M1.(a) (i) Appreciation that one component changes speed while the other component at right angles does not ✓

When entering a denser medium a corpuscle / light accelerates or its velocity / momentum increases perpendicular to the interface ✓

There is a (short range) attractive force between light corpuscle and the (denser) material ✓

Not allowed:

Attraction due to opposite charges

Force making them move faster is not enough

Accelerate in medium

Not gains energy

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(ii) Light (was shown by experiment to) travel slower in (optically) denser medium OWTTE ✓

Condone 'waves..' instead of 'light'

OWTTE e.g. speed in vacuum higher than speed in other medium

Newton's theory required light to travel faster, wave theory suggested slower speed ✓
or
Newton's theory could not explain the slower speed
or
Huygens theory could explain the slower speed

Not allowed:

Reference to Young's two slit- question asks them about refraction

2

(iii) A corpuscular theory predicts only two (bright) lines / high intensity patches of light whereas a wave theory predicts many fringes ✓

Corpuscles can only travel in straight lines
or
waves can produce fringes because (diffract and) interfere / superpose / arrive in and out of phase / have different path differences ✓

Need to describe the patterns ie not just interference fringes are seen for the first mark

2

(b) Substitutes data in photon wavelength = *hc / E* ; Allow for substitution with no conversion to J ✓

2.48×10^{-10} m ✓

For electron: Substitution in $\lambda = \frac{h}{\sqrt{2mE}}$

2.48×10^{-10}(or their λ)

$= 6.6 \times 10^{-34} / (2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19}\, V)^{1/2}$ ✓

No conversion to J gives $\lambda \approx 4 \times 10^{-29}$ *and* $V \approx 9 \times 10^{38}$ *V)*

$V = 24(.4)$ V ✓ $= 1.49 \times 10^{-18} / (\text{their } \lambda)^2$ ✓

Allow small rounding errors in dp

May calculate *v* using $v = h / m\lambda$ then substitution in $V = ½ mv^2 / e$ ✓ (for third mark)

4

[11]

M2.(a) (i) wavelength = $\frac{h}{mv}$ **(1)**

$= \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 1.2 \times 10^{3}}$ **(1)** $(= 6.1 \times 10^{-7}\ \text{m})$

(ii) charge (= current × time = $4.8 \times 10^{-13} \times 1.0 \times 10^{-3}$) = 4.8×10^{-16} C **(1)**

number of electrons per fringe = $\frac{4.8 \times 10^{-16}}{(1.6 \times 10^{-19} \times 6)}$ = 500 **(1)**

(4)

(b) (i) same **(1)**

(ii) interference fringes would be further apart **(1)**

at twice the spacing **(1)**

as the wavelength would be doubled **(1)**

because $\lambda \propto \frac{1}{\text{speed}}\left[\text{or} \propto \frac{1}{\text{momentum}}\right]$ **(1)**

(max 4)

(c) $f\left(=\frac{c}{\lambda}\right)=\frac{300\times10^{8}}{6.1\times10^{-7}}$ **(1)**

$= 4.9 \times 10^{14}$ Hz **(1)**

(2)

[10]