Question

Electron Spin: A beam of electrons enters a uniform $1.20\,T$ magnetic field. (a) Find the energy difference between electrons whose spins are parallel and antiparallel to the field. (b) Find the wavelength of radiation that can cause the electrons whose spins are parallel to the field to flip so that their spins are antiparallel.

Solution

a) In a magnetic field **B** the energy of an electron depends on the orientation of its spin vector **S** to the field and is higher or lower by $\mu_B B$ where the Bohr magneton $\mu_B = e\hbar/2m = 5.788 \times 10^{-5}\,eV/T$, hence the energy difference between those with 'spin up' and 'spin down'

$$\begin{aligned}\Delta E &= 2\mu_B B \\ &= 2(5.788 \times 10^{-5})\,1.2 \\ &= 1.389\end{aligned}$$

The energy difference is $1.39 \times 10^{-4}\,eV$

---

b) The required energy for a photon of the radiation is $h\nu$ or hc/λ, hence the wavelength to flip the electron spin is given by

$$\begin{aligned}\frac{hc}{\lambda} &= \Delta E \\ \lambda &= \frac{hc}{\Delta E} \\ &= \frac{(4.136 \times 10^{-15})(3 \times 10^{8})}{1.389 \times 10^{-4}} \\ &= 8.933 \times 10^{-3}\end{aligned}$$

The wavelength of radiation required to flip the electrons from 'spin up' to 'spin down' is $8.93\,mm$
