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Master of Science EPF-ETH degree in Nuclear Engineering
RPRA : Radiation protection and radiation applications

Basics of radiation physics
Chapter 4.
Dosimetry and radiation measurements

2nd October 2017
Exercises
Exercise: absorbed dose

What is the increase of temperature when 3.2 liters of water receive an absorbed dose of 1 Gy?
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**Solution**

\[
\Delta E = D \cdot m = 1 \text{ Gy} \cdot 3.2 \text{ kg} = 3.2 \text{ J}
\]

\[
\Delta E = c \cdot m \cdot \Delta T
\]

\[
\rightarrow \Delta T = \frac{3.2 \text{ J}/3.2 \text{ kg}}{4.185 \text{ kJ K}^{-1} \text{ kg}^{-1}} = 0.2 \text{ mK}
\]
Exercise: cell ionisation

Estimate the number of ionisations in a cell (diameter 10 μm) for a proton of 1 MeV. Assume a necessary ionisation energy of 30 eV.
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Solution

- The stopping power of a 1 MeV proton in water is roughly 200 MeV cm$^{-2}$ g$^{-1}$ (see lecture notes of 1$^{st}$ class).
- We assume a cellular density of 1 g cm$^{-3}$ (equivalent to water).
- The LET is therefore: $S/\rho \cdot \rho = 200$ MeV cm$^{-1}$
- The energy release per cell: $S \cdot d = 200$ MeV cm$^{-1} \cdot 10$ μm = 200 keV

→ 6667 ionisations per cell
Exercise: Equivalent dose

Compute the equivalent dose of a simultaneous irradiation with alphas and betas for the absorbed doses of \( D_\alpha = 1.4 \text{ mGy} \) and \( D_\beta = 10.1 \text{ mGy} \).
Solution: Equivalent dose

Compute the equivalent dose of a simultaneous irradiation with alphas and betas for the absorbed doses of $D_\alpha = 1.4 \text{ mGy}$ and $D_\beta = 10.1 \text{ mGy}$.

**Solution**

$$H = \sum_R w_R D_R = w_\alpha D_\alpha + w_\beta D_\beta$$

$$= (20 \cdot 1.4 + 1 \cdot 10.1) \text{ mSv} = 38.1 \text{ mSv}$$
Exercise: ionisation chamber

The average deposited energy in air is 34 eV per ionisation. Compute the charge that is produced in an ionisation chamber by an electron of 10 keV.
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**Solution**

\[
10'000 \text{ eV} / 34 \text{ eV} = 294 \text{ ionisations}
\]
Exercise: charge creation

In the case of a semiconductor, the average deposited energy 3.5 eV per ionisation. Compute the charge that is produced in an ionisation chamber by an electron of 10 keV and compare the result with the exercise above.
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In the case of a semiconductor, the average deposited energy 3.5 eV per ionisation. Compute the charge that is produced in an ionisation chamber by an electron of 10 keV and compare the result with the exercise above.

Solution

10'000 eV / 3.5 eV = 2857 ionisations

• We are able to measure much lower doses or dose rates with a semiconductor detector (active dosemeter or HPGe)

• Saturation at higher (doses and) dose rates