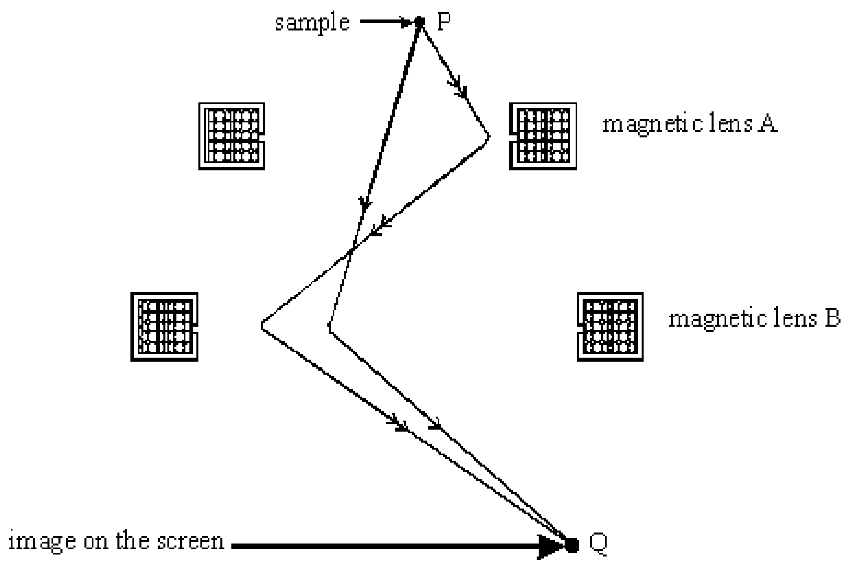
M1. (a) (i) straight paths outside the lenses **(1)**
correct direction of deflection on passing through A **(1)**
path through B correct for path drawn through A **(1)**

for examples
(only one required)



(ii) lens A: magnifies (or forms an intermediate image before B) **(1)**
lens B: magnifies and focuses (or forms an enlarged image on the screen) **(1)**

max 4

(b) increase of voltage causes increase of speed (of the electrons) **(1)**
hence a reduced de Broglie wavelength **(1)**
less diffraction for reduced wavelength **(1)**
better resolution if less diffraction **(1)**

max 3

[7]

M2. (a) waves/ wavelets are emitted by each slit **(1)**
each slit diffracts light **(1)**
the two slits are coherent emitters / sources of light waves **(1)**
bright fringes formed where light from one slit reinforces light from the other slit
[or dark fringes formed where light from one slit cancels light from the other slit] **(1)**
path difference to a bright fringe = whole number of wavelengths
[or path difference to a dark fringe = (whole number + half) wavelengths)] **(1)**

max 4
QWC 2

(b) (i) light consists of corpuscles/particles **(1)**
corpuscles would not be diffracted
[or pass straight through] **(1)**
only two bright fringes would be seen **(1)**

(ii) Newton's scientific pre-eminence
[or there was no evidence that light travelled slower in water as predicted by Huygens' theory]
[or Huygens' theory considered light waves as longitudinal and therefore could not explain polarisation] **(1)**

max 3

[7]

M3. (a) (i) suitable description and outline detail **(1)**
for an appropriate named particle **(1)**
(e.g. electron diffraction of a beam of electrons by a thin metal sample or tunnelling in the STM across a gap by electrons)

(ii) suitable description and outline detail **(1)**
for an appropriate named particle **(1)**
(e.g. a beam of electrons deflected by an electric or magnetic field or collision/impact on a screen of electrons/ions)

max 3

(b) (i) $E_k = 5.0 \times 10^6 \times 1.6 \times 10^{-19}$ (J) **(1)**

(use of $E_k = ½mv^2$ gives) $v \left(= \left(\frac{2E_k}{m}\right)^{1/2} \right)$

$= \frac{(2 \times 5.0 \times 1.6 \times 10^{-13})^{1/2}}{1.67 \times 10^{-27}}$ **(1)**

$(= 3.1 \times 10^{-7}\ ms^{-1})$

(ii) (use of $\lambda = \frac{h}{mv}$ gives) $\lambda = \frac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 3.1 \times 10^7}$ **(1)**

$= 1.3 \times 10^{-14}$ m

[or alternatively $\lambda \left(= \frac{h}{\sqrt{2meV}} \right) = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} \times 1.6 \times 10^{-19} \times 5 \times 10^6}}$

$= 1.3 \times 10^{-14}$ m] **(1)**

4

[7]

M4. (a) electrons can behave as waves
[or electrons can tunnel across gap] **(1)**
waves can cross narrow gaps
[or non-zero probability of crossing gap] **(1)**
electron waves would be attenuated too much by large gap
[or probability of transfer negligible if gap too wide]
[or the narrower the gap, the greater the probability] **(1)**
electron transfer is from – to + **(1)**

4
QWC 2

(b) constant height mode:

tip height constant **(1)**

current varies as gap width changes **(1)**

image built up as tip moves across surface

[or as tip moves across, a decrease (or increase)

of current means the gap widens (or narrows)] **(1)**

3

[or constant current mode:

tip height altered **(1)**

to keep current constant **(1)**

image built up as above or as tip moves across,

the tip

height rises (or falls) if the surface rises or

falls **(1)**]

[7]

M5. (a) particles of light/corpuscles **(1)**
attracted towards glass surface (on entry into glass) **(1)**
velocity/momentum normal to surface increased **(1)**
velocity/momentum parallel to surface unchanged **(1)**

max 3

(b) (i) Newton predicted $speed_{glass} > speed_{air}$
<u>and</u> Huygens predicted $speed_{glass} < speed_{air}$ **(1)**

(ii) named experiment **(1)**
relevance explained **(1)**
(e.g. Young's double slit **(1)** give rise to fringes/interference which is a wave property **(1)**
or diffraction of light **(1)** which is a wave property **(1)**)

3

[6]

M6. (i) reflected waves and incident waves form a stationary/standing wave pattern or interfere/reinforce/cancel **(1)**
nodes formed where signal is a minimum **(1)**

(ii) $\lambda/2 = 1.5$ (m) [or $\lambda = 3$ (m)]
[or nodes formed at half–wavelength separation] **(1)**

(use of $c = f\lambda$ gives) $f = \dfrac{3.0 \times 10^8}{2 \times 1.5}$ **(1)**

= 100 MHz **(1)**

[5]

M7. (a) light, passing through each slit, is diffracted **(1)**
diffracted light from one slit overlaps with (diffracted) light from the other slit **(1)**
bright fringes formed where light waves from each slit reinforce
(or in phase)
(or interfere constructively) **(1)**
dark fringes formed where light waves (from the two slits) cancel **(1)**
(or out of phase by 180°) **(1)**
path difference = whole number of wavelengths for a bright fringe
[or whole number + ½ wavelength for a dark fringe] **(1)**

max 4
QWC 1

(b) corpuscles passing through a slit form a bright fringe **(1)**
two slits produce only two bright fringes according to corpuscular theory **(1)**
more than two fringes are observed **(1)**
dark fringes (or cancellation) cannot happen with corpuscles **(1)**

max 2

[6]

M8. (a) light consists of photons **(1)**
an electron in the metal absorbs a photon **(1)**
an electron needs a minimum amount of energy to escape **(1)**
a blue photon has more energy than a red photon **(1)**
$hf > \phi$ for blue photon, $< \phi$ for red photon **(1)**

Max 4

(b) every electron would gain sufficient energy from the waves in time **(1)**
no matter what the frequency/colour/wavelength of the light is **(1)**

2

[6]

M9. (a) force on an electron in a magnetic field depends on speed **(1)**
electrons at different speeds would be focussed differently so image would be blurred **(1)**
[or electrons at different speeds would have different (de Broglie) wavelengths
therefore resolution would be reduced]

2

(b) increase in pd increases speed **(1)**
increase in speed/momentum/E_k causes reduction of (de Broglie) wavelength **(1)**
reduced (de Broglie) wavelength gives better resolution **(1)**

3

[5]

M10. (a) electrons have a wave-like nature **(1)**
there is a (small) probability that an electron can cross the gap
[or an electron can tunnel across the gap] **(1)**
transfer is from - to + only **(1)**

3

(b) constant height mode:

gap width varies as tip scans across at constant height **(1)**
current due to electron transfer is measured **(1)**
current decreases as gap width increases (or vice versa) **(1)**
variation of current with time is used to map surface **(1)**

[or constant current mode:

current due to electron transfer is measured **(1)**
feedback used to keep current constant
by changing height of probe tip **(1)**
height of probe tip changed to keep gap width constant **(1)**
variation of height of probe tip with time
used to map surface **(1)**]

3

[6]

M11. (a) diagram/description of electric wave and magnetic wave in phase **(1)**
diagram/description/statement that electric wave is at 90° to the magnetic wave **(1)**
diagram/description/statement that direction of propagation/travel is perpendicular to both waves **(1)**

3

(b) (i) (conduction) electron (in the metal) absorbs a photon and gains energy *hf* **(1)**
work function of a metal is the minimum energy needed by an electron to escape from the metal (surface) **(1)**
an electron can only escape if $hf \geq$ work function **(1)**

any two **(1)(1)**

(ii) the photon is the quantum of em radiation/light **(1)**
classical wave theory could not explain threshold frequency **(1)**
classical wave theory was replaced by the photon theory **(1)**
[or photons can behave as waves or particles]
[or photons have a dual wave/particle nature]

any two **(1)(1)**

4

[7]

M12. (a) **one feature** (1 mark for one of the following)

- there is a threshold (minimum) frequency (of light) for photoelectric emission from a given metal
- photoelectric emission is instant

explanation

- light consists of photons (or wavepackets) **(1)**
- energy of a photon = hf where f is the light frequency **(1)**
- work function ϕ of metal is the minimum amount of energy it needs to escape **(1)**
- 1 electron absorbs 1 photon and gains energy hf **(1)**
- electron can escape if energy gained $hf > \phi$ **(1)**

6

(b) (i) an electron requires 2.2 eV of energy to escape from the metal surface **(1)**

(ii) photon frequency, f (= c/λ = $\frac{3.0 \times 10^{8}}{5.2 \times 10^{-7}}$) = 5.77×10^{-19} J **(1)**

photon frequency (= hf) = $6.63 \times 10^{-34} \times 5.77 \times 10^{14} = 3.83 \times 10^{-19}$ J **(1)**

E_K max (= $hf - \phi$) = $3.83 \times 10^{-19} - (2.2 \times 1.6 \times 10^{-19})$ **(1)**

= 3.1×10^{-20} J **(1)**

5

[11]

M13. (a) particles of light (or corpuscles) **(1)**

attracted towards glass surface **(1)**
(*on entry to glass (or leaving glass)*)

velocity (or momentum) parallel to surface unchanged **(1)**

velocity (or momentum) perpendicular to surface increased (or decreased on leaving) **(1)**

direction (or velocity or momentum) same after leaving glass as before entry to glass **(1)**

max 4

(b) named experiment **(1)** observational evidence **(1)** how it supports Huygens' theory **(1)**

(e.g. Young's double slits **(1)** shows interference **(1)** which is a wave property **(1)** or measurement of the speed of light **(1)** speed of light is less than in air **(1)** as predicted by wave theory **(1)**)

max 3

[7]

M14. (a) (i) work done (due to stopping potential *V*) = *eV* **(1)**

E_{Kmax} = work done due to stopping potential

$= (1.6 \times 10^{-19} \times 0.35) = 5.6 \times 10^{-20}$ J **(1)**

2

(ii) (rearranging $hf = \phi + E_{Kmax}$) gives $\phi = hf - E_{Kmax}$ **(1)**

photon energy (= $hf = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{590 \times 10^{-9}}$)

$= 3.37 \times 10^{-19}$ J **(1)**

$\phi = hf - E_{Kmax} = 3.37 \times 10^{-19} - 5.6 \times 10^{-20} = 2.8(1) \times 10^{-19}$ J **(1)**

3

(b) (i) photons have the same energy (as in a)) **(1)**

when a (conduction) electron in the metal absorbs a photon, it gains all the energy of the photon **(1)**

work function (of Y) is the minimum energy needed by an electron to escape **(1)**

work function of Y is greater than the energy gained by an electron (so electron cannot escape) **(1)**

max 2

(ii) wave theory predicts that incident light (of any frequency) would cause photoelectric emission (from any metal) **(1)**

and any **one** of the following points

wave theory could not explain why light below a certain frequency (or below a threshold frequency) could not cause photoelectric emission **(1)**

or this (threshold) frequency is characteristic of the metal (or depends on the metal) **(1)**

or wave theory could not explain the instantaneous emission of photoelectrons **(1)**

2

[9]

M15. (a) (i) Newton's other theories were successful (or Newton was more eminent so Newton's view was accepted) ✓

alternatives, Huygens' theory was based on longitudinal waves which cannot explain polarisation **or**

Huygens' theory could not explain sharp shadows

1

(ii) **either**

Newton predicted that light travels faster in glass than in air, Huygens predicted the opposite ✓

or

there was no evidence (for many years) that light travels slower or faster in glass than in air ✓

the speed of light in water (or glass) was (eventually) found to be less than the speed of light in air ✓

diffraction/interference observations not conclusive ✓

max 2

(b) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear**.

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate provides a comprehensive, coherent and logical explanation which recognises that the pattern is due to interference of light which is a wave property. They should know that at a bright fringe, the waves from the two slits are in phase and therefore reinforce each other and this can happen at positions where the path difference is zero or a whole number of wavelengths.
They may not refer to the need for the waves to be coherent.
Their answer should be well-presented in terms of spelling, punctuation and grammar.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate provides a logical explanation which recognises that interference of light is a wave property. They should know either a bright fringe is where the waves from the two slits are in phase or a dark fringe is where they are out of phase by 180° and be aware there are different positions where these conditions apply. They may know the general condition for the path difference for a bright fringe or a dark fringe although they may not recognise that this condition explains why there are more than two bright fringes.
Their answer should be adequately or well-presented in terms of spelling, punctuation and grammar.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

The candidate recognises that interference of light is a wave property and that the waves from the two slits reinforce at a bright fringe or cancel at a dark fringe. They may confuse path difference and phase difference and their explanation of why there are more than two bright fringes may be vague or absent.
Their answer may lack coherence and may contain a significant number of errors in terms of spelling and punctuation.

Incorrect, inappropriate of no response: 0 marks

No answer or answer refers to unrelated, incorrect or inappropriate physics.

Statements expected in a competent answer should include some of the following marking points.

the pattern is due to interference of light from the two slits

interference is a wave property

light from the two slits is in phase at a bright fringe and therefore reinforces

the path difference (from the central bright fringe to the two slits) is zero

either bright fringes are formed away from the centre wherever the path difference is a whole number of wavelengths **or** dark fringes are formed away from the centre wherever the path difference is a whole number of wavelengths + a half wavelength

the path difference for the m^{th} bright fringe from the centre is *m* wavelengths where *m* is any whole number

since *m* is any whole number, more than two bright fringes are observed

max 6

[9]

M16. (a) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

High Level (Good to excellent): 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate provides a comprehensive and coherent answer that includes a stated property of light such as interference or diffraction that can only be explained in terms of the wave nature of light and a <u>stated property</u> such as photoelectricity that can only be explained in terms of the particle nature of light. In each case, a relevant specific <u>observational feature</u> should be referred to and should be accompanied by a <u>coherent explanation</u> of the observation. Both explanations should be relevant and <u>logical</u>.

For full marks, the candidate may show some appreciation as to why the specific feature of either the named wave property cannot be explained using the particle nature of light or the named particle property cannot be explained using the wave nature of light.

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate provides a logical and coherent explanation that includes a stated property of light such as interference or diffraction that can only be explained in terms of the wave nature of light ***and*** *a stated property such as photoelectricity that can only be explained in terms of the particle nature of light.*

For 4 marks, the candidate should be able to refer to a relevant specific observational feature of each property, at least one of which should be followed by an adequate explanation of the observation. Candidates who fail to refer to a relevant specific observational feature for one of the properties may be able to score 3 marks by providing an adequate explanation of the observational feature referred to.

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

The candidate provides some relevant information relating to two relevant stated properties for 1 mark. Their answer may lack coherence and may well introduce irrelevant or incorrect physics ideas in their explanation.

Points that can be used to support the explanation:

Wave-like nature property

- property is either interference **or** diffraction
- observational feature is either the bright and dark fringes of a double slit interference pattern or of the single slit diffraction pattern (or the spectra of a diffraction grating)
- explanation of bright or dark fringes (or explanation of diffraction grating spectra) in terms of path or phase difference
- particle/corpuscular theory predicts two bright fringes for double slits or a single bright fringe for single slit or no diffraction for a diffraction grating

Particle-like nature

- property is photoelectricity
- observational feature is the existence of the threshold frequency for the incident light **or** instant emission of electrons from the metal surface
- explanation of above using the photon theory including reference to photon energy *hf*, the work function of the metal and '1 photon being absorbed by 1 electron'
- wave theory predicts emission at all light frequencies **or** delayed emission for (very) low intensity

6

(b) (i) $m\ (= m_o (1 - v^2 / c^2)^{-0.5} = 9.11 \times 10^{-31} (1 - 0.890^2)^{-0.5})$

$(= 1.998 \times 10^{-30}$ kg$) = 2.0(00) \times 10^{-30}$ kg ✓

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{2.0(0) \times 10^{-30} \times 0.89(0) \times 3.0(0) \times 10^{8}}$$ ✓

$(= 1.2(4) \times 10^{-12}m)$

2

(ii) $E_{Ph} = \left(hf = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{1.24 \times 10^{-12}} \right) = 1.6(0) \times 10^{-13}$ J ✓

1

(iii) $E_K = (m - m_o)\, c^2$

$= (1.998 \times 10^{-30} - 9.11 \times 10^{-31}) \times (3.0 \times 10^8)^2$

$= 9.78 \times 10^{-14}$ J ✓ 3 sf only ✓

2

[11]

M17. (a) (vibrations of) the electric wave and magnetic wave;

perpendicular to each other ✓

perpendicular to direction of propagation ✓

in phase with each other ✓

3

(b) μ_o and ε_o determined experimentally (or μ_o and ε_o values were known) ✓

(substitution of values of μ_o and ε_o into) predicted equation gives $3(.0) \times 10^8$ m s^{-1} (or the speed of light) ✓

which is the speed of light (or $3(.0) \times 10^8$ m s^{-1}) ✓

2

(c) (i) magnetic wave vibrations perpendicular to (plane of) loop ✓

(magnetic wave) causes alternating (or changing) magnetic flux (linkage or cutting) through the loop ✓

alternating magnetic flux (or field) induces an alternating (or changing) emf (or pd) in the loop ✓

[**or** equivalent E-field statements

E-wave (or field) vibrations parallel to loop ✓

E-wave (or field) induces emf (or pd) in wire of loop ✓

E-wave (or field) alternates so induced emf is alternating ✓]

3

(ii) no magnetic flux (linkage or cutting) through the loop (as loop is now parallel to magnetic wave vibrations) so no induced emf (or pd) ✓

(**or** electric field perpendicular to loop so no induced emf (or pd) ✓)

1

[9]

M18. (a) **Quality of written communication:**

Good – Excellent

The candidate provides a comprehensive, coherent and logical explanation which recognises what a stationary wave is and that the conditions for the formation of a stationary wave are present. They should know that nodes and antinodes are formed at alternate positions along XY which are equally spaced with nodes every half wavelength. They should know how the detector is used to locate the position of each node or antinode and how the wavelength is determined from the distance between two such positions. They may know that the nodes can be located more accurately than the antinodes and that their chosen two positions should be as far apart as possible.

Their answer should be well-presented in terms of spelling, punctuation and grammar.

For top band,

explanation = at least b and e

description = at least f, g,h

(5-6 marks)

Modest – Adequate

The candidate provides a logical explanation which recognises what a stationary wave is and what some of the conditions for the formation of a stationary wave are. They may know that nodes and antinodes are formed at alternate positions along XY with nodes every half-wavelength. They may know how the detector is used to locate the position of each node or antinode and how the wavelength is determined from the distance between two such positions. They may know that the nodes can be located more accurately than the antinodes and that their chosen two positions should be as far apart as possible.Their answer should be well-presented in terms of spelling, punctuation and grammar.

For middle band ,

explanation = at least any two of a-e

description = at least any two of f-i

(3-4 marks)

Poor to Limited

The candidate may recognise that the reflector reflects radio waves which then form a stationary wave pattern with the incident waves. They may be unaware what the conditions for the formation of a stationary wave are and their understanding of nodes and antinodes may be poor. They may have some awareness that the stationary wave causes the detector signal to vary with position along XY and that the wavelength can be determined from this variation although they might not be able to link the wavelength to the changes of detector position correctly.

Their answer may lack coherence and may contain a significant number of errors in terms of spelling and punctuation.

For lowest band,

Any 2 points ,must be 1 of each for 2 marks

The explanations expected in a good answer should include most of the following physics ideas

Explanation of stationary wave formation;-

a. radio waves from the transmitter are reflected back towards the transmitter ✓

b. reflected and incident waves pass through each other ✓

c. both waves have same frequency (and speed) and amplitude ✓

d. superposition (of reflected and incident waves) occurs to form a stationary wave (as above) ✓

e. equally spaced nodes and antinodes formed along XY ✓

Description of measurement of wavelength;-

f. Detector signal is zero (or least) along XY at nodes ✓

g. distance between adjacent nodes is ½λ ✓

h. move detector along XY to measure distance between adjacent nodes and double to give the wavelength ✓

i. measure distance over n nodes and divide by n-1 to give distance between adjacent nodes ✓

6
(1-2 marks)

(b) Speed of radio waves (obtained by Hertz) is the same as the speed of light ✓

Speed of electromagnetic waves (calculated or predicted by Maxwell) is the same as the speed of light (or of radio waves) so radio waves are electromagnetic waves ✓

2
(Total 8 marks)

M19. (a) (Matter) particles have wave-like properties (owtte) ✓

Accept mv or mass x velocity in place of p

and an associated wavelength = *h / p where p* is the momentum of the particles ✓.

Accept 'inversely proportional to momentum (or mv)' after 'wavelength'

2

(b) E_K (= 0.021 eV) = 0.021 × 1.60 × 10^{-19} or 3.36 × 10^{-21} J ✓

(Using $E_K = ½ m v^2$ gives)

For 2^{nd} mark, allow individual values of e and V in place of E_K value in data substitution

$mv = (2 m E_K)^{1/2} = (2 \times 1.67(5)\times10^{-27} \times 3.36 \times 10^{-21})^{1/2}$

(= 3.35 × 10^{-24} kg m s^{-1}) ✓

For 3^{rd} mark, allow individual values of m and v in denominator

[OR

$v = (2 E_K / m)^{1/2} = (2 \times 3.36 \times 10^{-21} / \times 1.67(5)\times10^{-27})^{1/2}$

(= 2.0 × 10^3 m s^{-1})

mv = (1.67(5)×10^{-27} × 2.0 × 10^3 (= 3.35 × 10^{-24} kg m s^{-1})]

$$\lambda = \frac{h}{mv} (= \frac{6.63\times10^{-34}}{3.35\times10^{-24}}) = 1.88\times 10^{-10} \text{ m}$$ ✓

= 2.0 × 10^{-10} m to 2 sf ✓

Alternative;

Correct use of 0.021 eV in $\lambda = h / (2meV)^{1/2}$ ✓

$$= \frac{6.63\times10^{-34}}{(2\times1.67(5)\times10^{-27}\times0.021\times1.6\times10^{-19})^{0.5}}$$ ✓

= 1.88 × 10^{-10} m ✓ *= 2.0 × 10^{-10} m to 2 sf* ✓

Final sf mark - need to see some valid working

4

(c) electron's momentum (p) is the same (as that of the neutron) and its mass is (much) smaller than neutron mass ✓

kinetic energy = $p^2 / 2m$ so kinetic energy of electron is (much) greater ✓

Alternative for 2^{nd} mark;- (so) electron's speed is (much) greater and as kinetic energy = ½ mv^2, the electron's kinetic energy is (much) greater as v^2 is more significant than m (here) (owtte)

2^{nd} alternative for 2^{nd} mark using $\lambda = h / (2 mE_K)^{1/2}$

$\lambda = h / (2 mE_K)^{1/2}$ so (same λ means) mE_K (in equation) is the same for electron as for the neutron). So E_K is (much) greater as electron mass is (much) smaller than neutron mass (owtte)

Note; allow use of eV in place of E_K if eV is identified as E_K.

2

[8]