CHM152LL: Nuclear Chemistry Practice Worksheet Key

Exercise 1: Complete the following table:

Isotope	Mass Number	# of Protons	# of Neutrons	# of Electrons
Strontium - 90	90	38	52	38
^{222}Rn	222	86	136	86

Exercise 1: Identify the unknown element in each to complete the following nuclear equations:

a. Argon-40 is bombarded with a proton.

$$^{40}_{18}Ar + {}^{1}_{1}H \longrightarrow {}^{1}_{0}n + \_\_\_\_\_ \qquad {}^{40}_{19}K$$

b. Uranium-238 has a half-life of about 4.5 billion years and is used to date very old rocks.

$$^{238}_{92}U \longrightarrow 6\ {}^{0}_{-1}e + 8\ {}^{4}_{2}\alpha + \_\_\_\_\_ \qquad {}^{206}_{82}Pb$$

Exercise 2: Write complete nuclear equations for the following processes:

a. Uranium-234 is produced when a radioactive isotope undergoes alpha decay.

$$^{238}_{94}Pu \rightarrow {}^{4}_{2}\alpha + {}^{234}_{92}U$$

b. Cobalt-60 is produced when a radioactive isotope undergoes beta decay.

$$^{60}_{26}Fe \rightarrow {}^{0}_{-1}\beta + {}^{60}_{27}Co$$

Exercise 3: The inhalation of radon-222 and its decay to form other isotopes poses a health hazard. Write balanced nuclear equations for the decay of radon-222 to lead-206 in eight steps.

a. Step 1: Radon-222 decays by alpha emission. (Radon has the element symbol Rn.)

$$^{222}_{86}Rn \rightarrow {}^{4}_{2}\alpha + {}^{218}_{84}Po$$

b. Step 2: The daughter product in part a decays by alpha emission.

$$^{218}_{84}Po \rightarrow {}^{4}_{2}\alpha + {}^{214}_{82}Pb$$

c. Step 3: The daughter product in part b decays by beta and gamma emissions.

$$^{214}_{82}Pb \rightarrow {}^{0}_{0}\gamma + {}^{0}_{-1}\beta + {}^{214}_{83}Bi$$

d. Step 4: The daughter product in part c decays by beta and gamma emissions.

$$^{214}_{83}Bi \rightarrow {}^{0}_{0}\gamma + {}^{0}_{-1}\beta + {}^{214}_{84}Po$$

e. Step 5: The daughter product in part d decays by beta emission.

$$^{214}_{84}\text{Po} \rightarrow {}^{0}_{-1}\beta + {}^{214}_{85}\text{At}$$

f. Step 6: The daughter product in part e decays by alpha emission.

$$^{214}_{85}\text{At} \rightarrow {}^{4}_{2}\alpha + {}^{210}_{83}\text{Bi}$$

g. Step 7: The daughter product in part f decays by beta and gamma emissions.

$$^{210}_{83}\text{Bi} \rightarrow {}^{0}_{0}\gamma + {}^{0}_{-1}\beta + {}^{210}_{84}\text{Po}$$

h. Step 8: The daughter product in part g decays by alpha and gamma emissions.

$$^{210}_{84}\text{Po} \rightarrow {}^{0}_{0}\gamma + {}^{4}_{2}\alpha + {}^{206}_{82}\text{Pb}$$

The final stable isotope is **lead-206**.

III. Half-Life and the Amount of Sample Left

Exercise 1: a. What is the half-life for Thorium-230? _8000 y__

b. How many half-lives have passed for Thorium-230 after 32,000 years? __4__ half-lives (HL)

c. How much of an 95.6-mg sample of Thorium-230 would remain after 32,000 years?

95.6 mg ÷ 2 ÷ 2 ÷ 2 ÷ 2 = **5.98 mg**

or Amount remaining = initial amount x $(0.5)^n$ = 95.6 mg x $(0.5)^4$ = 5.98 mg

d. What is the value of the rate constant, k, for Th-230?

k = 0.693 / 8000 y = **8.66×10^{-5} y^{-1}**

e. How much of a 35.8-mg sample of Thorium-230 would remain after 18500 years?

$\ln [A_t / 35.8] = -(8.66 \times 10^{-5}\ y^{-1}) * 18500\ y$

$[A_t / 35.8] = e^{-1.60256} = 0.2014$

A_t = (0.2014)(35.8) = 7.21 mg

f. How much time will it take for a 280 mg sample of Thorium-230 to decay to 11.0 mg?

$\ln [11.0 / 280] = (-8.66 \times 10^{-5}\ y^{-1})t$

$t = (-3.237)/(-8.66 \times 10^{-5}\ y^{-1}) = 37378$ **yrs = 3.7×10^4 yrs**