Name: KEY Period:_______ Due:___________ RL:_______

Chapter 9 Nuclear Chemistry Homework

1. Define radioactivity. the emission of radiation or particles caused

2. Define nuclide. the nucleus of an atom

3. Define nuclear reaction. a change in the identity or characteristics of an atomic nucleus that results from being unstable

4. Define transmutation. the action of changing or the state of being changed into another form

5. What changes in atomic number and mass number occur in each of the following types of radioactive decay?
   a. Alpha atomic number decreases by 2; mass number decreases by 4
   b. Beta atomic number increases by 1 in beta + decay. atomic number decreases by 1 in beta negative decay
   c. Gamma ↳ atomic number & mass number do not change

6. Write the nuclear equation for the release of an alpha particle by $^{210}_{84}Po$.

$$^{210}_{84}Po \xrightarrow{\alpha} {}^{206}_{82}Pb + {}^{4}_{2}He$$

7. Write the nuclear equation for the release of a beta particle by $^{210}_{82}Pb$.

~~$^{210}_{84}Po \xrightarrow{\beta} {}^{210}_{85}At + {}^{0}_{-1}e$~~

$$^{210}_{82}Pb \longrightarrow {}^{210}_{83}Bi + {}^{0}_{-1}e$$

8. Write the nuclear equation for the release of an alpha particle by $^{210}_{82}Pb$ that also undergoes gamma radiation.

$$^{210}_{84}Po \xrightarrow{\alpha/\gamma} {}^{206}_{82}Pb + {}^{4}_{2}He + \gamma$$

$$^{210}_{82}Pb \longrightarrow {}^{206}_{80}Hg + {}^{4}_{2}He + \gamma$$

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9. How much energy is released when 1 mole of Francium-223 decays by alpha emission to produce Astatine-219? Express your answer in kilojoules (kJ).

$$^{223}_{87}Fr \xrightarrow{\alpha} {}^{219}_{85}At + {}^{4}_{2}He$$

Mass for Francium-223 = 223.0197359
Mass for Astatine-219 = 219.011162
Mass for Helium Particle is 4.00280

$\Delta m = (4.00280\,g + 219.011162\,g) - 223.0197359\,g =$

$0.0057739\,g = 0.0000057739\,kg$

$\boxed{E = 5.193E8\ kJ}$

$E = (0.0000057739\ kg)(3.00 \times 10^8)^2$

$E = 5.193\ E11\ J$

10. When uranium-226 decays by alpha emission to produce thorium-222, it produces 3.09 E 11 kJ of energy. What is the exact mass of the original Uranium-226?

Thorium-222 = 222.018468 g
~~Beta particle = 0.0005486 g~~

$$^{226}_{92}U \xrightarrow{\alpha} {}^{222}_{90}Th + {}^{4}_{2}He$$

$3.09\ E14J = m\ (3.00E8\ m/s)^2$

$m = \cancel{3.43\ E-9\ kg}\ 0.00343\ Kg$

$(222.018468 + 4.00280) - {}^{226}U = -3.43\ E-6\ g$

$\boxed{m = 2.26\ E2\ g}$

11. The energy released by the formation of a nucleus of $^{56}_{26}Fe$ is 7.89 X 10^{-11} J. Use Einstein's equation, to determine how much mass (in kg) is lost in this process.

$7.89 \times 10^{-11}\ J = m\ (3.00E8)^2$

$m = 8.77\ E-28\ kg$

12. The half-life of plutonium-239 is 24,1110 years. Of an original mass of 100 g, how much plutonium-239 remains after 96,440 years?

$t_{1/2} = 241,110\ yrs.$

$N_0 = 100\ g$

$t = 96,440\ yr$

$N_t =$

$k =$

$\frac{0.693}{k} = 241,110\ yr$

$k = 2.87\ E-6\ \frac{1}{yr}$

$\ln\left(\frac{N_t}{100g}\right) = -(2.87\ E-6\ 1/yr) \cdot (96,440)$

$\boxed{N_t = 75.8219\,g}$

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$$^{226}_{92}U \xrightarrow{\alpha} {}^{222}_{90}Th + {}^{4}_{2}He$$

$$E = mc^2$$

$$E = \frac{3.09\text{E}11\ \text{kJ}}{} \Big| \frac{1000\ \text{J}}{1\ \text{kJ}} = 3.09 \times 10^{14}\ \text{J}$$

$$3.09 \times 10^{14}\ \text{J} = m \cdot (3.00 \times 10^{8})^2$$

$$m = \frac{0.00343\ \text{kg}}{} \Big| \frac{1000\ \text{g}}{1\ \text{kg}}$$

$$m = 3.43\ \text{g}$$

$$\Delta m = m_f - m_i$$

$$3.43\ \text{g} = (4.00280\ \text{g} + 222.018468\ \text{g}) - m_i$$

$$-222.59\ \text{g} = -m_i$$

$$\boxed{222.59\ \text{g} = {}^{222}Th}$$

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13. The half-life of thorium-227 is 18.72 days. How many days are required for three-fourths of a given amount of thorium-227 to decay?

$\frac{1}{4}$ left = 2 half-lives

$$18.72 \cdot \text{days} \cdot 2 = \boxed{\text{37.44 days to decay}}$$

14. Exactly 1/16 of a given amount of protactinium-234 remains after 26.76 hours. What is the half-life of protactinium-234?

$\frac{1}{16} = \left(\frac{1}{2}\right)^x$ x = 4 half-lives $\frac{26.76 \text{ hrs.}}{4} = \boxed{6.69 \text{ hrs}}$

15. How many milligrams of a 15.0 mg sample of radium-226 remains after 6396 years? The half-life of radium-226 is 1,599 years.

$\frac{6396 \text{ yr}}{1599 \text{ yr}} = 4$ $\left(\frac{1}{2}\right)^4 = \frac{1}{16}$ $15.0 \text{ mg} \cdot \frac{1}{16} = \boxed{0.9375 \text{ mg left}}$

16. CHALLENGE: Atomic nuclei can decay in series. The parent nuclide of the thorium decay series is $^{232}_{90}\text{Th}$. The first four decays are as follows: alpha emission, beta emission, beta emission, and alpha emission. Write the nuclear equations for this series of emissions.

$${}^{232}_{90}\text{Th} \xrightarrow{\alpha} {}^{228}_{88}\text{Ra} + {}^{4}_{2}\text{He}$$

$${}^{228}_{88}\text{Ra} \xrightarrow{\beta^-} {}^{228}_{89}\text{Ac} + {}^{0}_{-1}e$$

$${}^{228}_{89}\text{Ac} \xrightarrow{\beta^-} {}^{228}_{90}\text{Th} + {}^{0}_{-1}e$$

$${}^{228}_{90}\text{Th} \xrightarrow{\alpha} {}^{224}_{88}\text{Ra} \quad {}^{4}_{2}\text{He}$$

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17. Complete the following nuclear equation: _____ → $^{187}_{76}Os + ^{0}_{-1}B$
    - a. $^{187}_{77}Os$
    - b. $^{187}_{75}Os$
    - c. $^{187}_{77}Ir$
    - [✓ d.] $^{187}_{75}Re$
18. Which type of radiation has the most penetrating ability?
    - a. Alpha
    - b. Beta
    - [✓ c.] Gamma
    - d. Neutron

19. Gamma rays
    - a. Have the same energy as beta particles do
    - b. Are visible light
    - [✓ c.] Have no charge and no mass
    - d. Are not a form of electromagnetic radiation

20. The half-life of thorium-234 is 24 days. If you have a 42.0 gram sample of thorium-234, how much will remain after 72 days?
    - a. 42 g
    - b. 21 g
    - c. 10.5 g
    - [✓ d.] 5.25 g

21. It takes 5.2 minutes for a 4.0 g sample of francium-210 to decay until only 1.0 g is left. What is the half-life of francium-210?
    - a. 1.3 min
    - [✓ b.] 2.6 min
    - c. 5.2 min
    - d. 7.8 min

22. Explain the difference between nuclear fission and nuclear fusion, and explain the energy changes that accompany each process. What are some potential advantages and drawbacks to using fission vs. fusion?

Fission	Fusion
What: splitting of nuclei by neutron	What: 4 hydrogen atoms fuse together to become helium and release energy
pros: less emissions, high amount of energy, low cost	pros: clean energy, limitless fuel, no chain reaction, no waste, tons of energy
cons: volatile (dangerous), workers in danger, initial costs are staggering, contamination,	cons: needs temperature of a star in order to be created