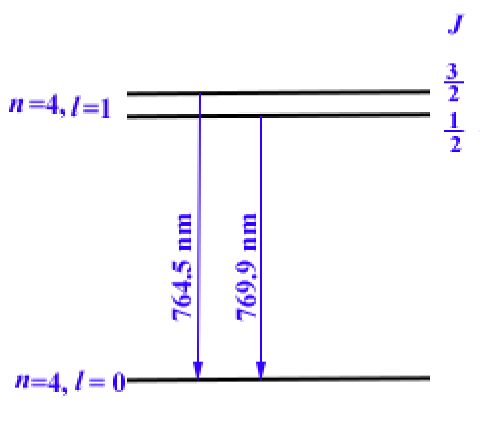
**767.**

**Problem 51.63 (RHK)**

*Potassium* $(Z = 19)$, *like sodium* $(Z = 11)$, *is an alkali metal, its single valence electron moving around a filled* 18-*electron argon-like core. As in sodium, there is a potassium doublet, its wavelengths being* 764.5 nm *and* 769.9 nm. *We have to calculate* (a) *the energy splitting between the upper two states and* (b) *the energy difference between the uppermost state and the ground state.*

**Solution:**



The wavelengths of the potassium doublets are

$\lambda_1 = 764.5 \text{ nm} = 764.5 \times 10^{-9} \text{ m}$,

and

$\lambda_2 = 769.9 \text{ nm} = 769.9 \times 10^{-9} \text{ m}$.

(a)

As the doublets arise because of transitions from the upper two states to the ground state, the energy splitting of the upper two states will therefore be

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

$$= \left(6.63\times10^{-34}\times3\times10^{8}\right)\left(\frac{5.4}{764.5\times769.9\times10^{-9}}\right) \text{ J}$$

$$= 1.82\times10^{-21} \text{ J} = \frac{1.82\times10^{-21}}{1.6\times10^{-19}} \text{ eV}$$

$$= 1.14\times10^{-2} \text{ eV}.$$

(b)

The energy difference between the uppermost state and the ground state will be equal to the energy of the photon of wavelength 764.5 nm. It is

$$\frac{hc}{\lambda_1} = \frac{6.63\times10^{-34}\times3\times10^{8}}{764.5\times10^{-9}} \text{ J}$$

$$= 2.60\times10^{-19} \text{ J}$$

$$= \frac{2.60\times10^{-19}}{1.6\times10^{-19}} \text{ eV} = 1.63 \text{ eV}.$$