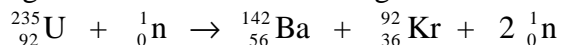


## 24 • Nuclear Chemistry

### STUDY QUESTIONS

- Write equations for the following reactions:
  - The production of  $^{56}\text{Mn}$  by neutron bombardment of  $^{59}\text{Co}$ .
  - The production of the new element dubnium by bombarding elements of  $^{249}_{98}\text{Cf}$  with  $^{15}_7\text{N}$  nuclei.
  - The bombardment of  $^{27}_{13}\text{Al}$  with  $\alpha$  particles to produce  $^{30}_{15}\text{P}$  and the subsequent decay of  $^{30}_{15}\text{P}$  to silicon by positron emission.
  - The conversion of potassium-40 to argon-40 by electron capture.
  - The production of carbon-14 in the upper atmosphere by neutron bombardment of  $^{14}_7\text{N}$ .
- Why are radioactive isotopes of intermediate half-lives more hazardous than radioisotopes with long half-lives or very short half-lives?
- Predict the radioactive ray of the following radioactive isotopes based upon their position relative to the band of stability:
  - carbon-14
  - krypton-87
  - thorium-230
  - phosphorus-29
  - europium-145
- Calculate the quantity of energy released when one atom of uranium-235 is split by the impact of a neutron into barium-142 and krypton-92 releasing one additional neutron. Then calculate the quantity of energy released when one gram of uranium-235 undergoes fission in the same way.



Atomic masses:

$$^{235}_{92}\text{U} \quad 235.04 \text{ amu}$$

$$^{142}_{56}\text{Ba} \quad 141.92 \text{ amu}$$

$$^{92}_{36}\text{Kr} \quad 91.92 \text{ amu}$$

$${}^1_0\text{n} \quad 1.0087 \text{ amu}$$

5. Charcoal retrieved from the site of Stonehenge in England has a carbon-14 activity 62.0% that of carbon-14 in living plants. Assuming that the abundance of carbon-14 in the atmosphere has remained more or less constant for the past few thousand years, how old is the charcoal?  
The half-life of carbon-14 is 5730 years.
6. Strontium-90 is a hazardous isotope present in the fallout from nuclear explosions. If 1.00 gram of strontium-90 diminishes to 0.786 gram in 10 years, as measured by its activity, what is the half-life of strontium-90?
7. Technetium-99 is prepared for medical imaging experiments by neutron bombardment of molybdenum-98. The unstable molybdenum-99 produced by this bombardment decays by  $\beta$  emission to an excited technetium-99, which in turns relaxes to its ground state by  $\gamma$  emission. The technetium-99 is itself radioactive and decays by  $\beta$  emission. Write the equations for this sequence of reactions.
8. If a radioactive isotope lies above the band of stability, which decay process would lead it toward the band, that is, form a more stable isotope?
9. Iron-56 is the isotope with the highest binding energy per nucleon. Calculate the binding energy per nucleon from the following data:
- mass of proton = 1.007275 amu  
mass of neutron = 1.008666 amu  
mass of electron = 0.0005486 amu  
atomic mass of iron-56 = 55.9349 amu
- Express your answer in units of J/nucleon.
10. a. The fission of an americium-244 isotopes produces iodine-134 and molybdenum-107.  
How many neutrons are also produced in each fission event?
- b. The fission of californium-252 nucleus produces one barium-142 nucleus and one molybdenum-106 nucleus. How many neutrons are produced in this reaction?
11. Moderator rods and control rods in a nuclear fission reactor serve different functions. What are their functions and how are they different?