2. A portion of the body receives 0.15 mGy from radiation with a quality factor Q=6 and 0.22 mGy from radiation with Q=10.

(a) What is the total dose?

\[ D = (0.15 + 0.22) \text{ mGy} = 0.37 \text{ mGy} \]

(b) What is the total dose equivalent?

\[ H = (0.15 \times 6 + 0.22 \times 10) \text{ mSv} = 3.1 \text{ mSv} \]

8. A free-air ionization chamber is to be constructed so that saturation current of \(10^{14}\) A is produced when the exposure rate is 10 mRh\(^{-1}\). The temperature is 20°C, and the pressure is 750 torr.

(a) Calculate the size of the sensitive volume needed.

\[
\rho = (0.00129)(273/293)(750/760) \text{ g cm}^{-3} = 1.186 \times 10^{-3} \text{ g cm}^{-3}
\]

\[ V = I \times E \times 10^{-14} \times 3600 / 0.01 / 2.58 / 10^{-7} / 1.186 / 10^{-3} \text{ cm}^3 \]

\[ = 11.73 \text{ cm}^3 \]

(b) What would be the current in this chamber if it were exposed to 20 mRh\(^{-1}\) at a temperature of 30°C, and the pressure is 750 torr.

\[
\rho = (0.00129)(273/303)(750/760) \text{ g cm}^{-3} = 1.147 \times 10^{-3} \text{ g cm}^{-3}
\]

\[ I = V \times E \times \rho = 11.73 \times 0.02 \times 2.58 \times 10^{-7} / 3600 \times 1.147 \times 10^{-3} \text{ A} = 1.93 \times 10^{-14} \text{ A} \]

14. A pocket air-well ionization chamber has a volume of 6.2 cm\(^3\) and a capacitance of 8.0 pF. Assume STP conditions.

(a) If the instrument is to register a range of exposure up to a maximum of 1.0 R, what must the charging voltage be?

\[ M = 0.00129 \times 6.2 \text{ g} = 7.998 \times 10^{-3} \text{ g} \]

\[ Q = C \text{ dV} = 8 \times 10^{-12} \text{ dV} \]

\[ \text{dE} = 2.58 \times 10^{-7} \text{ C g}^{-1} = Q / M = 8 \times 10^{-12} \text{ dV} / 7.998 / 10^{-3} \text{ C g}^{-1} \]

\[ \text{dV} = 258 \text{ V} \]

(b) If everything else remained the same, what would the range of the instrument be if the capacitance were doubled?
Range of exposure would double.

(c) With everything else the same as in (a), what would the range be if the volume were doubled?

Range of exposure would be halved.

16. What minimum wall thickness of carbon is needed to satisfy the Bragg-Gray principle if the chamber pictured in Fig.12.4 is to be used to measure absorbed dose from photons with energies up to 5 MeV? (Assume same mass stopping powers for carbon and water and use numerical data given in Chapter 6.)

Maximum KE for scattered electron would be 5 MeV. The range in water for 5MeV electron could be approximately estimated from table 6.1 to be $2gcm^{-2}$

Density of carbon $2.267 g cm^{-3}$.

Thickness is $R/\rho = 2/2.267 = 0.88cm$

24. A C-CO$_2$ chamber like that in Fig.12.4 is calibrated to read directly in mGyh$^{-1}$ for 1-MeV photons. The chamber satisfies the Bragg-Gray principle for neutrons as well as gamma rays.

(a) The chamber is exposed to 1-MeV neutrons and gives a reading of 22 mGyh$^{-1}$. What is the neutron dose rate for soft tissue?

$$D_{n1} = D_n*P(E) = D_n*0.149 = 22 \text{ mGyh}^{-1}$$

$$D_n = 147.65 \text{ mGyh}^{-1}$$

(b) A 1-MeV gamma source is added, and the reading is increased to 84 mGyh$^{-1}$. What is the gamma dose rate to tissue?

$$D_{\gamma 2} = 84-22 \text{ mGyh}^{-1} = 62 \text{ mGyh}^{-1}$$

(c) What would a tissue-equivalent chamber read in part (b) when exposed to both the neutrons and gamma rays together?

$$D_{n2} + D_{\gamma 2} = (147.65 + 62) \text{ mGyh}^{-1} = 209.65 \text{ mGyh}^{-1}$$

31. Tritium often gets into body water following an exposure and quickly becomes distributed uniformly throughout the body. What uniform concentration of $^3$H, in Bqg-1, would give a dose-equivalent rate of 1 mSvwk-1?

$$D = 1.60*10^{-10} \text{ A E Gys}^{-1}$$

$$1/7/24/60/60 * 10^{-3} \text{ Sv s}^{-1} = 1.60 * 10^{-10} \text{ A} * 5.7*10^{-3} \text{ Gy s}^{-1}$$

$$A = 1813 \text{ Bqg}^{-1}$$
(could also use one third of the max energy to approximate average energy)

34. A soft-tissue disc with a radius of 0.5 cm and thickness of 1 mm is irradiated normally on its flat surface by a 6-μA beam of 100-MeV protons. Calculate the average dose rate in the sample.

Proton flux rate = \( N = \frac{6 \times 10^{-6}}{1.6 \times 10^{-19}} \text{ s}^{-1} / \pi (0.25) \text{cm}^2 \)

Total stopping power of tissue for 100 MeV proton \((-dE/\rho \text{ dx})\) = 7.409 MeV cm\(^2\)/g

Average dose rate = \( D = N A(-dE/\rho \text{ dx})x / \rho Ax \)

\[ = N (-dE/\rho \text{ dx}) \]
\[ = 3.75 \times 10^{13} \text{ s}^{-1}/\pi(0.25)\text{cm}^2 \times 7.409 \text{ MeV cm}^2/\text{g} \times 10^3 \text{ g/kg} \times 1.6 \times 10^{-13} \text{ J/MeV} \]
\[ = 56600 \text{ Gy/s} \]