Name: _____ PHYS 7501, FS 2017

Homework 1 **Due:** Start of class, September 7th

1. Which of the following reactions are possible without non-standard model physics? For invalid reactions, indicate what the issue is.

   a. $^{69}Kr \rightarrow {}^{69}Br + e^{+} + \bar{\nu}_e$

   b. $^{44}Ti(\alpha,p)^{48}Cr$

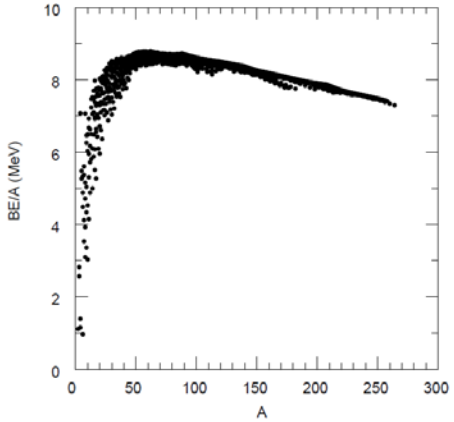
   c. $e^{-} + {}^{55}Sc \rightarrow {}^{55}Ca + \nu_e$

   d. $^{15}O(\alpha,\gamma)^{19}Ne$

2. Suppose I were to start with pure ^{226}Th, what nuclide would I mostly wind up with? Write the dominant decay sequence. Roughly how long would it take for half of the material to undergo this conversion? (Hint: This does not require complex math …or even addition!)

3. There is a stable isotope of each element within Z=1–82, except Tc and what other element?

4. The plot below depicts experimentally measured binding energies per nucleon. The peak is located at ^{58}Fe, meaning this is the lowest energy state for nuclear matter. Why isn't everything around you (including yourself) made of ^{58}Fe?



From B. Alex Brown, Lecture Notes on Nuclear Structure Physics, 2005

5. Calculate the Q-values for the reactions $^{12}C(\alpha,\gamma)$, $^{12}C(\alpha,p)$, and $^{12}C(\alpha,n)$. Show your work.

6. A table of experimental binding energy per nucleon as compiled in the 2012 Atomic Mass Evaluation has been provided.
   Fit these data using the 5-parameter liquid drop model and report fit-parameter values. (*Don't forget to report the fit-function to give the parameters context!*)
   Attach to this homework a plot of the fit residuals as a function of neutron number and, separately, as a function of proton number, as well as a copy of the code used to perform the fit (e.g. ROOT, gnuplot, … script).

7. An optical potential describing the interaction of a projectile and target nucleus typically has the form V(r)+iW(r). Since this potential generally describes the interaction between a tiny projectile and a distribution of nucleons in a nucleus, what is a plausible functional form for the radial dependence of V and R? I.e. if $V(r) = -V_o f(r)$, what is $f(r)$?

8. What impact would deformation have on the terms in the semi-empirical mass formula?