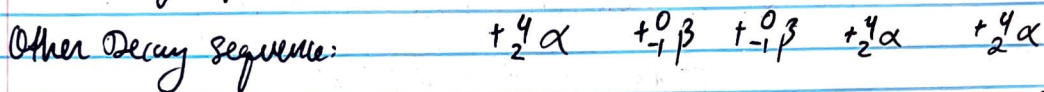
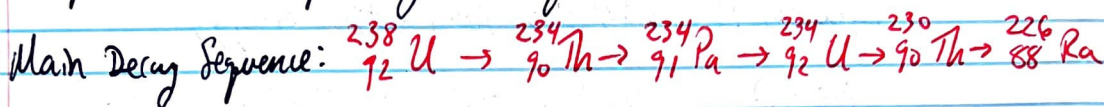


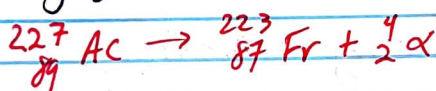
Week 6 Discussion Answers.

- 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:



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

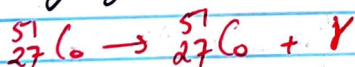
a) Alpha decay of Ac-227



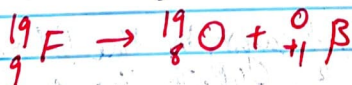
b) Beta decay of Pb-214



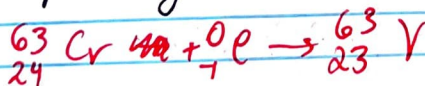
c) Gamma decay of Co-51



d) Positron emission by F-19



e) Electron Capture by Cr-63



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

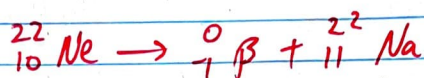
This question was written in 2015, so there might be a lot of answers. The following is reasonable:



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

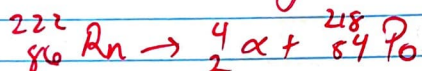
a) The $A=22$ isotope of the element in period 2 that requires the highest ionization energy.

Ne-22 is neutron rich. So β -decay:



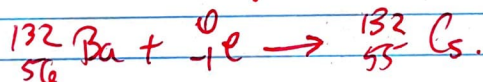
b) Radon-222

Rn-222 is heavy $\Rightarrow \alpha$ -decay



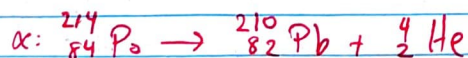
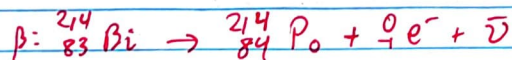
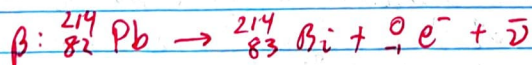
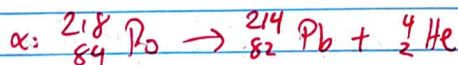
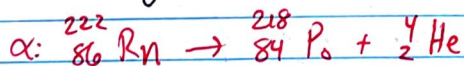
c) A nuclide of the 2nd largest alkaline earth metal that contains 70 neutrons.

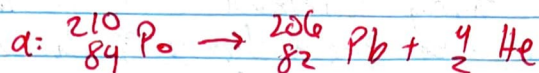
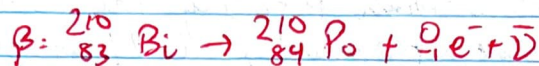
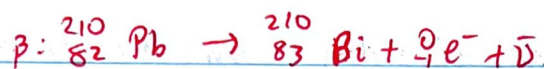
Ba-132 is neutron poor. So e^- capture.



Note: positron emission is NOT a natural form of decay.

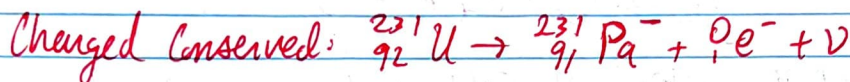
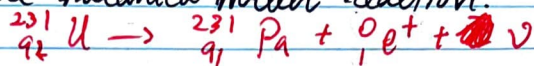
5) Radon-222 is unstable, decaying by the following sequence of emissions: $\alpha, \alpha, \beta, \beta, \alpha, \beta, \beta, \alpha$. Write the sequence of nuclear reactions leading to the final product nuclide, which is stable.





6) Uranium-231 undergoes positron emission.

a) Write the balanced nuclear reaction.



b) Is this process spontaneous? How do you know.

$$\Delta m = (m({}^{231}_{91}\text{Pa}) + 2m({}^0_{+1}e^+)) - m({}^{231}_{92}\text{U})$$

$$= 231.035879 \text{ u} + 2(0.0005485799 \text{ u}) - 231.036289 \text{ u}$$

$$\Delta m = 0.0006872 \text{ u} > 0$$

So NOT spontaneous since $\Delta m > 0$.

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

$$\Delta E = c^2 \Delta m$$

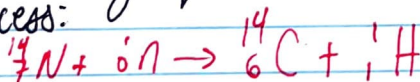
$$= (6.872 \times 10^{-4} \text{ u}) \left(931.494 \frac{\text{MeV}}{\text{u}} \right)$$

$$= 0.6401 \text{ MeV}$$

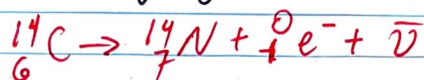
Requires 0.6401 MeV

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 + hydrogen. Write the balanced nuclear reaction for this process:



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



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

$$A = A_i e^{-kt} \quad \frac{A}{A_i} = e^{-kt} \Rightarrow t = -\frac{1}{k} \ln\left(\frac{A}{A_i}\right)$$

$$k = \frac{\ln 2}{t_{1/2}} \Rightarrow k = \frac{\ln 2}{5.73 \times 10^3 \text{ y}} = 1.21 \times 10^{-4} \text{ year}^{-1}$$

$$t = -\frac{1}{1.21 \times 10^{-4} \text{ year}^{-1}} \ln\left(\frac{11.2}{15.3}\right) = 2.579 \times 10^3 \text{ years}$$

$$= \boxed{2579 \text{ years}}$$

- d) What year was the chariot made?

$$2022 - 2579 = -557$$

year 0 didn't happen
 $-557 - 1 = -558$

$$\Rightarrow \boxed{558 \text{ BC or BCE}}$$