ES 105 RADIOACTIVITY AND HALF LIFE, RADIOMETRIC DATING

I. Radioactivity
   A. Spontaneous breaking apart (decay) of atomic nuclei
   B. Review of atomic structure
      1. nucleus of protons and neutrons
         a. total is the atomic mass number
         b. protons is the atomic number
      2. surrounded by electron cloud
      3. negative + positive = neutral
         a. neutron can disintegrate into proton and electron
         b. proton and electron can combine to be neutron
   C. ISOTOPES Au 188 is gold one hundred eighty eight
      1. Remember that isotopes are the same element with differing numbers of protons
         a. Different atomic mass number
         b. Distribution results in atomic weight shown on periodic table
      2. Some isotopes of particular elements will undergo radioactive decay, and others will not
      3. some radioactive isotopes are common, natural; others are rare and/or artificially created
      4. # of each type of nucleons
         a. Cl-37: 17 protons (its chlorine), so 20 neutrons
         b. U-238: 92 protons, 146 neutrons
   D. Nucleus bound with ‘Strong interaction’ force, strong nuclear force
      1. protons and neutrons bind more tightly to one another than either would bind to one of same nucleon type
         a. many small atoms have the same number of protons and neutrons
         b. greater numbers of neutrons leads to stability of nucleus
            1) Protons within nucleus tend to repel one another
            2) neutrons counteract this tendency
         c. larger atoms have more neutrons than protons—increases stability of the nucleus

E. Types of radioactive decay—classified by their ability to penetrate matter and ionize air (by Rutherford, 1890s)
   1. Alpha emission
      a. two protons and two neutrons (He atom) *Alpha particles*
      b. reduces nucleons by 4, reduces protons by 2
      c. positive electrical charge
   2. Beta emission
      a. Electron generated by neutron division into proton and electron *Beta particles*
      b. Increases proton number by 1, nucleon number unchanged
      c. Negative electrical charge
   3. Gamma emission
      a. electromagnetic radiation—
         1) proton beam released from daughter nucleus that is left in elevated energy after decay
         2) same as x-rays, but from nucleus not electron cloud
      b. Enlightens us to structure of nucleus
      c. No electrical charge
      $Ni - 60^* \rightarrow Ni - 60 + \gamma$
   4. other types of radioactivity
      a. electron capture—nucleus catches its own inner electron
      b. positron emission—opposite of beta decay
      c. internal conversion—excited daughter ejects electron from atom
   5. Decay of many isotopes is complicated series of steps to get to final daughter product
   6. decay type? $Co - 60 \rightarrow Ni - 60 + {}^{0}_{-1}e^{-}$ beta
   7. If Fm-250 undergoes alpha decay, what do you get?
      $Fm - 250 \rightarrow \alpha + Cf - 246$ subtract 2 from atomic number of 100
      Subtract 4 from mass number of 250

F. Measuring Radioactivity
   1. Free fragments of nuclei form ions as they travel
      a. Geiger counter
         1) These ions attracted to charged wire
         2) Electric current created by ions arriving at wire counted
      b. Scintillation counter uses fluorescent material excited to glow by gamma rays or charged particles
      c. Cloud and bubble chambers rely on low pressure gas or pressurized liquefied gas
         1) Ion creates vapor trail in low pressure gas
         2) Ion leaves bubble train with release of pressure in liquefied gas

II. Half life

A. Will the nucleus of unstable material disintegrate (radioactivity decay)?

1. can't tell for any particular atom
2. one half of the atoms of the substance will decay over a finite amount of time
   a. parent atoms decay into daughter products
   b. one half of them in ONE HALF LIFE
      1) tritium (hydrogen-3) half life is 12.3 years
      2) cobalt-60 half life is 5.25 years
      3) carbon -14 half life is 5730 years
   c. This DECAY RATE is constant—unaffected by external conditions
3. known number of half lives, can calculate amount of material remaining

   $R = I\frac{1}{2^n}$ where I is initial amount, n is number of half lives, and R is the amount remaining

   a. if you know the length of one half life, and the amount of time, you can determine number of half lives
   b. if you know the original amount and ending amount, you can calculate the number of half lives
   c. if you know the number of half lives, and the length of the half life, you can calculate the amount of time
   d. ICA # 4 How much is left after 3 half lives