Due: Thursday, 22-April-2004 at the beginning of class. Remember that this is to be your own work.

1) Write the correct nuclear equation for the following processes:
   a) $^{52}\text{Fe}$ emits a positron and a gamma photon
   b) A sample of tellurium with 71 neutrons captures an electron
   c) $^{59}\text{Fe}$ undergoes $\beta^-$ and $\gamma$ decay
   d) $^{212}\text{Bi}$ decays to $^{212}\text{Po}$
   e) The decay of an unstable nucleus produces $^8\text{Be}$ and $\beta^-$.

2) A laboratory investigation shows that a sample of uranium ore contains 5.37 mg $^{238}\text{U}$ and 2.52 mg $^{206}\text{Pb}$. Given the half-life of $^{238}\text{U} = 4.5 \times 10^9$ years, calculate the age of the ore.

3) The isotopic mass of $^{210}\text{Rn}$ is 209.989669 amu. When it decays by electron capture it emits 2.368 MeV. What is the isotopic mass of the resulting nuclide? (Hint: write the balanced nuclear equation first.)

4) The mass ratio of $^{40}\text{Ar}$ to $^{40}\text{K}$ also can be used, as stated in class, to date geologic materials. Potassium-40 decays by two routes:

   $^{40}\text{K} + \beta^- \rightarrow ^{40}\text{Ar} (10.7\%)$ \hspace{1cm} $t_{1/2} = 1.27 \times 10^9$ years
   $^{40}\text{K} \rightarrow ^{40}\text{Ca} + \beta^- (89.3\%)$

   a) Why are $^{40}\text{Ar}/^{40}\text{K}$ ratios used to date material rather than $^{40}\text{Ca}/^{40}\text{K}$ ratios?
   b) A sedimentary rock has an $^{40}\text{Ar}/^{40}\text{K}$ ratio of 0.95. Calculate the age of the rock.

5) The starship *Voyager*, like many other vessels of the newly designed 24th-century fleet, uses antimatter as fuel.

   a) How much energy is released when 1.00 g each of $^1\text{H}$ and anti-hydrogen annihilate each other? (Hint: One can write this as $^1\text{H} + ~^1\text{H} \rightarrow 2 \gamma$ [where $~^1\text{H}$ is anti-hydrogen])

   b) Suppose the engines can only utilize 33% of this value. What would be the minimum grams of zinc needed for the standard voltaic cell $\text{Zn}|\text{Zn}^{2+}||\text{Cu}^{2+}|\text{Cu}$ to obtain this same amount of electrical energy?