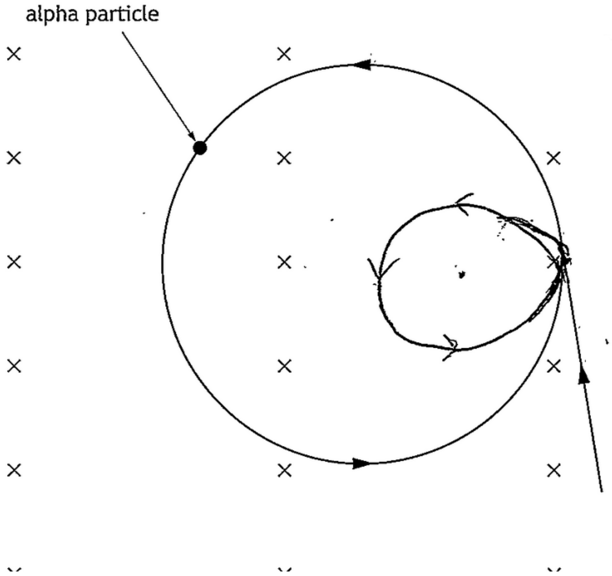
$$= \frac{(6.645\times10^{-27})(5\times10^6)}{(2.72\times10^{-12})}$$

$$= 0.061075\ldots$$

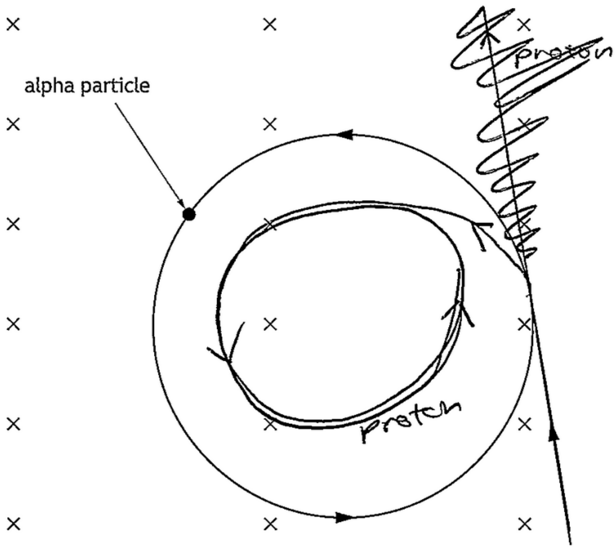
$$= \underline{\underline{0.06\,m}}$$

Q10(a)(ii) Maximum mark: 3

Response 1 **Marks**



Response 2



Q10(b) **Maximum mark: 2**

Response 1 **Marks**

This is due to the uniform speed of the perpendicular component of the particle which is perpendicular to the direction of the magnetic field and the parallel component which also has uniform speed but parallel to the magnetic field.

Response 2

because a charge has entered a magnetic field so will experience a force perpendicular to both the direction the charge is going and the magnetic field. The path will be helical instead of circular as the particle already has a constant velocity upon entering eath's atmosphere.

Response 3

The component of velocity perpendicular to the Earth's magnetic field lines causes the particle to follow a circular path

However, the component of velocity parallel to the Earth's magnetic field lines has no force so the particles also travel in a horizontal path parallel to the field lines which results in helical motion.

Q10(c) Maximum mark: 2

Response 1 **Marks**

Particles from cosmic rays have incredibly short lifetimes so ~~[illegible] altitude~~ not many will breach a lower altitude, ~~So placing an observatory at a lower~~ ~~altitude would result in less~~ which makes a higher altitude observatory more viable. The equator is also a lot more repulsive and will repel more particles than if it were further south.

Response 2

As cosmic rays spiral towards the poles so an observatory at the equator wouldn't see them.

cosmic rays decay and most don't make it to sea level so a higher altitude observatory would be able to detect more before they decay.

Response 3

- The observatory needs to be high as cosmic rays may decay by the time they reach ~~the~~ sea level. ~~[illegible]~~
- Charged particles that make up the majority of the cosmic rays will be closest to earth at the poles, where the magnetic force of attraction is strongest. This makes them the best place for observation.

Q11(a)(i) **Maximum mark: 2**

Response 1 **Marks**

$T = \frac{60}{580} = \frac{3}{29}$ s

$\omega = \frac{2\pi}{T} = \frac{2\pi}{3/29} = 61 \text{ rad s}^{-1}$

Response 2

580 60
9.67 oscillations per second

$\omega = 2\pi f$

$\omega = 2\pi \times 9.67$

$\omega = \underline{61 \text{ rad s}^{-1}}$

Response 3

$\frac{580}{60} = 9.67$

$\omega = 2\pi f$

$= 2\pi \times 9.67$

$= 61 \text{ rad s}^{-1}$

Q11(a)(ii) Maximum mark:3

Response 1 **Marks**

$E_k = \frac{1}{2} m\omega^2 (A^2 - y^2)$

$= \frac{1}{2} \times 3.67 \times 61^2 \times 0.013$

$= 88.8\ J$

Response 2

$\frac{1}{2} m\omega^2 y^2 = \frac{1}{2} \times 3.67 \times (61)^2 \times (0.0\overset{13}{\cancel{\ }})^2$

$= \cancel{\ } = 1.15\ J$

Response 3

$E_k = \frac{1}{2} m\omega^2 (A^2 - y^2)$

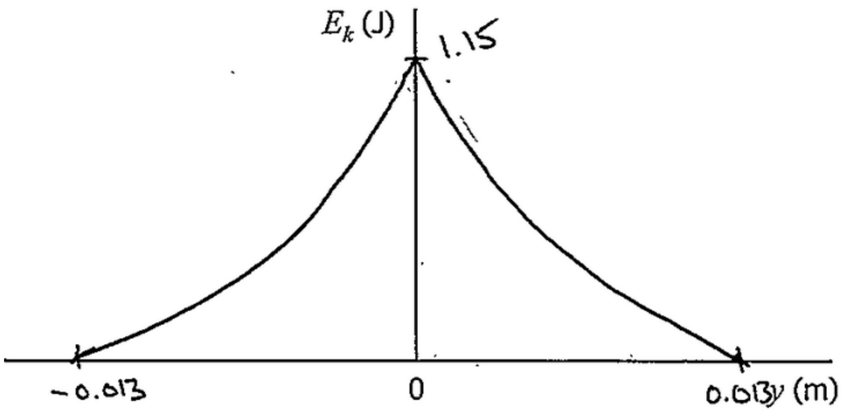
$E_k = \frac{1}{2} (3.67)(61)^2 (0.013)^2$

$E_k = 1.15\ J$

Q11(a)(iii) **Maximum mark: 3**

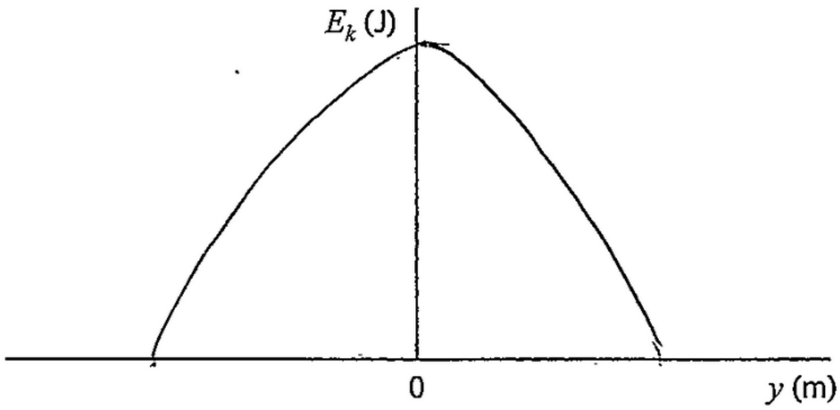
Response 1 **Marks**

The candidate's final answer to Q11(a)(ii) was 1·15 J.



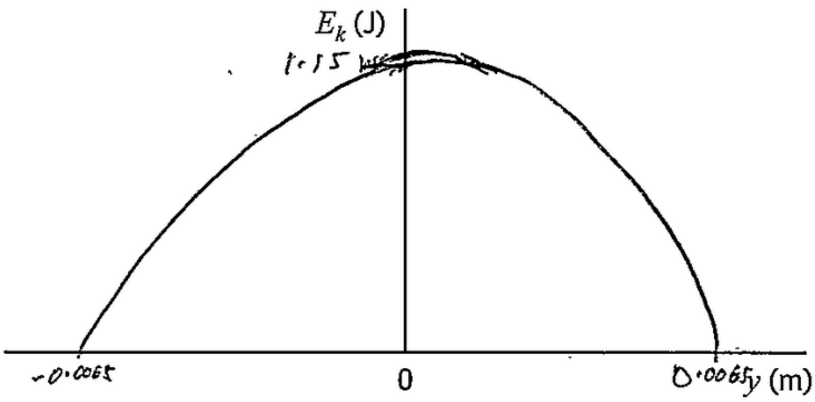
Response 2

The candidate's final answer to Q11(a)(ii) was 1·2 J.



Response 3

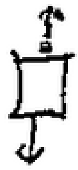
The candidate's final answer to Q11(a)(ii) was 1·15 J.



Q11(b)(i) Maximum mark: 1

Response 1 **Marks**

$-9.8\ m/s^2$ downwards.



Response 2

$9.8\ ms^{-2}$ downward.

Response 3

$9.8\ ms^{-1}$ downwards

Q11(b)(ii) Maximum mark: 3

Response 1

Marks

The candidate's final answer from Q11(b)(i) was 9·8 ms^{-2}.

$a = -\omega^2 y$

$-9.8 = -(61)^2 y$

$\underline{y = 0.0026 m}$

Response 2

The candidate's final answer from Q11(b)(i) was 9·8 ms^{-2}.

$a = -\omega^2 y$

$9.8 = -(61)^2 y$

$y = \frac{9.8}{-(61)^2}$

$y = -2.63 \times 10^{-3} m$

Response 3

The candidate's final answer from Q11(b)(i) was 9·8 ms^{-2}.

~~$a = -w^2 y$~~

~~$-9.8 = (61)^2$~~

$a = -w^2 y$

$-9.8 = (61)^2 y.$

$y = \frac{-9.8}{61^2}$

$y = -2.4455.. \times 10^{-3}.$

$\underline{y = -2.45 \times 10^{-3} m.}$

Q12(a)(i) Maximum mark: 1

Response 1 **Marks**

When the Sound Wave reflects off the closed end of the tube and comes back it interferes with the SoundWaves just emitted. places where the Waves travelling to the right interfere with the one to the left consturctively are anti-nodes and where they interfere destructively are nodes.

Response 2

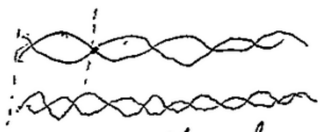
A Stationary wave ~~if~~ is formed when a wave is interferred with by its own reflection

Response 3

A stationary wave is formed as the reflected wave interferes with the speakers wave and cancels it.

Q12(a)(ii) Maximum mark: 2

Response 1 **Marks**



• It gradually becomes quieter untill no sound is heard.

Response 2

The sound detected will decrease when the frequency is 1.5× its original as destructive interference is occuring.
Then the sound will increase back to loud at twice its original value.

Response 3

Loudness will increase before decreasing to the same loudness at the starting frequency

Q12(b)(i) Maximum mark: 2

Response 1 **Marks**

$f = \frac{nv}{4L}$ $v = \frac{4 \times 2 \times 510}{11}$

$v = \frac{4Lf}{n}$ $v = 371\ ms^{-1}$

Response 2

$f = \frac{nv}{4L}$ $v = \frac{4fL}{n}$

$v = \frac{4 \times 510 \times 2}{11} = 371\ ms^{-1}$

Response 3

$f = \frac{nv}{4L}$

$510 = \frac{11 \times v}{4 \times 2}$ ~~$v = 370.9$~~

$v = 370.91\ m/s$

Q12(b)(ii) Maximum mark: 4

Response 1 **Marks**

The candidate's final answer from Q12(b)(i) was 371 ms^{-1}.

$\% \; \cancel{to} \; \Delta f = \frac{10}{510} \times 100 = 1 \cdot 961 \%$

$\% \; \Delta L = \frac{0 \cdot 02}{2} \times 100 = 1 \cdot 0 \%$

$\% \; \Delta v = \sqrt{1 \cdot 961^2 + 1^2} = 2 \cdot 20 \%$

absolute uncertainty $= \frac{2 \cdot 20}{100} \times 371 = 8 \; ms^{-1}$

$\therefore$ absolute uncertainty $= \pm 8 ms^{-1}$ $\quad v = (371 \pm 8) ms^{-1}$

Response 2

The candidate's final answer from Q12(b)(i) was 371 ms^{-1}.

$\% \Delta L = \frac{0.02}{2} \times 100 = 1\%$

$\% \Delta f = \frac{10}{510} \times 100 = 2\%.$

$\% \Delta v = \sqrt{1^2 + 2^2}$

$= 2.24\%$

Absolute uncertainty $= 2.24\%$ of 371

$= 8.31 ms^{-1}.$

so $\Delta v = 8.31 ms^{-1}.$

Response 3

The candidate's final answer from Q12(b)(i) was 371 ms^{-1}.

L

$\frac{0.02}{2} \times 100 = 1\%$ $\quad f = 1.96\%$

$\sqrt{\left(\frac{0.02}{2}\right)^2 + \left(\frac{10}{510}\right)^2} \times 100 = 2.00\%$

2% of $37\cancel{0} = 7.42$ $\quad \therefore (371 \pm 7.42) ms^{-1}$

Q12(c)(i) Maximum mark: 3

Response 1 **Marks**

(2.35 - 830).

(0.6 - 240).

$v = \text{gradient.} \quad \frac{y_1 - y_2}{x_1 - x_2} =$

$\frac{830 - 240}{2.35 - 0.6} = \frac{590}{1.75}$

$v = 337.1\,ms^{-1}$

Response 2

$f = \frac{nv}{4L} \qquad f : 2\cancel{1}0Hz$

$v = \frac{4Lf}{n} \qquad \frac{n}{4L} = 0.5$

$v = f \cdot \frac{n}{4L}$

$= (210)(0.5)$

$= 105\,ms^{-1}$

Response 3

$V = \frac{4Lf}{n}$

(2, 700) (1.55, 560)

$m = \frac{\Delta y}{\Delta x} = \frac{700 - 560}{2 - 1.55}$

$= 311\,ms^{-1}$

Q12(c)(ii) A **Maximum mark: 1**

Response 1 **Marks**

The candidate's calculated % uncertainty from the single point method was: 2·2 %.

2% < 2·2% ∴ graphical method is more precise.

Response 2

The candidate's calculated % uncertainty from the single point method was: 2·2 %.

They are both as precise as each other as they both give an answer to 3 sig figs.

Response 3

The candidate's calculated % uncertainty from the single point method was: 1·5 %.

The value in (b) is more precise than the value obtained from the graph

Q12(c)(ii) B **Maximum mark: 1**

Response 1 **Marks**

The candidate's value from Q12(b)(i) was 371 ms^{-1}.
The candidate's value from Q12(c)(i) was 337 ms^{-1}.

It is more accurate.

Response 2

The candidate's value from Q12(b)(i) was 370 ms^{-1}.
The candidate's value from Q12(c)(i) was 400 ms^{-1}.

value of b) is closer to the actual speed of sound, so is therefore more accurate.

Response 3

The candidate's value from Q12(b)(i) was 370 ms^{-1}.
The candidate's value from Q12(c)(i) was 333 ms^{-1}.

The accuracy of the graphical method was better as it had a lower uncertainty.

Q12 (c)(iii)

Maximum mark: 1

Response 1 **Marks**

systematic error in the frequency of the signal generator

Response 2

A systematic uncertainty could be that the software recorded the wrong values

Response 3

The Student measured the length incorrectly.
The oscilloscope constantly gave readings higher than reality (calibrated incorrectly).

Q13(a)(i) Maximum mark: 4

Response 1 **Marks**

$\cancel{d \sin\theta = m\lambda}$

$\Delta x = \frac{\lambda l}{2d}$

$\frac{43.4}{14} = 3.1\,mm$

$3.1 \times 10^{-3} = \frac{550 \times 10^{-9} \times 2.95}{2d}$

$6.2 \times 10^{-3} d = 1.6225 \times 10^{-6}$

$d = 2.62 \times 10^{-4}\,m$

Response 2

$D = 2.95\,m$

$\Delta x = (43.4 \times 10^{-3}) \div 14 = 3.1 \times 10^{-3}\,m$

$\lambda = 509 \times 10^{-9}\,m$

$\Delta x = \frac{\lambda D}{d}$ $\quad 3.1 \times 10^{-3} = \frac{509 \times 10^{-9} \times 2.95}{d}$

$d = 4.84 \times 10^{-4}\,m$

Response 3

$\lambda = 550 \times 10^{-9}$

$D = 2.95$

$d = 3.1 \times 10^{-3}$

$\Delta x = ?$

$\Delta x = \frac{\lambda D}{d}$

$= \frac{550 \times 10^{-9} \times 2.95}{3.1 \times 10^{-3}}$

$= 5.23 \times 10^{-4}\,m$

Q13(a)(ii) Maximum mark: 1

Response 1 **Marks**

It is a lot more accurate to measure the 14 fringes as it is a lot easier to measure.

Response 2

As it is a larger ~~distance~~ distance so the uncertainty is less.

Response 3

By measuring more fringes it decreases the uncertainty in the distance between the fringes.

Q13(b) Maximum mark: 2

Response 1 **Marks**

Since red light has a higher wavelength than green light the fringe pattern will become more spread (ie fringe separation increases)

$\Delta x = \frac{\lambda D}{d}$ ↑

Response 2

The fringes will be further apart ~~closer together~~ as if all other variables remain constant $\Delta x = \frac{\lambda D}{d}$ so if λ increases so does fringe seperation

Response 3

$\Delta x = \frac{\lambda D}{d}$

$\Delta x = \frac{656 \times 10^{-9} \times 2.95}{5.2 \times 10^{-4}}$

$= 3.72 \times 10^{-3}$ m

There is a bigger seperation between the fringes because the wavelength has increased.

Q13(c)(i) Maximum mark: 3

Response 1 **Marks**

$o.p.d = 2nl$

$o.p.d = 9.8988 \times 10^{-6} m$

$o.p.d = 9.90 \times 10^{-6} m$

Response 2

~~optical path difference $= m\lambda$~~

~~$= (2)(550 \times 10^{-9})$~~

~~$= 1.1 \times 10^{-6}$~~

$d = \frac{\lambda}{4n}$

$= \frac{550 \times 10^{-9}}{4(1.46)}$

$= 9.4 \times 10^{-8}$

$\Rightarrow \Delta x = \frac{\lambda L}{2d}$

$= \frac{(550 \times 10^{-9})(3.39 \times 10^{-6})}{2(9.4 \times 10^{-8})}$

$= 9.9 \times 10^{-6}$ m

Response 3

optical = n x geometrical

$= 1.46 \times 3.39 \times 10^{-6}$

$= 4.95 \times 10^{-6}$

Q13(c)(ii) Maximum mark: 1

Response 1 **Marks**

The candidate's final answer from Q13(c)(i) was: $4{\cdot}95 \times 10^{-6}$ m.

$\cancel{m+\frac{1}{2}\lambda = 4.95\times10}$ $\cancel{(m+\frac{1}{2})\lambda} = 4.95\times10^{-6}$

$\cancel{m+\frac{1}{2} = 9\times10^{-3}}$?

$$\left(m+\frac{1}{2}\right)550\times10^{-9} = 4.95\times10^{-6}$$

Response 2

The candidate's final answer from Q13(c)(i) was: $9{\cdot}9 \times 10^{-6}$ m.

$$OPD = m\lambda$$

$$m = \frac{9.9\times10^{-6}}{550\times10^{-9}}$$

$$= 18$$

$\Rightarrow$ next destructive inteference occurs at $m=17$

$$OPD = m\lambda$$

$$= 17\times550\times10^{-9}$$

$$= 9.4\times10^{-6}\ m$$

Q14(a)(i) Maximum mark: 2

Response 1 **Marks**

$$V = \frac{Q}{4\pi \varepsilon_0 r} \qquad V = \frac{9\times10^{9} \times 1.3\times10^{-14}}{0.048}$$

$V = 2.4\times10^{-3}\,V$ AS Shown

Response 2

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

$$= \frac{1.3\times10^{-14}}{4\pi\varepsilon_0(0.048)^2} = 2.4\times10^{-3}\,V$$

Response 3

$$V = \frac{1.3\times10^{-14}}{4\pi\times 8.85\times10^{-12} \times 48\times10^{-3}}$$

$$= 2.4\times10^{-3}$$

Q14(a)(ii) Maximum mark: 3

Response 1 **Marks**

$V_2 = \frac{Q}{4\pi\varepsilon_0 r}$ $V_1 = 2.4\times10^{-3}$ V

$= \frac{-1.3\times10^{-14}}{4\pi\times(8.85\times10^{-12})\times(52\times10^{-3})}$

$= -2.2\times10^{-3}$ V

$V_{A+P} = (2.4\times10^{-3}) + (-2.2\times10^{-3})$

$= 0.2\times10^{-3}$ V $= \underline{2\times10^{-4}}$ V

Response 2

$V_1 = 2.4\times10^{-3}$ V

$V_2 = -2.2\times10^{-3}$ V

$V_2 = \frac{-1.3\times10^{-14}}{4\pi(8.85\times10^{-12})\times(52\times10^{-3})}$

$= \underline{-2.2\times10^{-3}\ V}$

Response 3

$V = V + V$

$V = \frac{9\times10^{9}\times1.3\times10^{-14}}{0.048} + \frac{-1.3\times10^{-14}\times9\times10^{9}}{0.052}$

$\underline{V = 1.88\times10^{-4}\ V}$

Q14(b) **Maximum mark: 2**

Response 1 **Marks**

As it moves towards the electrode, r, the distance between the charges decreases so as $V_1 \propto \frac{1}{r_1}$, V_1 increases. Hence, ~~the overall~~ as $V_{Total} = V_1 + V_2$, when V_1 increases, V_{Total} increases.

Response 2

It would decrease as the positive charge is getting closer and thus increasing the -ve potential while the negative charge is staying the same.

Response 3

The total electrical potential will decrease since the electrical potential due to the Iris will increase but the electrical potential at the retina remains the same.

Q15(b)(i) Maximum mark: 3

Response 1 **Marks**

$V = Ed$ sub in $E = \frac{F}{Q}$

$V = \frac{Fd}{Q}$ sub in $F = qvB$

$V = \frac{\cancel{q}vBd}{\cancel{Q}}$ charges cancel

$V = vBd$

$v_d = \frac{V}{Bd}$ as required

Response 2

$F = qvB$ as they are ~~balanceg~~ ballanced,

$F = qE$

where $E = \frac{V}{d}$

so $F = \frac{qV}{d}$

$\cancel{q}vB = \frac{\cancel{q}V}{d}$

$\therefore v = \frac{V}{\cancel{q}Bd}$ as required.

Response 3

$E = vd$ $F = Bqv$ $V = Ed$

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

$vd = Bqv$

$\frac{a}{v} = Bqv$

$vd = \frac{V}{Bd}$.

Q15(b)(ii) Maximum mark: 2

Response 1 **Marks**

$v_d = \frac{V}{Bd}$

$\frac{3.47 \times 10^{-6}}{1.25 \times 3.25 \times 10^{-2}}$

$= 8.54 \times 10^{-5}$

Response 2

$V_d = \frac{V}{Bd}$ $V_d = \frac{(3.47 \times 10^{-6})}{(3.25 \times 10^{-2}) \times 1.25}$

$V_d = 8.54\ m/s$

Response 3

$v = \frac{V}{Bd} = \frac{3.47 \times 10^{-6}}{1.25 \times 3.25 \times 10^{-2}}$

$= 8.54 \times 10^{-5}\ ms^{-1}$

Q15(b)(iii) Maximum mark: 2

Response 1 **Marks**

If magnetic induction increases, so more electrons are deflected to the bottom of the plate.
This increase the ~~electrons~~ electric force as well, which means that ~~H~~ magnetic force and electric force remain balanced.
~~So no~~ ~~drift velocity~~ ~~change in does~~
~~& change in Vd occurs.~~

So no change occurs.

Response 2

If the magnetic induction is increasing, then so does the potential difference so that the drift velocity balances out.

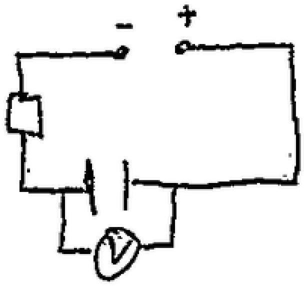
Response 3

$$v = \frac{V}{B\,d}$$

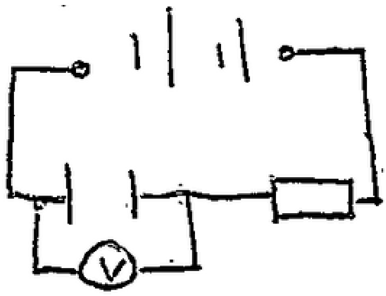
As the magnetic induction is increased, the Voltage also increases. This is because the force on the particle becomes greater causing more charge to gather. ~~this~~. Hence, ~~the~~ v_d remain constant.

Q16(a)(i) Maximum mark: 1

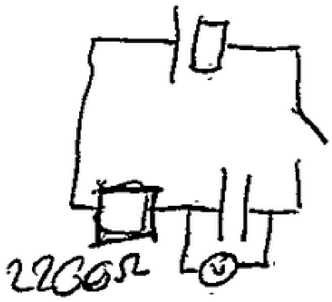
Response 1 **Marks**



Response 2



Response 3



Q16(a)(ii) Maximum mark: 2

Response 1 **Marks**

67% of 6v
=4.02v

0.6s

Response 2

37% of 6 = 2.22 6 - 2.22 = 3.78

6(5). 0.55s

Response 3

t = 0.35s

Q16(a)(iii) Maximum mark: 3

Response 1 **Marks**

The candidate's final answer from Q16(a)(ii) was: 0·54 (s).

$T = RC$

$0 \cdot 54 = 2.2 \times 10^3 \, C$

$C = 2.45 \times 10^{-4} \, CV^{-1}$

Response 2

The candidate gave no response for Q16(a)(ii).

$R = 2.2 k\Omega$

$C = ?$

$t = 2$

$t = RC$

$C = \frac{t}{R}$

$= \frac{2}{2.2 \times 10^3} = 9.1 \times 10^{-4}$ Capictance

Response 3

The candidate's final answer from Q16(a)(ii) was: 5·5 s.

$\tau = RC$

$5 \cdot 5 = 2 \cdot 2 \times 10^3 C$

$C = 400 \, \Omega s^{-1}$

Q16(b)(i) Maximum mark: 3

Response 1

Marks

$$\mathcal{E} = -L\frac{dI}{dt}$$

$$-9 = -L \times 95{\cdot}8$$

$$L = 0{\cdot}09 \text{ Henries}$$

Response 2

$$\mathcal{E} = -L\frac{dI}{dt}$$

$$9 = -95{,}8L \quad \therefore \underline{\underline{L = -0{,}09\,H}}$$

Response 3

$$\mathcal{E} = -L\frac{dI}{dt}$$

$$L = \frac{9}{95{\cdot}8}$$

$$= 9{\cdot}39 \times 10^{-2}\ \text{VsA}^{-1}$$

Q16(b)(ii) Maximum mark: 2

Response 1 **Marks**

• The d.c. ~~ac~~ reading is greater. In a d.c. circuit the current flows in 1 direction so the rate of change of current will eventually be 0. As $\mathcal{E} = -L\frac{dI}{dt}$, this means that back emf will be zero so the current can pass through the inductor ~~freely~~ unbothered. However, for a.c, $\frac{dI}{dt}$ never reaches zero, so $\mathcal{E} > 0$, so current never reaches its max.

Response 2

The dc ammeter reading as inductor produce a back emf when pluggedr into an ac supply

Response 3

• The d.c. ammeter
• X_L in ~~ac~~ a.c. circuits will mean current is lower, due to extra total resistance.
• So d.c. current higher