Answers to Coursebook questions – Chapter I2

1 **a** For the top curve the HVT is 6.0 mm and for the other it is about 4.0 mm.

b The larger energy corresponds to the curve with the longer HVT.

2 **a** The HVT is about 5.0 mm and so the liner attenuation coefficient is about $\frac{\ln 2}{5.0} = 0.139 \approx 0.14\ \text{mm}^{-1}$.

b The transmitted intensity must be 20% of the incident, and from the graph this corresponds to a length of about 11.5 mm.

3 $0.60 = e^{-\mu \times 4}$ and so $\mu = -\frac{1}{4}\ln 0.6 = 0.128\ \text{mm}^{-1}$.

Then, $0.20 = e^{-\mu x}$ and so $x = -\frac{1}{\mu}\ln 0.2 = -\frac{1}{0.128}\ln 0.2 = 12.6 \approx 13\ \text{mm}$.

4 $\mu = \frac{1}{3}\ln 2 = 0.231\ \text{mm}^{-1}$ and so $I = I_0 e^{-0.231\times 1} = 0.794 I_0 \approx 0.8 I_0$.

5 It means that as the beam moves through the metal the proportion of the total energy of the X-rays carried by high energy photons increases. This is because the low energy photons get absorbed, leaving only the high energy photons to move through.

For the 20 keV photons the transmitted intensity is $I_{20} = I_0 e^{-\frac{\ln 2}{2.2}\times 5} = 0.207 I_0$.

For the 25 keV photons it is $I_{25} = I_0 e^{-\frac{\ln 2}{2.8}\times 5} = 0.290 I_0$. Hence $\frac{I_{25}}{I_{20}} = \frac{0.290 I_0}{0.207 I_0} = 1.4$.

6 **a** Assuming radiation in all directions equally, the intensity will increase by a factor of $\left(\frac{20}{10}\right)^2 = 4$, i.e. will become $4 \times 0.28 = 1.12\ \text{kW m}^{-2}$.

b The foil will reduce the intensity by a factor of $e^{-\frac{\ln 2}{2.0}\times 3} = 0.354$.
So at 10 cm the intensity will be $0.354 \times 1.12 = 0.396 \approx 0.40\ \text{kW m}^{-2}$.

7 After 6 h the activity would be reduced to $3.6 \times 10^3 \times e^{-\frac{\ln 2}{14}\times 6} = 2675\ \text{Bq}$ due to radioactive decay. But the activity in the 10 cm^3 sample is 5.0 Bq, and this has to do with the fact that the radioactive isotope has been mixed in with a large volume of blood. Thus $\frac{5.0}{2675} = \frac{10}{V+10} \approx \frac{10}{V} \Rightarrow V = 5350\ \text{cm}^3$.

8 The wavelength of this ultrasound is $\lambda = \frac{v}{f} = \frac{1540}{5\times10^{6}} = 3.1\times10^{-4}\ \text{m} = 0.3\ \text{mm}$.

The order of magnitude of the size that can be resolved is of the order of the wavelength, and so about 0.3 mm.

