Option B — Quantum Physics and Nuclear Physics

B1. (a) $eV = \frac{hc}{\lambda}$;

$\lambda = \frac{6.6\times10^{-34}\times3\times10^{8}}{(1.6\times10^{-19}\times25000)}$; *(condone power of ten error in this mark)*

$= 4.95\times10^{-11}\,\text{m}$; ***[3]***

(b) shows twice $25\,\text{kV}$ maximum frequency by eye;
characteristic spectrum position unchanged; ***[2]***

B2. (a) electron occupies one of a finite number of levels;
photon <u>emitted</u> when electron <u>drops to lower</u> level / photon <u>absorbed</u> when electron <u>rises to higher</u> level;
spectral line corresponds to energy difference / reference to $\frac{hc}{\lambda}$; ***[3]***

(b) (i) $\frac{1.88\times6.56}{4.86}(=2.54\,\text{eV})$ ***or*** explicit working from $E = hf$; ***[1]***

(ii) arrow connects $n=3$ and $n=2$ <u>and</u> arrow connects $n=4$ and $n=2$;
both arrows from higher to lower level <u>and</u> lines correctly identified by wavelength; ***[2]***

B3. (a) (i) (electron) anti-neutrino; ***[1]***

(ii) lepton; ***[1]***

(b) (i) $\lambda = \frac{\ln 2}{5700}$; ***[1]***

(ii) $0.075 = 0.24\times e^{-1.21\times10^{-4}\times t}$;

$t = \frac{\ln\left(\frac{240}{75}\right)}{1.21\times10^{-4}}$;

$t = 9.7\times10^{3}$ year; ***[3]***

(c) measure activity of source;
determine number of molecules chemically;
activity $= \lambda\times N$, hence half-life; ***[3]***
*Award **[1 max]** for method that measures activity and then waits before re-measuring.*

Option H — Optics

H1. (a) (i) ray drawn to surface with correct refraction;
second ray with correct refraction and image location; ***[2]***

(ii) $n = \frac{\text{real depth}}{\text{apparent depth}}$;
$6.5\,\text{m}$; ***[2]***

(b) (i) ray drawn to surface with correct reflection by eye;
second ray with correct reflection by eye;
construction lines to show image formed above water; ***[3]***

(ii) disturbed surface leads to many reflections in different directions / diffuse reflection; ***[1]***

H2. (a) one correct ray;
second correct ray;
image construction lines clear <u>and</u> image drawn in, labelled I; ***[3]***

(b) (i) <u>point</u> closer than which eye cannot focus; ***[1]***

(ii) image formed 21cm from lens $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$; $\begin{cases} (\textit{real is} + \textit{ve, allow new} \\ \quad \textit{Cartesian solution}) \end{cases}$
so $\frac{1}{u} = \frac{1}{8} + \frac{1}{21}$;
$u = 5.8\,\text{cm}$; ***[3]***
*Award **[2 max]** if 25 cm used for v.*

(c) (i) *chromatic*:
different amounts of refraction for different colours/wavelengths;
colour fringing of image;

spherical:
rays parallel to principal axis at edge of lens brought to different focus from those near centre of lens / *OWTTE*;
image blurred / *OWTTE*; ***[4]***

(ii) restrict aperture; ***[1]***