Name: _____ PHYS 7501, FS 2021

Homework 1 **Due:** Start of class, September 2nd

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

   a. $^{69}\mathrm{Kr} \rightarrow {}^{69}\mathrm{Br} + e^{+} + \nu_e$

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

   c. $e^{-} + {}^{55}\mathrm{Sc} \rightarrow {}^{55}\mathrm{Ca} + \bar{\nu}_e$

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

2. Smoke detectors work by monitoring the current generated from $^{241}\mathrm{Am}$ α decay. When this material finally stops undergoing radioactive decay, what will it mostly become? Write the dominant decay sequence.

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

4. $^{11}\mathrm{Li}$ has an rms radius of 3.5fm. What mass-number A would you predict from this radius given the empirical formula for matter radii? What rms radius would you predict for A=11?

5. Calculate the Q-values for the reactions $^{44}\mathrm{Ti}(\alpha,\gamma)$, $^{44}\mathrm{Ti}(\alpha,\mathrm{p})$, and $^{44}\mathrm{Ti}(\alpha,\mathrm{n})$. 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, Mathematica).

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

8. Calculate the experimental binding energy difference between ^{15}N and ^{15}O.
   Assuming this is due to the Coulomb term of the SEMF, what radius corresponds to A=15?
   Note that compared to a point-charge, a uniformly charged sphere has $U_{sphere} = (3/5)U_{point}$.
   Compare this to the usual approximation for the nuclear radius (using r_0=1.2fm).