# Answers Chapter 19 Study Questions

1. a) ${}^{239}_{94}Pu + {}^{1}_{0}n \rightarrow {}^{130}_{50}Sn + {}^{107}_{44}Ru + 3{}^{1}_{0}n$, fission
   b) ${}^{2}_{1}H + {}^{6}_{3}Li \rightarrow 2{}^{4}_{2}He$, fusion
   c) ${}^{210}_{84}Po \rightarrow {}^{4}_{2}He + {}^{206}_{82}Pb$, α-decay
   d) ${}^{66}_{31}Ga + {}^{0}_{-1}e \rightarrow {}^{66}_{30}Zn$, other
   e) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{72}_{30}Zn + {}^{160}_{62}Sm + 4{}^{1}_{0}n$, fission
   f) ${}^{234}_{90}Th \rightarrow {}^{0}_{-1}e + {}^{234}_{91}Pa$, β-decay
   g) ${}^{238}_{92}U \rightarrow {}^{4}_{2}He + {}^{234}_{90}Th$, α-decay
   h) ${}^{60}_{29}Cu \rightarrow {}^{60}_{28}Ni + {}^{0}_{1}e$, other

2. a) ${}^{137}_{55}Cs \rightarrow {}^{0}_{-1}e + {}^{137}_{56}Ba$

   b) $n = \frac{60 years}{30 years} = 2$ fraction left $= \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^2 = \frac{1}{4} = 0.25$ left

   c) $n = \# half - lives = \frac{90 years}{30 years} = 3$ fraction left $= \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$ $24.0g \times \frac{1}{8} = 3.0g$

   d) $n = \frac{120 years}{30 years} = 4$ fraction left $= \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$ fraction decayed $= \frac{15}{16} = 0.94$

3. 75% decayed = 25% left = 1/4 left

   $\frac{1}{4} = \left(\frac{1}{2}\right)^n \Rightarrow$ n = 2 # half-lives = n = 2 $= \frac{timepast}{half - life} = \frac{16 days}{half - life}$

   half life $= \frac{16 days}{2} =$ 8 days

4. Isotopes are radioactive due to an unstable nucleus. Nuclei can be unstable because they are too large or if their neutron-to-proton ratio is "incorrect". Radioactive decay enables a nucleus to become more stable. Alpha-decay makes a nucleus smaller and beta-decay reduces the neutron-to-proton ratio. The energy released in nuclear reactions is several orders of magnitude greater than the energy released in ordinary chemical reactions. This enormous amount of energy reflects the loss in mass that accompanies nuclear reactions.

5. a) ${}^{83}_{38}Sr \rightarrow {}^{0}_{1}e + {}^{83}_{37}Rb$
   b) ${}^{12}_{6}C + {}^{12}_{6}C \rightarrow {}^{1}_{0}n + {}^{23}_{12}Mg$
   c) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{140}_{56}Ba + {}^{93}_{36}Kr + 3{}^{1}_{0}n$

6. ${}^{40}_{19}K \rightarrow {}^{0}_{-1}e + {}^{40}_{20}Ca$; calcium
   It is likely to be stable because 40 is close to the atomic mass of calcium.

7. Nuclear fission is a chain reaction because it uses up one neutron but produces two or more neutrons, making it possible for the process to escalate rapidly. The critical mass is the mass needed by a uranium sample for the reaction to be self-sustaining. Nuclear fission produces radioactive waste because the two fission products have a neutron-to-proton ratio similar to the uranium from which they were derived. Therefore, as smaller elements, these products always have too many neutrons and are highly radioactive.