Option B — Quantum Physics and Nuclear Physics

B1. (a) (i) substitution into formula $E = \frac{hc}{\lambda}$
to give $E = 4.48\times10^{-19}\,\text{J}$; ***[1]***
Units need not be stated.

(ii) photon energy $= 2.8\,\text{eV}$ ***or*** work function $= 7.36\times10^{-19}\,\text{J}$;
photon energy < work function;
hence no emission; ***[3]***

(b) electron emitted from surface will have energy $(2\times2.8-4.6) = 1.0\,\text{eV}$;
photon can interact with an electron below surface;
so energy is required to bring the electron to the surface;
this energy is deducted from maximum kinetic energy of electron; ***[4]***

B2. (a) γ-ray photons have discrete values of energy;
which correspond to energy differences between energy states in nucleus; ***[2]***

(b) (i) ratio is $\frac{1}{2}$ so two parts Co, one part Ni ***or*** $2\text{Ni} = \text{Co}$;
cobalt has two of three parts *i.e.* $\frac{2}{3}$ $2\text{Ni} + \text{Co} = N_0$ *i.e.* $\text{Co} = \frac{2}{3}N_0$; ***[2]***

(ii) $N = N_0\,\text{e}^{-\lambda t}$;
$0.67 = \text{e}^{-3\lambda}$ giving $\lambda = 0.133\,\text{yr}^{-1}$;
use of $\lambda T_{\frac{1}{2}} = \ln 2$
to give $T_{\frac{1}{2}} = 5.2$ years; ***[3]***

B3. (a) (electric) charge;
strangeness;
lepton number;
parity;
baryon number;
angular momentum;
isotopic spin; ***[3 max]***

(b) (i) lepton number / angular momentum is not conserved; ***[1]***

(ii) ${}^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e + \bar{\nu}$; ***[1]***