South Pasadena • AP Chemistry

Name _____
Period ___ Date ___/___/___

24 • Nuclear Chemistry

STUDY QUESTIONS

1. Write equations for the following reactions:
   a. The production of ^{56}Mn by neutron bombardment of ^{59}Co.

   b. The production of the new element dubnium by bombarding elements of $^{249}_{98}Cf$ with $^{15}_{7}N$ nuclei.

   c. The bombardment of $^{27}_{13}Al$ with α particles to produce $^{30}_{15}P$ and the subsequent decay of $^{30}_{15}P$ to silicon by positron emission.

   d. The conversion of potassium-40 to argon-40 by electron capture.

   e. The production of carbon-14 in the upper atmosphere by neutron bombardment of $^{14}_{7}N$.

2. Why are radioactive isotopes of intermediate half-lives more hazardous than radioisotopes with long half- lives or very short half-lives?

3. Predict the radioactive ray of the following radioactive isotopes based upon their position relative to the band of stability:
   a. carbon-14
   b. krypton-87
   c. thorium-230
   d. phosophorus-29
   e. europium-145

4. 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.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{92}_{36}Kr + 2\,{}^{1}_{0}n$$

Atomic masses:

$^{235}_{92}$U	235.04 amu
$^{142}_{56}$Ba	141.92 amu
$^{92}_{36}$Kr	91.92 amu
$^{1}_{0}$n	1.0087 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. Technicium-99 is prepared for medical imaging experiments by neutron bombardment of molybdenum-98. The unstable molybdenum-99 produced by this bombardment decays by ß emission to an excited technicium-99, which in turns relaxes to its ground state by γ emission. The technicium-99 is itself radioactive and decays by ß 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?