Week 6 Worksheet

Chem 11300-2: Section 33

May 3, 2022

Problem 1: U-238 is an unstable nuclide that undergoes the following series of decays to become more stable: $\alpha, \beta, \beta, \alpha, \alpha$. Fill in the daughter isotope for each step along the sequence:

Main decay sequence: $^{238}\text{U} \longrightarrow \qquad \longrightarrow \qquad \longrightarrow \qquad \longrightarrow \qquad \longrightarrow$

Other decay products: $\qquad +^{4}_{2}\alpha \qquad +^{0}_{-1}\beta \qquad +^{0}_{-1}\beta \qquad +^{4}_{2}\alpha \qquad +^{4}_{2}\alpha$

Problem 2: Write a nuclear equation for the indicated decay of each nuclide:

a) Alpha decay of Ac-227

b) Beta decay of Pb-214

c) Gamma decay of Co-51

d) Positron emission by F-19

e) Electron capture by Cr-63

Problem 3: Imagine that a stable atom of $^{296}_{117}\text{Q}$ were discovered. Write a balanced nuclear chemical reaction for one reasonable way that this specific nuclide of Q could be formed from an element that already exists on the periodic table.

Problem 4: Write a balanced nuclear reactions that represents the most likely first *natural* decay pathway for each of the following nuclides:

a) The A= 22 isotope of the element in period 2 that requires the highest ionization energy.

b) Radon-222

c) A nuclide of the 2nd largest alkaline earth metal that contains 76 neutrons.

The following problems are written by Professor Mcleod or Head TA Miah Turke. They may mimic homework problems closely, but will be highly beneficial for the midterms and final.

Problem 5: Radon-222 is unstable, decaying by the following sequence of emissions: $\alpha, \alpha, \beta, \beta, \alpha, \beta, \beta, \alpha$. Write the sequence of nuclear reactions leading to the final product nucleus, which is stable.

Problem 6: Uranium-231 undergoes positron emission.

a) Write the balanced nuclear reaction.

b) Is the process spontaneous? How do you know?

c) How much energy in MeV does this process either release or require?

Problem 7: A sample of wood from a Thracian chariot was found in an excavation in Bulgaria. It has a carbon-14 activity of 11.2 disintegrations per minute per gram.

a) Carbon-14 is produced continuously in the atmosphere when cosmic rays of very high energy cause nuclear reactions to produce neutrons. These neutrons can collide with nitrogen-14 to yield carbon-14 and hydrogen. Write the balanced nuclear reaction for this process.

b) Organisms get carbon-14 from the atmosphere while simultaneously losing is through β decay. This equilibrium leads to a fairly constant amount of carbon-14 in living organisms and hence a fairly-constant carbon-14 activity. When a plant or animal dies, the exchange of carbon with the atmosphere stops, and the activity of carbon-14 decreases as β decay of carbon-14 continues. Write the balanced nuclear reaction for the β decay of carbon-14.

c) If the activity of carbon-14 in living materials is 15.3 disintegrations per minute per gram and the half-life of carbon-14 is 5.73×10^3 years, estimate the age of the chariot.

d) What year was the chariot made?