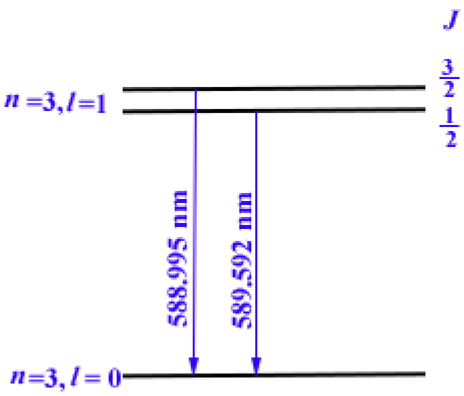
768.

Problem 51.64 (RHK)

The wavelengths of the lines of the sodium doublet are 588.95 nm *and* 589.592 nm. (a) *We have to find the energy difference between the upper two levels*. (b) *This energy difference comes about because the electron's spin magnetic dipole moment can be oriented either parallel or antiparallel to the internal magnetic field associated with the electron's orbital motion*. *Using the result in* (a) *we have to find the strength of this internal magnetic field. The electron's spin magnetic dipole moment has a magnitude of* 1 *Bohr magneton*.

Solution:



The difference in energy between the upper two levels will be

$$\Delta E = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = hc\frac{(\lambda_2 - \lambda_1)}{\lambda_1\lambda_2}$$

$$= \left(6.63\times10^{-34}\times3\times10^{8}\right)\frac{0.597\times10^{9}}{588.99\times589.59}\ \text{J}$$

$$= 3.417\times10^{-22}\ \text{J}$$

$$= \frac{3.417\times10^{-22}}{1.6\times10^{-19}}\ \text{eV} = 2.13\times10^{-3}\ \text{eV}.$$

(b)

Let the magnetic field experienced by the electron in the $n=3$-shell be *B*. As the splitting of the energy level is due to the action of the magnetic field arising because of the orbital motion on the spin magnetic moment of the electron, we have

$$2\mu_B B = \Delta E,$$

where

$$\mu_B = \frac{eh}{4\pi m_e} = 9.274\times10^{-24}\ \text{J T}^{-1} = 5.788\times10^{-5}\ \text{eV T}^{-1}.$$

$$\therefore\ B = \frac{2.13\times10^{-3}}{2\times5.788\times10^{-5}}\ \text{T} = 18.4\ \text{T}.$$