

Classroom Activity Chapter 19 Number 1

10 April 2017

1. Complete and balance the following nuclear equations:

1a. $^{126}_{50}\text{Sn} \rightarrow ^0_{-1}\text{e} +$	$^{126}_{51}\text{Sb}$
1b. $^{210}_{88}\text{Ra} \rightarrow ^4_2\alpha +$	$^{206}_{86}\text{Rn}$
1c. $^{77}_{37}\text{Rb} \rightarrow ^0_1\text{e} +$	$^{77}_{36}\text{Kr}$
1d. $^{76}_{36}\text{Kr} \rightarrow ^0_{-1}\text{e} +$	$^{76}_{37}\text{Rb}$
1e. rhenium-160 \rightarrow alpha particle +	$^{156}_{73}\text{Ta}$
1f. erbium-159 \rightarrow positron +	$^{159}_{67}\text{Ho}$
1g. beta emission of $^{157}_{63}\text{Eu}$	$\rightarrow ^0_{-1}\beta + ^{157}_{64}\text{Gd}$
1h. electron capture of $^{126}_{56}\text{Ba}$	$+ ^0_{-1}\text{e} \rightarrow ^{126}_{55}\text{Cs}$
1i. alpha emission of $^{146}_{62}\text{Sm}$	$\rightarrow ^4_2\alpha + ^{142}_{60}\text{Nd}$
1j. positron emission of $^{125}_{56}\text{Ba}$	$\rightarrow ^0_{+1}\beta + ^{125}_{55}\text{Cs}$

2. Complete and balance the following nuclear equations:

2a. $^{24}_{11}\text{Na} \rightarrow ^{24}_{12}\text{Mg} +$	$^0_{-1}\beta$
2b. $^{218}_{85}\text{At} \rightarrow ^{214}_{83}\text{Bi} +$	$^4_2\alpha$
2c. $^{135}_{60}\text{Nd} \rightarrow ^{135}_{59}\text{Pr} +$	$^0_{+1}\beta$
2d. uranium-239 \rightarrow neptunium-239 +	$^0_{-1}\beta$

3. ^{226}Ac can decay by three different nuclear processes, α -emission, β -emission, and electron capture. Write a balanced equation for each of these processes for ^{226}Ac .

$^{226}_{89}\text{Ac} \rightarrow ^4_2\alpha + ^{222}_{87}\text{Fr}$
$^{226}_{89}\text{Ac} \rightarrow ^0_{-1}\beta + ^{226}_{90}\text{Th}$
$^{226}_{89}\text{Ac} + ^0_{-1}\text{e} \rightarrow ^{226}_{88}\text{Ra}$

4. Of the two isotopes of iodine, ^{136}I and ^{122}I , one decays by beta emission and one by positron emission. Which does which?

^{136}I has too many electrons and decays by β -decay
 ^{122}I positron

5. Radon-222 decays by a series of three α -emissions and two β -emissions. What is the final stable nucleus?

$^{222}_{86}\text{Rn} \rightarrow 3 ^4_2\alpha + 2 ^0_{-1}\beta + ^{210}_{82}\text{Pb}$

Questions in final exam format:

6. Which of the following statements about positrons is false?

- T A. The positron has same mass as an electron. T
- T B. A positron is ejected from the nucleus during the conversion of a proton into a neutron. $p \rightarrow n + e^+$
- T C. A positron is a positive electron.
- F D. When positron emission occurs, the atomic number of the nucleus increases.

7. Which of the following statements about electron capture is false?

- A. The electron is used to convert a proton to a neutron.
- B. The electron involved is most likely an outer shell valence electron.
- C. In electron capture decay, the atomic number decreases by one.
- D. In electron capture decay, the mass number remains unchanged.

8. Which process **decreases** the neutron/proton ratio?

- A. alpha emission
- B. beta emission
- C. electron capture
- D. positron emission

Classroom Activity Chapter 19 Number 2

12 April 2017

1. The half-life of plutonium-239 is 24,000 years.

1a. What is the decay constant (rate constant)?

$$k = \frac{.693}{24000} = 2.9 \times 10^{-5} \text{ yr}^{-1}$$

1b. What fraction of a sample of Pu-239 remains after 1000 years?

$$\ln\left(\frac{N_0}{N_t}\right) = 2.9 \times 10^{-5} \text{ yr}^{-1} \times 1000 \text{ yr}$$

$$\frac{N_0}{N_t} = 1.029 \quad \frac{N_t}{N_0} = 0.97$$

2. What fraction of a sample of a radioactive isotope remains after 3 half lives? After 10 half lives?

$$\frac{1}{2^3} = 0.125 \quad \frac{1}{2^{10}} = 9.8 \times 10^{-4}$$

3. The age of igneous rock that has solidified from magma can be analyzed by the amount of ^{40}K and ^{40}Ar it contains. No ^{40}Ar would be present in the initial rock as it is a gas; all of it is created by the following decomposition: $^{40}\text{K} \rightarrow ^{40}\text{Ar} + ^0_{+1}\beta$ $t_{1/2} = 1.25 \times 10^9$ yrs. What is the minimum age of the rock if it contains 3.35 mg ^{40}K and 0.25 mg ^{40}Ar ?

$$k = \frac{.693}{1.25 \times 10^9 \text{ yr}} = 5.5 \times 10^{-10}$$

$$\ln\left(\frac{3.35 + 0.25}{3.35}\right) = 5.5 \times 10^{-10} \cdot t$$

$$t = 1.3 \times 10^8 \text{ yr}$$

Its OK to use masses bec both are mass 40

4a. A sample of radioactive ^{28}Mg decays at a rate of 53,500 disintegrations/min (dpm), but after 48 hrs, the decay rate drops to 10,980 dpm. What is the half-life of this isotope?

$$\ln\left(\frac{53500}{10980}\right) = k \cdot t$$

$$k = 3.3 \times 10^{-2}$$

$$t_{1/2} = \frac{.693}{k} = 21.0 \text{ hr}$$

4b. Can you predict if ^{28}Mg is a β -emitter? Explain.

Magnesium has atomic mass of 24.3 g/mol. Therefore Mg-28 has too many neutrons; β -emitter

5. All living organisms contain an amount of C-14 that gives 15.3 dpm per gram of carbon. Given that the half-life for C-14 is 5720 yrs, what is the rate of decay in dpm/g C for a mummified turtle that is thought to be 4000 years old?

$$\ln\left(\frac{15.3}{N_t}\right) = 1.21 \times 10^{-4} \text{ yr} \cdot 4000 \text{ yr}$$

$$k = \frac{.693}{5720} = 1.21 \times 10^{-4} \text{ yr}^{-1}$$

$$\ln\left(\frac{15.3}{N_t}\right) = 0.485$$

$$\frac{15.3}{N_t} = 1.62$$

$$N_t = 9.42 \text{ dpm/g C}$$

6. Using the information above, how old is an artifact that emits 6.0 dpm/g C?

$$\ln\left(\frac{15.3}{6.0}\right) = 1.21 \times 10^{-4} \text{ yr} \cdot t$$

$$t = 7730 \text{ yr}$$

7. Iodine-123, used in thyroid therapy, has a half-life of 13.27 hours. How many half-lives are required for a 160 mg sample of iodine-123 to decay to 5.0 mg?

A. 0.031
B. 1.0
C. 5.0
D. 32

$$\frac{160}{5} = 2^x = 32$$

$$x = 5$$

Classroom Activity Chapter 19 Number 3

12 April 2017

1. ^{36}Cl is a β -emitter with a half life of 3.0×10^5 years. How many β -emissions are emitted in one minute from a 5.0 mg sample of chlorine-36?

$$k = \frac{0.693}{3.0 \times 10^5} = 2.31 \times 10^{-6} \text{ yr}^{-1}$$

$$\text{rate} = \frac{2.31 \times 10^{-6} / \text{yr}}{365 \text{ d} / 24 \text{ h} / 60 \text{ min}} = 4.4 \times 10^{-12} \text{ min}^{-1} \times N_{\text{Cl atoms}}$$

$$5.0 \text{ mg Cl} \rightarrow 8.36 \times 10^{19} \text{ Cl atoms}$$

$$\text{rate} = 4.4 \times 10^{-12} \text{ min}^{-1} \times 8.36 \times 10^{19} \text{ atoms}$$

$$= 3.7 \times 10^8 \text{ dpm}$$

$$\Rightarrow 3.7 \times 10^8 \beta\text{-particles/min}$$

2a. Calculate the mass defect in g/mol for S-32 (atomic mass 31.97207 u). Given: the mass of one neutron is 1.00866 amu and the mass of one proton is 1.00728 amu.

Isotopic mass with 16 electrons

$$\begin{array}{l} 16 \text{ p } \quad 16 \times 1.00728 = \\ 16 \text{ n } \quad 16 \times 1.00866 = \end{array} \quad \underline{32.25504}$$

↑
Σ nucleons

$$16 \text{ e}^-: 16 \times 5.486 \times 10^{-4} \text{ } \Sigma \text{ nucleons}$$

Actual (nucleus only)

$$\begin{array}{r} 31.97207 \\ - 0.0087776 \\ \hline 31.96329 \end{array} \quad \rightarrow \Delta m = 0.2917 \text{ g/mol}$$

2b. Calculate the binding energy in MeV/nucleon for S-32.

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

$$= 0.2916 \times 10^{-3} \text{ kg} \times (3.0 \times 10^8 \frac{\text{m}}{\text{s}})^2$$

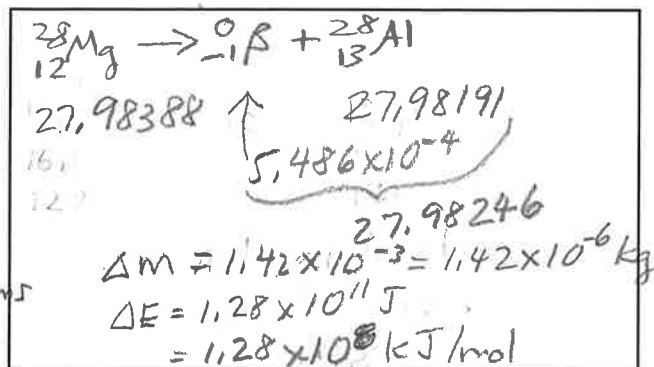
$$= 2.63 \times 10^{13} \frac{\text{J}}{\text{mol}} = 2.63 \times 10^{10} \frac{\text{kJ}}{\text{mol}}$$

1 MeV = $1.602 \times 10^{-13} \text{ J}$

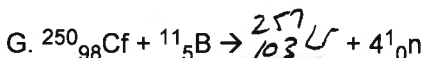
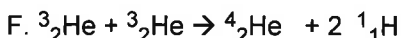
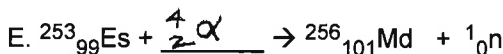
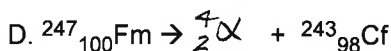
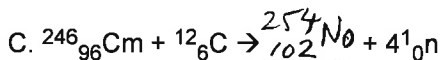
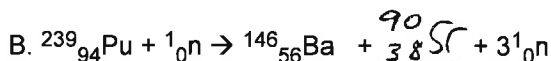
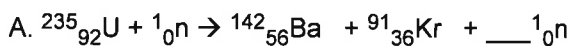
And divide by $N_A \times 32$:

$$E = 8.51 \text{ MeV/nucleon}$$

3. Mg-28 (isotopic mass 27.98388 u) is a β -emitter that decays to Al-28 (isotopic mass 27.98191 u). How much energy is associated with this reaction in units of kJ/mol?



4. Balance the following nuclear transformations.



5. Which of the above are examples of...

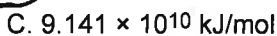
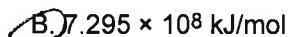
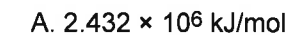
5a. a fission reaction? **A B**

5b. a fusion reaction? **F**

5c. a decay process? **D**

5d. a nuclear transmutation? **C E G**

6. Nitrogen-14 (14.003074 amu) is synthesized in the sun by fusion of ^{13}C (13.003355 amu) and ^1H (1.007825 amu). How much energy is released in this nuclear reaction?



$$\begin{array}{r} 13.003355 \\ + 1.007825 \\ - 14.003074 \\ \hline \Delta m = 8.11 \times 10^{-3} \text{ g} \\ = 8.11 \times 10^{-6} \text{ kg} \\ E = 7.3 \times 10^{11} \text{ J} \\ = 7.3 \times 10^8 \text{ kJ} \end{array}$$