Chemistry 822 Worksheet NAME: Key

Nuclear Decay Reactions Block: _____

1. These two radioactive elements that are alpha particle (α) emitters. Write the nuclear reactions for each decay including the formation of the daughter products:

   a. $^{213}_{84}Po \rightarrow {}^{4}_{2}He + {}^{209}_{82}Pb$

   b. $^{241}_{93}Np \rightarrow {}^{4}_{2}He + {}^{237}_{91}Pa$

2. These two radioactive elements that are beta particle (β^-) emitters. Write the nuclear reactions for each decay including the formation of the daughter products:

   a. $^{15}_{7}N \rightarrow {}^{0}_{-1}e + {}^{15}_{8}O$

   b. $^{41}_{19}K \rightarrow {}^{0}_{-1}e + {}^{41}_{20}Ca$

3. These two radioactive elements that are positron (β^+) emitters. Write the nuclear reactions for each decay including the formation of the daughter products:

   a. $^{56}_{27}Co \rightarrow {}^{0}_{+1}e + {}^{56}_{26}Fe$

   b. $^{80}_{33}As \rightarrow {}^{0}_{+1}e + {}^{80}_{32}Ge$

4. These two radioactive elements decay by electron capture (*EC*). Write the nuclear reactions for each decay including the formation of the daughter products:

   a. $^{35}_{16}S + {}^{0}_{-1}e \rightarrow {}^{35}_{15}P$

   b. $^{69}_{35}Sr + {}^{0}_{-1}e \rightarrow {}^{69}_{34}Se$

5. Balance each nuclear decay equation by filling in the blanks. Classify each nuclear decay as alpha (α), beta (β^-), positron (β^+), or electron capture (EC):

   a. $^{238}_{92}U \rightarrow {}^{4}_{2}He + {}^{234}_{90}Th$ Type of decay: alpha

   b. $^{128}_{56}Ba + {}^{0}_{-1}e \rightarrow {}^{128}_{55}Cs$ Type of decay: E Capture

   c. $^{34}_{15}P \rightarrow {}^{0}_{-1}e + {}^{34}_{16}S$ Type of decay: Beta

   d. $^{22}_{11}Na \rightarrow {}^{0}_{+1}e + {}^{22}_{10}Ne$ Type of decay: Positron

   e. $^{0}_{-1}e + {}^{27}_{14}Si \rightarrow {}^{27}_{13}Al$ Type of decay: E Capture

   f. $^{212}_{84}Po \rightarrow {}^{4}_{2}He + {}^{208}_{82}Pb$ Type of decay: alpha

   g. $^{82}_{35}Br \rightarrow {}^{0}_{-1}e + {}^{82}_{36}Kr$ Type of decay: Beta

   h. $^{48}_{21}Sc \rightarrow {}^{48}_{22}Ti + {}^{0}_{-1}e$ Type of decay: Beta

Nuclear Half-lives Block: _____

Table 19.1
Various Types of Radioactive Processes

Process	Example
β-particle (electron) production	$^{227}_{89}Ac \rightarrow {}^{227}_{90}Th + {}^{0}_{-1}e$
positron production	$^{13}_{7}N \rightarrow {}^{13}_{6}C + {}^{0}_{1}e$
electron capture	$^{73}_{33}As + {}^{0}_{-1}e \rightarrow {}^{73}_{32}Ge$
α-particle production	$^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$
γ-ray production	excited nucleus (excess energy) → ground-state nucleus (lower energy) + $^{0}_{0}\gamma$

Show all work; observe all significant figures, and record units with all answers.

6. Americium-247 undergoes beta decay to curium-247 with a half-life of 23 minutes.
   a. Write the complete nuclear decay reaction for this process, using full symbols for all isotopes and particles.

$$^{247}_{95}Am \rightarrow {}^{0}_{-1}e + {}^{247}_{96}Cm$$

   b. How many half-lives will it take for 75% of a 350 gram sample of americium-247 to decay to curium-247?

1st cycle (50%) → 2nd cycle (25%) = 2 cycles

   c. If one starts with a 1000 g sample of americium-247, what mass of americium-247 will remain after 92 minutes?

½ life → $\frac{92\text{ min}}{23\text{ min}} = 4$ half-life cycles

$1000\text{ g sample} \times \left(\frac{1}{2}\right)^4 = 62.5\text{ g}$

$\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$

7. The half life of cobalt-60 is 5.3 years. How much of a 1.000 mg sample of cobalt-60 is left after a 2.15 year period? 4 cycles

½ life → $\frac{2.15\text{ yr}}{5.3\text{ yr}} = 0.4$ cycle

$1.000\text{ mg}\left(\frac{1}{2}\right)^{0.4} = 0.75\text{ mg}$

8. The half-life of tritium (hydrogen-3) is 12.3 years. If 48.0 mg of tritium is released from a nuclear power plant during the course of an accident, what mass of this nuclide will remain after 12.3 years? After 74.2 years?

$\frac{12.3\text{ yr}}{12.3\text{ yr}} = 1$ cycle $\quad 48.0\text{ mg}\left(\frac{1}{2}\right)^1 = 24.0\text{ mg}$

$\frac{74.2\text{ yr}}{12.3\text{ yr}} = 6$ cycles $\quad 48.0\text{ mg} \times \left(\frac{1}{2}\right)^6 = 0.75\text{ mg}$

9. The half life of Plutonium- 239 is 24,000 years. What fraction of the Plutonium-239 present in nuclear wastes generated today will be present in the year 3000?

3000 − 2014 = 986 yr (2014)

$\frac{986\text{ yr}}{24{,}000} = 0.041$ cycles $\quad 100\text{ g sample}\left(\frac{1}{2}\right)^{0.041} = 97.2\text{ g}$

$\frac{97.2\text{ g}}{100\text{ g sample}} = 0.972$