PHYC10007 Physics for Biomedicine
Tutorial Sheet 12 — *Radiation*

Last updated: 24/12/2019

1. A typical human body of mass 70 kg contains a total of 15 kg Carbon.

(a) Given the isotopic fraction of ^{14}C is 1.3x10^{-12}, calculate the number of ^{14}C nuclei present in 15 kg of carbon.

(b) ^{14}C undergoes radioactive decay via beta decay. In the following show the number of protons and nucleons for the nucleus after decay.

$$^{14}_{6}C \rightarrow ^{A}_{Z}N + e^{-} + \bar{\nu}_e$$

(c) The half-life of ^{14}C is 5730 years. Calculate the number of ^{14}C nuclei that decay each second in the 70 kg body.

(d) On average each nuclear decay of ^{14}C deposits 0.05 MeV of ionizing energy within the body. What is the total ionizing energy absorbed by the body per year? Calculate your answer in Joules.

(e) What is the average dose in milli-Sieverts per year from ^{14}C within the 70 kg body?

2. Sarah is a molecular biologist, using ^{32}P as a radioactive label for her experiments. ^{32}P has a 14-day half-life. Sarah uses Perspex (clear acrylic plastic) as a radiation shield. The half-thickness is 6.7 mm; that is, 6.7 mm thick Perspex reduces the radiation intensity by 50%.

(a) Which one or more of the following will halve Sarah's dose rate?

A. Halving the initial quantity of radioactive material
B. Storing the ^{32}P for 7 days before using it
C. Doubling the thickness of Perspex
D. Doubling her typical working distance from the radioactive material
E. None of the above.

(b) Which one of the following is true?

i. The weight of the ^{32}P source will be halved after 14 days
ii. After 28 days, the activity will be reduced to half the initial value
iii. The source will be completely depleted after 28 days
iv. The activity will be reduced by 25% after 14 days
v. None of the above

(c) Write the equation for radioactive decay of ^{32}P.

(d) Given the ^{32}P half-life, calculate how long will it take for a sample to decay to 1/*e* of its initial activity.

(e) Calculate the activity in standard SI units, for a sample containing 1.0×10^{15} nuclei of ^{32}P.

(f) Sarah also uses ^{125}I, which has a half-life of 60 days. Which one or more of the following are correct?

A. Relative to its initial activity, after 30 days the ^{125}I activity will be reduced by a quarter.
B. The weight of the sample containing ^{125}I will be halved in 60 days.
C. If the ^{125}I activity is measured to be 30,000 decays per second now, then in 54 days it will be 27,000 per second.
D. If the activity is measured to be 30,000 decays per second for both ^{32}P and ^{125}I, they must have the same number of radioactive atoms.
E. If the activity is measured to be 30,000 decays per second for both ^{32}P and ^{125}I, the ^{125}I sample must be heavier.

1. (a) 9.8×10^{14} ; (b) $^{14}_{7}N$; (c) $3.8 \times 10^{3}\,s$; (d) 0.94mJ; (e) 0.013mSv

2. (a) A; (b) v; (d) 20 days; (e) $5.7 \times 10^{8}\,Bq$; (f) E.