Chapter 7

1. \( H \text{ (rem)} = \text{rad} \times Q_\alpha \quad Q_\alpha = 20 \)

\[
H \text{ (mrem)} = 55 \text{ mrad} \times 20 = 1100 \text{ mrem} \times \frac{1 \text{ mSv}}{100 \text{ mrem}} = 11 \text{ mSv}
\]

2. Use Eq. 7.7:

\[
\text{Exposure (mR/h)} = \frac{6 \Lambda E n}{d^2}
\]

\[
337 \text{ mrad} = \frac{6 \Lambda (1.67 \text{ MeV}) (1)}{(3.28 \text{ ft})^2}
\]

\[
\Lambda = 362 \text{ mCi}
\]

3. \[
1 \text{ rad} = \frac{10^{-2} \text{ J}}{\text{kg}} \times \frac{1 \text{ eV}}{1.60219 \times 10^{-19} \text{ J}} = 6.24 \times 10^{16} \text{ eV}
\]

\[
6.24 \times 10^{16} \text{ eV} \times \frac{1 \text{ ion pair}}{35 \text{ eV}} = 1.78 \times 10^{15} \text{ ion pairs}
\]

4. \[
V = 12 \text{ ft} \times 12 \text{ ft} \times 8 \text{ ft} = 1152 \text{ ft}^3 \times \frac{(30.48 \text{ cm})^3}{(1 \text{ ft})^3} \times \frac{(1 \text{ m})^3}{(10^2 \text{ cm})^3} = 32.6 \text{ m}^3
\]

\[
32.6 \text{ m}^3 \times \frac{(10 \text{ dm})^3}{(1 \text{ m})^3} \times \frac{1 \text{ L}}{1 \text{ dm}^3} = 3.26 \times 10^4 \text{ L}
\]

\[
1.0 \text{ \mu Ci} \times \frac{10^6 \text{ pCi}}{1 \text{ \mu Ci}} = \frac{1 \times 10^6 \text{ pCi}}{3.26 \times 10^4 \text{ L}} = 30.7 \text{ pCi/L}
\]

\[
30.7 \text{ pCi/L} \times \frac{1 \text{ L}}{1 \text{ dm}^3} \times \frac{1000 \text{ dm}^3}{1 \text{ m}^3} \times \frac{1 \text{ Ci}}{10^{12} \text{ pCi}} \times \frac{3.7 \times 10^{10} \text{ Bq}}{1 \text{ Ci}} = 1130 \text{ Bq/m}^3
\]
Problem Solutions for
W. D. Ehmann and D. E. Vance, Radiochemistry and Nuclear Methods of Analysis
(Rev 0)

Chapter 7

5. Use Eq. 7.7:

\[ \text{Exposure (mR/hr)} = \frac{6AE}{d^2} \]

\[ A = A_0 e^{-\lambda t} \]
\[ \lambda_{Co} = \frac{0.693}{5.27 \text{ y}} = 0.132 \text{ y}^{-1} \]

\[ A = (5 \text{ Ci}) e^{-((0.137 \text{ y})^{-1})(15 \text{ y})} = 0.690 \text{ Ci} = 690 \text{ mCi} \]

\[ \frac{mR}{hr} = \frac{(6)(0.690 \text{ mCi})[(1.173 \text{ MeV})(1) + (1.332 \text{ MeV})(1)]}{(3 \text{ ft})^2} = 1.16 \frac{mR}{hr} \]

6. Use Eq. 7.8:

\[ \text{Dose rate, mrad/hr} = \frac{338,000 A}{d^2} \]

\[ \text{dose rate} = \frac{(338,000)(2.5 \text{ mCi})}{(75 \text{ cm})^2} = 150 \frac{\text{mrad}}{\text{hr}} \]

for β radiation, \( Q = 1 \), so 150 mrad/hr = 150 mrem/hr

\[ \frac{150 \text{ mrem}}{\text{hr}} \times 0.75 \text{ hr} = 113 \text{ mrem} \times \frac{1 \text{ mSv}}{100 \text{ mrem}} = 1.13 \text{ mSv} \]

7.

\[ \frac{1 \text{ esu}}{0.001293 \text{ g}} \times \frac{10^3 \text{ g}}{1 \text{ kg}} \times \frac{1.6 \times 10^{-19} \text{ C}}{4.8 \times 10^{-10} \text{ esu}} = 2.58 \times 10^{-4} \frac{\text{C}}{\text{kg}} \]

8. Literature

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Chapter 7

9. Heavy metals are often toxic even when not radioactive.

Alpha emitters are especially hazardous when ingested because of their high specific ionization - they do a great deal of biological damage.

10. $^{252}$Cf decays by alpha emission and spontaneous fission. Thus, the emitted radiation would include alpha particles, fission products, neutrons, and gamma rays.

The alpha particles and charged particles will be shielded by anything used for the neutrons and gamma rays because the range of heavy charged particles is very short.

Lower Z materials are best for n shielding (recall Eq. 6.27 from Chap 6). A polyethylene tank of water surrounding the source would be suitable.

Higher Z materials are needed for the gamma rays. A lead sheet surrounding the outer tank of water could be used.