

**Assignment #1, Physics 274**  
Solutions

1. The decay process can be found on <http://education.jlab.org/thatselemental/>.

(a) Sr-90: negative beta decay. This changes a neutron into a proton, so it moves one space up the periodic table to become Y-90.

(b) U-230: alpha decay. Since an alpha decay changes both the number of protons and number of neutrons, it moves two steps down the periodic table to become Th-226. Note that U-230 may also undergo spontaneous fission.

(c) Pb-206: this is stable! It does not decay.

(d) O-15: electron capture. It loses a proton, so it moves one step down the periodic table to become N-15.

(e) The degree of radioactivity can loosely be judged from the isotopes half-life. So, ranking each from least to most radioactive, we get:

Pb-206 (not radioactive), U-230 (20.8 days), Sr-90 (28.8 years), O-15 (122.24 seconds).

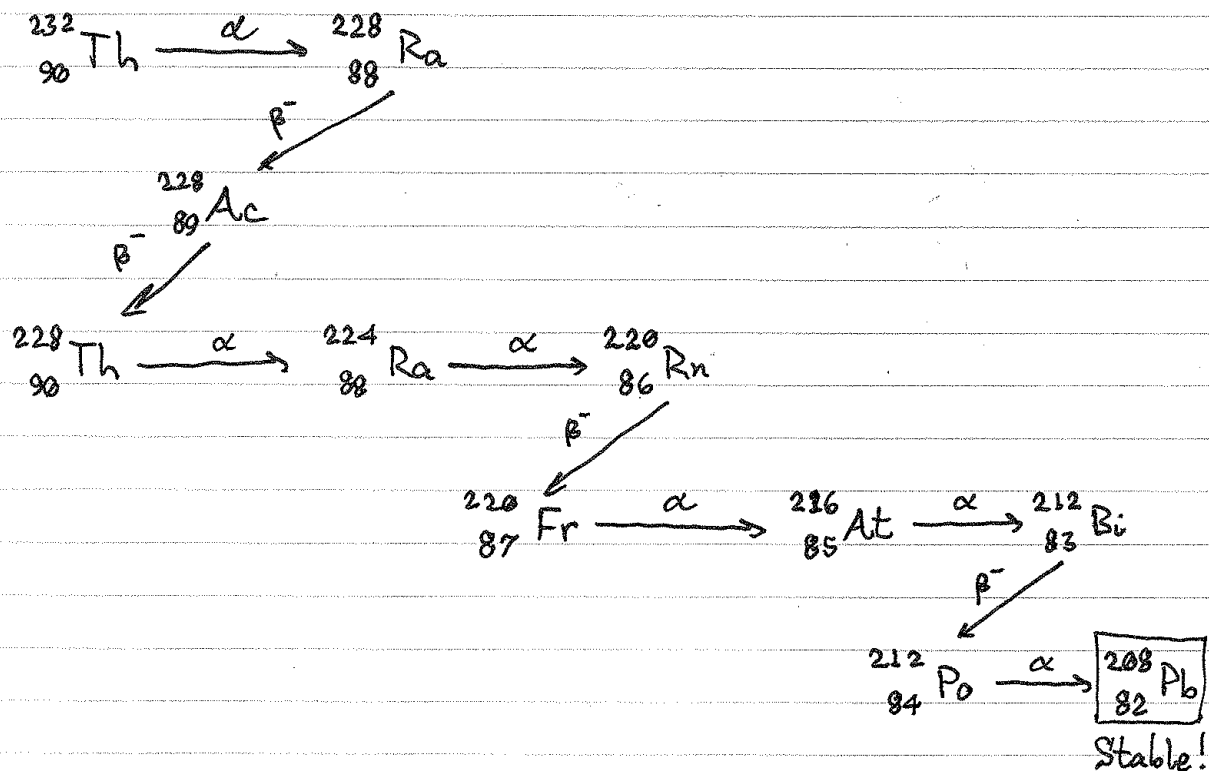
2. The easiest way to approach this problem is by mass. We know the mass of a proton and neutron is on the order of  $10^{-27}$  kg. Electrons are a thousand times less massive, so we can ignore them. The earth is made up of three kinds of matter: solid (dirt and rock), liquid (water), and gas (air). The dirt and rock far outweighs the others, so we can assume the earth is entirely made of this type of substance. Most minerals are composed of iron, copper, nickel, and so forth, which have atomic weights around 60 (which we can round up to 100, or  $10^2$ ). So, each atom in the earth is made up of about 100 protons and neutrons, and so each atom has a mass of  $10^2 \times 10^{-27} = 10^{-25}$  kg. The mass of the earth is about  $10^{25}$  kg, so the number of atoms that make it up must be

$$\frac{\text{Mass of earth}}{\text{Mass of atom}} = \frac{10^{25}}{10^{-25}} = 10^{50} \text{ atoms!}$$

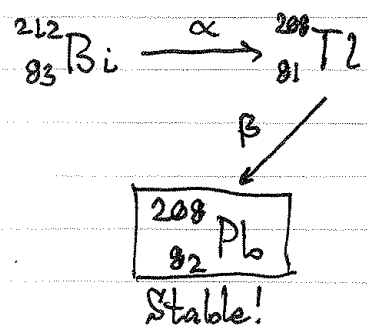
That seems like a lot, but it turns out that it's a drop in the bucket. The total number of atoms in the universe is about  $10^{120}$ !

3. (a) Remember that every alpha decay reduces the atomic number (bottom) by 2, and the atomic weight (top) by 4. Every beta decay increases the atomic number by 1, but leaves the atomic weight alone. (See decay chain on following page).

(b) To be a possible end-product of the decay chain, the difference in the atomic weight of the Pb isotope and the original (Th-232) must be divisible by 4, because only alpha decays can change the atomic weight. Since  $232 - 206 = 26$ , this is not divisible by 4, so Pb-206 isn't a possible decay product of Th-232.



\* Note that  ${}_{83}^{212}\text{Bi}$  might also  $\alpha$ -decay, so we could have:



but the total number of  $\alpha$ - and  $\beta$ -decays is still the same! ( $6\alpha, 4\beta$ ).