Chemistry 121 Name:

Exercise 9: Nuclear and organic chemistry

From the University of California's Lawrence Berkeley Lab website (6/7/99): http://enews.lbl.gov/Science-Articles/Archive/elements-116-118.html

"Discovery of two new "superheavy" elements has been announced by scientists at the U.S. Department of Energy's Lawrence Berkeley National Laboratory. Element 118 and its immediate decay product, element 116, were discovered at Berkeley Lab's 88-Inch Cyclotron by bombarding targets of lead with an intense beam of high-energy krypton ions….The isotope of element 118 with mass number 293 identified at Berkeley Lab

contains 118 protons and _____ neutrons in its nucleus."

1. Fill in the blank above.

2. Assume the element symbol for element 118 is "X". Write the isotope symbol for the X isotope mentioned above.

More from that site:

"Elements 118 and 116 were discovered by accelerating a beam of krypton-86 ions to an energy of 449 million electron volts and directing the beam into targets of lead-208. This yielded heavy compound nuclei at low excitation energies."

3. Write the **nuclear equation** for the generation of element 118 that the sentence above suggests. Add neutrons as necessary to either the product or reactant side. Make sure the mass number and the atomic number are balanced.

As a footnote: "On July 27, 2001, the results reported [above] were retracted through a correspondence with *Physical Review Letters*." This shows the scientific method in action, as the authors of the original report reviewed their own work carefully, and, with the help of other researchers, were able to disprove their own results.

A less peaceful use: Breeder reactors generate the radioactive element plutonium from uranium. Plutonium is a key component in nuclear weapons technology.

From http://www.nukeworker.com/study/nuclear_energy/ne3-power_reactors.shtml

“The key feature of a breeder reactor is that it produces more fuel than it consumes. It does this by promoting the absorption of excess neutrons in a fertile material. Several breeder reactor systems are technically feasible. The breeder system that has received the greatest worldwide attention uses uranium-238 as the fertile material. When uranium-238 absorbs neutrons in the reactor, it is transmuted to a new fissionable material, plutonium, through a nuclear process called β (beta) decay. The sequence of nuclear reactions is:

Equation (3):

In beta decay a nuclear neutron decays into a proton and a beta particle (a high-energy electron).

When plutonium-239 itself absorbs a neutron, fission can occur, and on the average about 2.8 neutrons are released. In an operating reactor, one of these neutrons is needed to cause the next fission and keep the chain reaction going. On the average about 0.5 neutron is uselessly lost by absorption in the reactor structure or coolant. The remaining 1.3 neutrons can be absorbed in uranium-238 to produce more plutonium via the reactions in equation (3).”

4. Fill in equation (3). There are actually three reactions: First, a neutron collides and fuses with a uranium-238 nucleus. Next, that new nucleus undergoes a beta decay. Finally, *that* product undergoes another beta decay, which results in a plutonium nucleus.

Radiometric decay dating

Using accelerator mass spectrometry (AMS), one can count the number of (radioactive) carbon-14 atoms in a sample of fossil bone. If:

• N = the number of carbon-14 atoms per gram in a fossil bone
• N_0 = the number of carbon-14 atoms per gram in bone of a similar living organism
• $t_{1/2}$ = the half-life of the carbon-14 isotope = 5730 years (yr)

then the age of the sample's death, t, measured in years before present (yr BP), is given by the equation:

$t = (t_{1/2}/0.693) \bullet \ln (N_0/N)$

where "ln" is the natural logarithm function.

5. a. If living bone has $N_0 = 1000$ atoms and a fossil bone has N = 500 atoms, how old (yr BP) is the fossil? Why does this number of years make sense?

b. If living bone has $N_0 = 1000$ atoms and a fossil bone has N = 2 atoms, how old (yr BP) is the fossil? This is approximately the age limit for carbon-14 dating. Why isn't carbon-14 dating used to date the bones of "Lucy", the human ancestor fossil from Africa?

Calculate your own radiation dosage!

6. Go to the Environmental Protection Agency site for calculating your own radiation dosage at
http://www.epa.gov/radiation/understand/calculate.html

What is your annual radiation dose (in millirem)? Is this higher or lower than the national average?

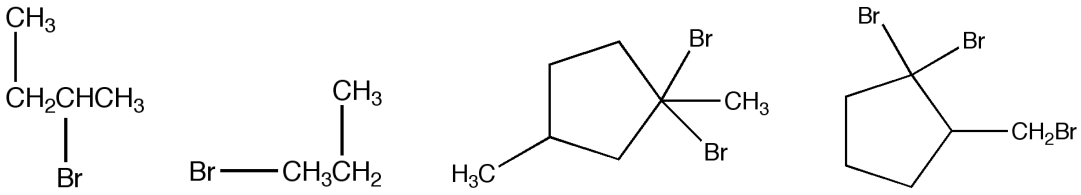
Organic chemistry

7. a. In this class so far, we have written acetic acid as "$HC_2H_3O_2$". Draw the *expanded* structural formula for acetic acid. The drawing at the top of page 433 may be helpful.

b. Draw the *condensed* structural formula for acetic acid.

c. Draw the *line-bond* structure for acetic acid.

8. Consider the four molecules below:



a. Circle the "illegal" structures. What common reason do they each have to make them "illegal"?

b. Give the IUPAC name for the molecule second from the left.

c. The molecule below is a structural isomer of one of the "legal" molecules above. Draw a line between them. Write the chemical formula to prove that the molecules are isomers.