Concepts of Physics: Homework 11

Due: 7 December 2022

1 Atomic isotopes

Determine how many protons and neutrons there are in each of the following isotopes. Explain your answer.

a) Calcium-46: $^{46}_{20}\mathsf{Ca}$

b) Calcium-42: $^{42}_{20}\mathsf{Ca}$

c) Argon-40: $^{40}_{18}\mathsf{Ar}$

2 Atomic isotopes

Consider the three isotopes: Zinc-64 ($^{64}_{30}\mathsf{Zn}$), Copper-63 ($^{63}_{29}\mathsf{Cu}$), Copper-65 ($^{65}_{29}\mathsf{Cu}$).

a) Which have the same number of neutrons?

b) Which have the same number of protons?

3 Alpha decay

The following nuclear isotopes decay via alpha decay. Determine the daughter nuclei.

a) Radon-222: $^{222}_{86}\mathsf{Rn}$

b) Iodine-108: $^{108}_{53}\mathsf{I}$

4 Beta decay

The following nuclear isotopes decay via beta decay. Determine the daughter nuclei.

a) Iodine-131: $^{131}_{53}\mathsf{I}$. This is a common byproduct of nuclear fission reactions and occurs in nuclear fallout as a result of nuclear weapons tests or nuclear power plant accidents. Since Iodine is easily absorbed by humans via consumption of food that contains Iodine, this byproduct is one of the major health hazards associated with one of these nuclear events. In controlled doses, however, it is useful in certain medical procedures.

b) Strontium-90: $^{90}_{38}\mathsf{Sr}$. This is also a common byproduct of nuclear fusion reactions. It has a similar chemistry to Calcium and is absorbed by the human body and some will be fixed in bones and this presents a health hazard. It is also used as the "fuel" in the electricity generators on some satellites.

5 Half-life of an imaginary atom

Imagine an element that has a half-life of 3 years. At an initial instant a sample contains 16 g.

a) How long will it take before there is only 8 g of the sample remaining?
b) How much of the sample will remain after 6 years?
c) How much of the sample will remain after 9 years?
d) How long will it take for the sample to reduce to 1/8 of it's original quantity?

Explain your answers.

6 Cesium-137 decay

Cesium-137 is a radioactive isotope that decays via beta decay. It has a half-life of 30.17 years. This exists in the waste from nuclear power plants.

a) If a waste pile contained 40 kg of Cesium-137 at one moment, how much would it contain three half-lives later?
b) If a waste pile contained 40 kg of Cesium-137 at one moment, how long would it take for the pile to only contain 5 kg?

7 Nuclear reaction byproducts

Iodine-131 and Strontium-90 are both byproducts of the nuclear reactions that occur in nuclear power plants. Iodine-131 has a half life 8.02 days of while Strontium-90 has a half-life of 28.79 years. Both of these were produced in the Fukushima nuclear power plant accident that occurred in Japan in March 2011. Both were released in the disaster although some preventive measures contained most of the strontium.

a) Roughly how long did it take for the Iodine-131 to decay to the point where only one eighth of the initial amount remained? Explain your answer.
b) After a year would even as much as 1% of the initial Iodine-131 remain? Explain your answer.
c) Ignoring containment measures and the total amounts of these released at the time of the accident, which of these two isotopes would be more prevalent today? Explain your answer.

8 Hobson, *Physics, Concepts and Connections, 5ed*, Ch. 14 Conceptual Exercise 32, page 346. Explain your answer.

9 Hobson, *Physics, Concepts and Connections, 5ed*, Ch. 14 Conceptual Exercise 36, page 346. Explain your answer.

10 Hobson, *Physics, Concepts and Connections, 5ed*, Ch. 14 Problem 4, page 346. Explain your answer.