Answers to Coursebook questions – Chapter I3

1 $D = \dfrac{E}{m} \Rightarrow E = mD = 70 \times 0.2 = 14\ \text{J}$.

2 $H = QD = Q\dfrac{E}{m} \Rightarrow E = \dfrac{Hm}{Q} = \dfrac{0.2 \times 70}{3} = 4.7\ \text{J}$.

3 **a** The dose equivalent would be larger for the alpha particles and so the damage done would be greater.

b Since the dose equivalent is the same the damage done is also the same.

4 In 3 hours the dose equivalent would be $3 \times 2 = 6\ \mu\text{Sv}$

and so the number of trips is $\dfrac{1\ \text{mSv}}{6\ \mu\text{Sv}} \approx 167 \approx 170$.

5 **a** The absorbed dose is 0.40 mGy since the quality factors for X-rays is 1.

b $D = \dfrac{E}{m} \Rightarrow E = mD = 0.75 \times 0.40 \times 10^{-3} = 0.30\ \text{mJ}$.

c The energy of one photon is 50 keV and so the number of photons is $\dfrac{0.30 \times 10^{-3}}{50 \times 10^{3} \times 1.6 \times 10^{-19}} = 3.75 \times 10^{10}$.

6 Since the time of 30 min is short compared to the half-life, we may assume that the activity during this interval of time remains constant at $8.0 \times 10^{4}\ \text{Bq}$.
The energy released is then $8.0 \times 10^{4} \times 3.5 \times 10^{6} \times 1.6 \times 10^{-19} \times 30 \times 60 = 8.06 \times 10^{-5}\ \text{J}$.

The mass of the tumour is $m = \rho V = 1.3 \times 10^{3} \times \dfrac{4\pi \times (1.0 \times 10^{-2})^{3}}{3} = 0.00545\ \text{kg}$.

The absorbed dose is $D = \dfrac{8.06 \times 10^{-5}}{0.00545} = 0.0148 \approx 15\ \text{mGy}$.
The quality factor is 1, so the dose equivalent is 15 mSv.
The quality factor for gamma rays is also 1, so the answer would not change.

7 The energy released is $0.03 \times 3.0 \times 10^{12} \times 2.7 \times 10^{6} \times 1.6 \times 10^{-19} \times 5.0 = 0.194\ \text{J}$.

The absorbed dose is $D = \dfrac{0.194}{70} = 0.00277 \approx 2.8\ \text{mGy}$.
The quality factor is 1, so the dose equivalent is 2.8 mSv.

8 **a** The intensity is

$$\frac{1.5\times10^{9}\times1.4\times10^{6}\times1.6\times10^{-19}}{4\pi\times5^{2}}=1.069\times10^{-6}\approx1.1\times10^{-6}\text{ W m}^{-2}.$$

b The absorbed energy by the exposed area is $\frac{1}{4}\times0.09\times1.069\times10^{-6}\approx2.4\times10^{-8}\text{ J}$.

c The absorbed dose is $\frac{2.4\times10^{-8}\times2\times60\times60}{70}=2.47\times10^{-6}\approx2.5\ \mu\text{Gy}$.

d The quality factor is 1, so the dose equivalent is $2.5\ \mu\text{Sv}$.

9 In therapy the radioisotopes must remain active for a long time in order to destroy tumours etc. in the body, and so a long half-life is required. In the case of diagnosis the radioisotope must remain in the body for as short a time as possible in order not to do damage to healthy organs.