Problem 5.10 *The half life of radioactive cobalt-60 is* 5.26 yr.

(a) *Calculate its mean life and disintegration constant.*
(b) *What is the activity of* 1 gm *of* ^{60}Co*? Express this in curies and in rutherfords.*
(c) *What is the mass of a* 10-Ci *sample of cobalt-60?*

We are given that ^{60}Co has a half-life

$$t_{1/2}^{(^{60}\mathrm{Co})} = 5.26\,\mathrm{yr} \approx 5.26 \times 3.1 \times 10^{7}\,\mathrm{sec} \approx 1.6 \times 10^{8}\,\mathrm{sec}. \tag{5.53}$$

(a) It follows from the definitions that

$$\begin{aligned} \tau^{(^{60}\mathrm{Co})} &= \text{mean life} = \frac{t_{1/2}^{(^{60}\mathrm{Co})}}{\ln 2} \approx \frac{1.6 \times 10^{8}\,\mathrm{sec}}{0.693} \approx 2.3 \times 10^{8}\,\mathrm{sec}, \\ \lambda^{(^{60}\mathrm{Co})} &= \text{decay constant} = \frac{1}{\tau^{(^{60}\mathrm{Co})}} \approx \frac{1}{2.3 \times 10^{8}\,\mathrm{sec}} \\ &\approx 4.3 \times 10^{-9}/\mathrm{sec}. \end{aligned} \tag{5.54}$$

(b) One gram of ^{60}Co has

$$N_{^{60}\mathrm{Co}} \approx \frac{6 \times 10^{23}}{60} = 10^{22} \tag{5.55}$$

nuclei of ^{60}Co. The activity of 1 g of ^{60}Co is therefore

$$\begin{aligned} \mathcal{A}(0) &= \lambda^{(^{60}\mathrm{Co})} N_{^{60}\mathrm{Co}} \approx 4.3 \times 10^{-9}/\mathrm{sec} \times 10^{22}\,\mathrm{decays} \\ &= 4.3 \times 10^{13}\,\mathrm{decays/sec}. \end{aligned} \tag{5.56}$$

(c) The sample with 10 Ci activity has

$$10\,\mathrm{Ci} = 10 \times 3.7 \times 10^{10}\,\mathrm{decays/sec} = 3.7 \times 10^{11}\,\mathrm{decays/sec}. \tag{5.57}$$

Since the activity of 1 g of ^{60}Co is 4.3×10^{13} decays/sec, we conclude that the sample must have a mass

$$\frac{3.7 \times 10^{11}\,\mathrm{decays/sec}}{4.3 \times 10^{13}\,\mathrm{decays/sec/g}} \approx 0.86 \times 10^{-2}\,\mathrm{g} = 8.6\,\mathrm{mg}. \tag{5.58}$$