1. Nuclear Chemistry:
   a. What is the difference between "regular elements" and radioactive elements?
      "regular elements" have stable nuclei, while radioactive elements have unstable nuclei, high
      neutron to proton ratios and their nuclei undergo radioactive decay
   b. How are the following two reactions different?
      i. $\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$ ← only electrons involved; less energy
      ii. $\text{U} \rightarrow \text{Th} + \text{He}$ ← nucleus splits, LOTS of energy released

2. Half-life
   a. What is half life?
      The amount of time it takes for half of the mass of a radioactive element to decay.
   b. Why is it beneficial that different substances have different half lives?
      Radioactive dating - allows us to accurately date samples that are thousands of years old,
      as well as samples that are millions of years old.

3. Fission
   a. What is fission?
      Splitting of nuclei
   b. Draw a picture of U-235 atom going through fission.
      See notes
   c. What are the key "things" that keep fission going?
      Neutrons
   d. Which element was used in the atomic bomb named "Little Boy"?
      Uranium
   e. What is "Critical mass?"
      Minimum mass of a radionuclide required to sustain a chain reaction
   f. Why did scientists begin creation of the atomic bomb in the first place?
      To develop something so powerful that its threat could end all wars.

4. Nuclear reactors
   a. What is the purpose of a nuclear reactor? (What does it do?)
      To split atoms and therefore generate tremendous amounts of energy.
   b. What do the control rods do? How do they do the "controlling?"
      To absorb neutrons, and therefore slow or speed up the fission reaction
   c. What do you do with the control rods if you want to increase fission?
      Take them out of the core
   d. What do you do with the control rods if you want to decrease fission?
      Push them back into the core
5. Chernobyl
   a. Why did people die right away after Chernobyl exploded?
      Blast of the explosion; massive doses of radiation
   b. How did radiation reach 20 other countries?
      It was carried by the wind; it even traveled up into the jet stream

6. Fusion
   a. What is fusion?
      Nuclei combining
   b. Where does fusion commonly take place?
      Stars (i.e. our sun)
   c. Why is fusion difficult to start?
      Requires incredibly high temperatures!

7. Write balanced nuclear equations for the following reactions:
   a. Radium-223 undergoes alpha decay
      \[ ^{223}_{88}Ra \rightarrow ^{4}_2\alpha + ^{219}_{86}Rn \]
   b. Carbon-14 undergoes negative beta decay
      \[ ^{14}_6C \rightarrow ^{0}_{-1}\beta + ^{14}_7N \]
   c. Fission of uranium-235 activated by the bombardment of a neutron to form tellurium-137, another large nucleus and three neutrons.
      \[ ^{1}_0n + ^{235}_{92}U \rightarrow ^{137}_{52}Te + ^{96}_{40}Zr + ^{3}_0n + ^{1}_0n \]

8. The half-life of cesium-137 is 30.2 years. If the initial mass of a sample of cesium-137 is 1.00 kg, how much will remain after 162 years?

   \[ k = \frac{0.693}{30.2 \text{ yr}} = 0.022947 \text{ yr}^{-1} \]
   \[ \log \left( \frac{A_n}{A} \right) = \frac{kt}{2.303} \]
   \[ \log \left( \frac{1.00 \text{ kg}}{A} \right) = \frac{(0.0229 \text{ yr}^{-1})(162 \text{ yr})}{2.303} \]
   \[ \left( \frac{1.00 \text{ kg}}{A} \right) = \text{antilog}(1.6074) \]
   \[ \left( \frac{1.00 \text{ kg}}{A} \right) = 40.4916696 \]
   \[ A = 0.024696 \text{ kg or } 24.7 \text{ g} \]
9. Given that the half-life of carbon-14 is 5730 years, consider a sample of fossilized wood that, when alive, would have contained 22.5 g of carbon-14. It now contains 1.5 g of carbon-14. How old is the sample?

\[ k = \frac{0.693}{5730 \text{ yr}} = 0.18237 \text{ yr}^{-1} \]

\[ \log \left( \frac{22.5 \text{ g}}{1.5 \text{ g}} \right) = \frac{(1.209 \times 10^{-4} \text{ yr}^{-1})(t)}{2.303} \]

\[ t = 22,403 \text{ years} \]
\[ t = 22,000 \text{ years} \]

10. A sample of air from a basement is collected to test for the presence of radon-222, which has a half-life of 3.8 days. However, delays prevent the sample from being tested until 9.0 days have passed. Measurements indicate the presence of 6.5 micrograms of radon-222. How much radon-222 was present in the sample when it was initially collected?

\[ k = \frac{0.693}{3.8 \text{ days}} = 0.18237 \text{ day}^{-1} \]

\[ \log \left( \frac{A_0}{6.5 \mu g} \right) = \frac{(0.18237 \text{ day}^{-1})(9.0 \text{ days})}{2.303} \]

\[ \frac{A_0}{6.5 \mu g} = \text{antilog}(0.712686) \]

\[ \frac{A_0}{6.5 \mu g} = 5.16043 \]

\[ A_0 = 33.54 \mu g \approx 34 \mu g \]