Exercise 2.7
Kinetics of Nuclear Reactions

1. ^{210}Po is an alpha emitter with a decay constant of 0.00501 d^{-1}.

(a) Write a balanced equation for the reaction in which ^{210}Po undergoes alpha decay.

(b) Calculate the half-life of ^{210}Po.

(c) Calculate the radioactivity of a 1.00 g sample of ^{210}Po.
$M_{Po\text{-}210}$ = 209.982 874 g/mol

(d) Calculate the radioactivity of the sample from part (c) of this question after 365 days have passed. *(The product of the alpha decay of ^{210}Po is stable, so you can assume that all radioactivity is due to ^{210}Po.)*

2. ^{99m}Tc is used as a tracer in diagnostic imaging because it emits gamma radiation with a similar energy to X rays. It is attached to a compound which transports it to the appropriate part of the body (brain, lungs, kidney, liver, etc.) then a detector generates an image based on the radiation released.

The "m" in ^{99m}Tc stands for "metastable". This means that this is not the most stable arrangement of protons and neutrons possible for ^{99}Tc. In fact, ^{99}Tc is the product generated when ^{99m}Tc decays, emitting gamma rays. As a result, ^{99m}Tc is relatively short-lived and must be generated as-needed from ^{99}Mo (which is, in turn, generated from ^{235}U).

(a) Write a balanced equation for the reaction in which ^{99}Mo decays to ^{99m}Tc.

(b) Write a balanced equation for the reaction in which ^{99m}Tc decays to ^{99}Tc.

(c) The half-life of ^{99}Mo is 2.75 days. The half-life of ^{99m}Tc is 6.01 hours. The half-life of ^{99}Tc is 2.11×10^5 years.

i. Calculate the decay constant for each of these three nuclides.

ii. Which of these three nuclides is the most stable?

iii. Suggest one advantage of using a nuclide with a relatively short half-life in nuclear medicine.

(d) If a patient is injected with 1 000 MBq ^{99m}Tc for a bone scan, how long will it take for the radiation emitted by ^{99m}Tc to drop to 1 MBq?

This calculation does not account for any biological clearing of ^{99m}Tc.