

Option B — Quantum Physics and Nuclear Physics

B1. (a) there exists a frequency of light (incident on a metal surface) below which no electrons are emitted/ejected from the surface / *OWTTE*;
the emission/ejection of electrons from a metal surface (upon which light is incident) is instantaneous / maximum KE of electrons is independent of intensity; [2]

(b) (i) the threshold frequency is the frequency below which no electrons are emitted / *OWTTE*;
(this corresponds to $E_K = 0$) so $f = 4.5 \times 10^{14}$ Hz; [2]

(ii) from Einstein's (photoelectric) theory $E_K = hf - hf_0$;
therefore, $h = \text{gradient/slope of graph}$;
 $= \frac{4.8 \times 10^{-19}}{(11.8 - 4.5) \times 10^{14}}$ *or* values consistent with at least half length of line;
 $= 6.7 (\pm 0.2) \times 10^{-34}$ J s; [4]

B2. (a) all particles have an associated wavelength / *OWTTE*;
the wavelength λ is given by $\frac{h}{p}$ where h is the Planck constant and p is the momentum of the particle; [2]

(b) combine $E = \frac{p^2}{2m}$ and $p = \frac{h}{\lambda}$;
to get $E = \frac{h^2}{2m\lambda^2}$;
substitute to get $E = 2.2 \times 10^{-18}$ J; [3]

B3. (a) the rate at which atoms decay (in a sample) is proportional to the number of atoms (in the sample) / *OWTTE*; [1]

(b) ${}_{40}^{81}\text{Zr} = {}_{39}^{81}\text{Y} + \beta^+ + \nu$;
 ${}_{39}^{81}\text{Y}$;
 β^+ *or* e^+ *or* ${}_{+1}^0e$;
 ν ; [3 max]

(c) $\lambda = \frac{dN}{dt}$;
 $= \left(\frac{7.4 \times 10^{14}}{1.6 \times 10^{16}} \right) = 0.046 \text{ s}^{-1}$;
 $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \left(\frac{0.69}{0.046} \right) = 15 \text{ s}$; [3]

Values in brackets do not need to be shown to gain full credit.

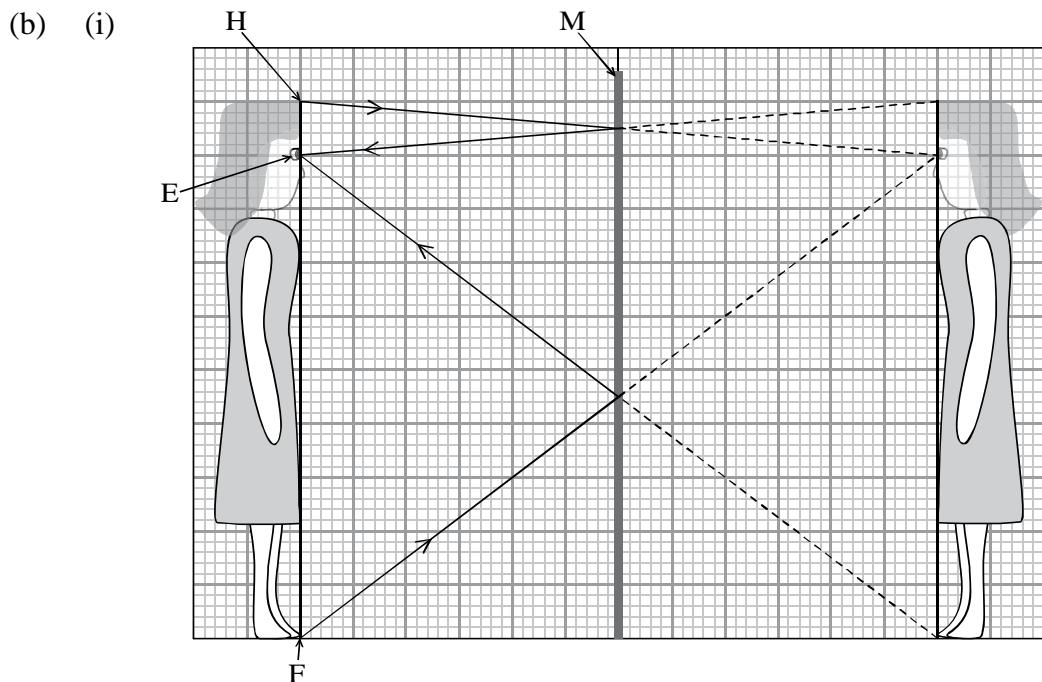
Option H — Optics

H1. (a) $\frac{\sin i}{\sin r}$ *or* $\frac{c}{v}$ with terms for each expression defined; [1]

(b) $= \frac{3.0 \times 10^8}{2.1 \times 10^8}$;
 = 1.4; [2]

(c) speed of light in a medium depends on frequency;
 the refractive index depends on frequency;
 light of different frequencies refracted by different amounts / *OWTTE*; [3]

H2. (a) 1. the angle of incidence is equal to the angle of reflection;
 2. incident ray, reflected ray and normal are coplanar/in the same plane; [2]



same height;
 image distance equal object distance; [2]

(ii) correct ray construction for F;
 correct ray construction for H;
*The rays should be shown with equal angles at mirror judged by eye.
 Arrows on rays are not required.* [2]

(c) (i) 0.75 (±0.03) m; [1]

(ii) 0.68 (±0.03) m; [1]

(d) no effect; [1]