PROBLEM 1 – 10 points

[5 points] (a) You have equal numbers of two radioactive nuclei to start with. The A nuclei have a half-life of 4 days, while the half-life of the B nuclei is unknown. After waiting for 12 days, you find that there are twice as many B nuclei remaining as there are A nuclei. What is the half-life of the B nuclei?

The A nuclei have gone through three half-lives. If there are now twice as many B nuclei remaining, the B nuclei must only have gone through two half-lives. Because 12 days represents two half-lives for the B nuclei, the B nuclei have a half-life of 6 days.

[5 points] (b) Uranium-235 has a half-life of about 700 million years. The Earth today has approximately $1/32^{nd}$ of the Uranium-235 that it had when the Earth was formed. Use this information to approximate the age of the Earth.

32 is 2^5, so a time equal to five half-lives must have elapsed (the original number would then be divided by 2 five times). Five half-lives is 3.5 billion years, so the Earth must be about 3.5 billion years old, based on this data.

PROBLEM 2 – 10 points

Note: you will find a periodic table to be helpful for this problem.

[2 points] (a) Americium-241, which is used in many smoke detectors, is radioactive, decaying via alpha decay. Complete the alpha decay equation below to show what americium-241 decays into.

$$^{241}_{95}\text{Am} \rightarrow \underline{^{237}_{93}\text{Np}} + \underline{^{4}_{2}\text{He}}$$

[2 points] (b) Oxygen-15 decays via beta-plus decay, which means it gives off a positron and an electron neutrino. Because of this, oxygen-15 is often used in positron emission tomography studies. Complete the decay equation below to show what oxygen-15 decays into.

$$^{15}_{8}\text{O} \rightarrow \underline{^{15}_{7}\text{N}} + ^{0}_{1}\text{e}^{+} + \nu_e$$

[2 points] (c) Scandium-46 decays via beta-minus decay, which means it gives off an electron and an electron antineutrino. Complete the decay equation below to show what scandium-46 decays into.

$$^{46}_{21}\text{Sc} \rightarrow \underline{^{46}_{22}\text{Ti}} + ^{0}_{-1}\text{e}^{-} + \bar{\nu}_e$$

[2 points] (d) Nickel-60 is an emitter of gamma rays. Complete the decay equation below to show what an excited nickel-60 nucleus decays into.

$$^{60}_{28}\text{Ni}^{*} \rightarrow \underline{^{60}_{28}\text{Ni}} + \gamma$$

The gamma decay is the only decay that does not result in a different isotope. Here, the assumption is that the nickel decays from an excited state to the ground state, but it could also decay from one excited state to a lower excited state.

[2 points] (e) How many neutrons are produced in the following fission reaction for a uranium-235 atom that combines with a neutron?

$$^{1}_{0}\text{n} + ^{235}_{92}\text{U} \rightarrow ^{236}_{92}\text{U} \rightarrow \ ^{139}_{52}\text{Te} \ + ^{94}_{40}\text{Zr} + ?\left(^{1}_{0}\text{n}\right)$$

__3__ neutrons are produced. **There have to be 236 nucleons on both sides, which requires 3 neutrons on the right-hand side.**