Chemistry

Answers to 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) $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{72}_{30}Zn + ^{160}_{62}Sm + 4^{1}_{0}n$, fission

   e) $^{125}_{53}I \rightarrow ^{125}_{53}I$ + γ-ray, γ-decay f) $^{238}_{92}U \rightarrow ^{4}_{2}He + ^{234}_{90}Th$, α-decay

   g) $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{86}_{35}Br + ^{147}_{57}La + 3^{1}_{0}n$, fission h) $^{234}_{90}Th \rightarrow ^{0}_{-1}e + ^{234}_{91}Pa$, β-decay

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 = $\frac{time past}{half-life} = \frac{16 days}{half-life}$

   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) $^{12}_{6}C + ^{12}_{6}C \rightarrow ^{1}_{0}n + ^{23}_{12}Mg$ b) $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{56}Ba + ^{93}_{36}Kr + 3^{1}_{0}n$

6. $^{131}_{53}I \rightarrow ^{0}_{-1}e + ^{131}_{54}Xe$; xenon
   It is likely to be stable because 131 is close to the atomic mass of xenon.

7. Nuclear fission is a "chain reaction" because it is a self-sustaining reaction than can increase in magnitude as it proceeds. The critical mass is the mass of fissionable material (commonly U-235) needed for a sample to maintain fission. Nuclear fission produces radioactive waste because when a large nucleus splits, the two smaller nuclei it produces always have too many neutrons, and are therefore highly radioactive. The source of energy in fission is from the splitting of the nucleus.