Physics in Modern Medicine **Winter 2025**

Chapter 7 – Radiation Therapy and Radiation Safety in Medicine

Questions

Q7.2 To judge the severity you would need to know the exposure time and the RBE of the radiation used.

Q7.3 The thin metal filters could be designed to stop low energy particles while allowing high-energy particles to be passed and measured. The thickness of the filters is determined by the energy of the particle that you need to filter. You could use filters of different thicknesses to determine the energy of the incident particles and their numbers

Q7.5 Electrons and photons are primarily used in cancer treatment because they can damage the DNA of cancer cells both directly and indirectly. This prevents the cancer cells from growing and dividing. We can also target tumors and deliver large doses with precision and this minimizes damage to surrounding healthy tissues

Protons have an advantage for cancer treatments because they deposit their energy at the end of their travel, where their velocity goes to zero. This is called the Bragg peak. There is minimal dose to tissues along the proton path and there is no dose after the proton is brought to rest. WE can control the depth of the protons in the tissues with great precision and this gives us better tumor control and treatment.

Q7.7 CT scanners are used for anatomy and certainly PET and SPECT scans cannot. MRI certainly can give anatomy, but it cannot measure exposure. CT scanners can be used in-situ during a treatment, whereas PET, SPECT and MRI cannot.

Problem

P7.1 We want some fraction of the initial source activity ΦA_0 to be deposited in the body. This activity is related to the decay constant of the reaction and to the number of nuclei, or $\Phi A_0 = \lambda N \rightarrow N = \frac{\Phi A_0}{\lambda}$. Each radioactive decay produces $80.3 keV$, as a worst-case scenario, so the total energy that's deposited will be $E_{total} = NE_{x-ray}$. The dose to the patient

$$D = \frac{E_{total}}{m} = \frac{NE_{x-ray}}{m} = \frac{\Phi A_0}{\lambda m} E_{x-ray} = \frac{0.8 \times 1 \times 10^6 Bq}{\frac{\ln 2}{72hr \times \frac{3600s}{1hr}} \times 60kg} \times 80.3 \times 10^3 eV \times \frac{1.6 \times 10^{-19} J}{1eV}$$

$$D = 6.4 \times 10^{-5} Gy = 0.06 mGy$$

P7.2 The source activity (per unit body mass of $70kg$) of potassim-40 is given as $\frac{4630Bq}{70kg} = 66\frac{Bq}{kg}$. Here, we don't have to worry about the half-life of the isotope since the body's supply is reasonably constantly and is continually being refreshed from the environment. For an annual dose, the exposure time, $t = 1yr = 31.5 \times 10^6 s$ and the energy released in every radioactive decay is given by the energy of the beta particles. $E = 0.39MeV = 0.39 \times 10^6 eV \times \frac{1.6\times10^{-19}J}{1eV} = 6.24 \times 10^{-14}J$. The dose is then:

$$D = \frac{E_{total}}{m} = 66\frac{Bq}{kg} \times 6.24 \times 10^{-14}J \times 31.5 \times 10^6 s = 1.3 \times 10^{-4}Gy$$
$$D = 0.13mGy$$

This is about one-third of the total annual dose from all internally deposited radioisotopes.