HALF-LIFE CALCULATIONS

Name: Key

Half-life is the time required for one-half of a radioactive nuclide to decay (change to another element). It is possible to calculate the amount of a radioactive element that will be left if we know its half-life.

Example: The half-life of Po-214 is 0.001 second. How much of a 10 g sample will be left after 0.003 seconds?

Answer: Calculate the number of half-lives:

$$0.003 \text{ seconds} \times \frac{1 \text{ half-life}}{0.001 \text{ second}} = 3 \text{ half-lives}$$

After 0 half-lives, 10 g are left.
After 1 half-life, 5 g are left.
After 2 half-lives, 2.5 g are left.
After 3 half-lives, 1.25 g are left.

Solve the following problems.

1. The half-life of radon-222 is 3.8 days. How much of a 100 g sample is left after 15.2 days?

   (100g) $\frac{15.2}{3.8}$ = 4 half lives $\left(\frac{1}{(2)^4}\right) \times 100$ = 6.25g

2. Carbon-14 has a half-life of 5,730 years. If a sample contains 70 mg originally, how much is left after 17,190 years?

   $\frac{17190}{5730}$ = 3 half-lives $\left(\frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2}\right) \times (70)$ = 8.75 mg

3. How much of a 500 g sample of potassium-42 is left after 62 hours? The half-life of K-42 is 12.4 hours?

   $\frac{62}{12.4}$ = 5 half-lives $\left(\frac{1}{(2)^5}\right) \times (500g)$ = 15.63 g

4. The half-life of cobalt-60 is 5.26 years. If 50 g are left after 15.8 years, how many grams were in the original sample?

   $\frac{15.8}{5.26}$ = 3 half lives 50×2^3 = 400 g

5. The half-life of I-131 is 8.07 days. If 25 g are left after 40.35 days, how many grams were in the original sample?

   $40.35 \div 8.07$ = 5 half lives 25×2^5 = 800g

6. If 100 g of Au-198 decays to 6.25 g in 10.8 days, what is the half-life of Au-198?

   4 half lives passed
   $10.8 \div 4$ = 2.7 days

HALF-LIFE OF RADIOACTIVE ISOTOPES

Name ____________________

1. How much of a 100.0 g sample of ^{198}Au is left after 8.10 days if its half-life is 2.70 days?

   3 half lives $100 \times \frac{1}{(2)^3} =$

   12.5 g

2. A 50.0 g sample of ^{16}N decays to 12.5 g in 14.4 seconds. What is its half-life?

   2 half lives

   $\frac{14.4}{2} =$

   7.2 sec

3. The half-life of ^{42}K is 12.4 hours. How much of a $75\bar{0}$ g sample is left after 62.0 hours? ← this means zero is significant

   $\frac{62}{12.4}$ = 5 half lives $750g \times \frac{1}{(2)^5}$ =

   23.4g

4. What is the half-life of ^{99}Tc if a $50\bar{0}$ g sample decays to 62.5 g in 639,000 years?

   3 half lives

   $\frac{639{,}000}{3}$ =

   213,000 years

5. The half-life of ^{232}Th is 1.4×10^{10} years. If there are 25.0 g of the sample left after 2.8×10^{10} years, how many grams were in the original sample?

   $\frac{2.8 \times 10^{10}}{1.4 \times 10^{10}}$ = 2 half lives

   25×2^2

   100g

6. There are 5.0 g of ^{131}I left after 40.35 days. How many grams were in the original sample if its half-life is 8.07 days?

   $\frac{40.35}{8.07}$ = 5 half lives 5×2^5 =

   160g

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Name ______________________ Date ____________ Class ____________

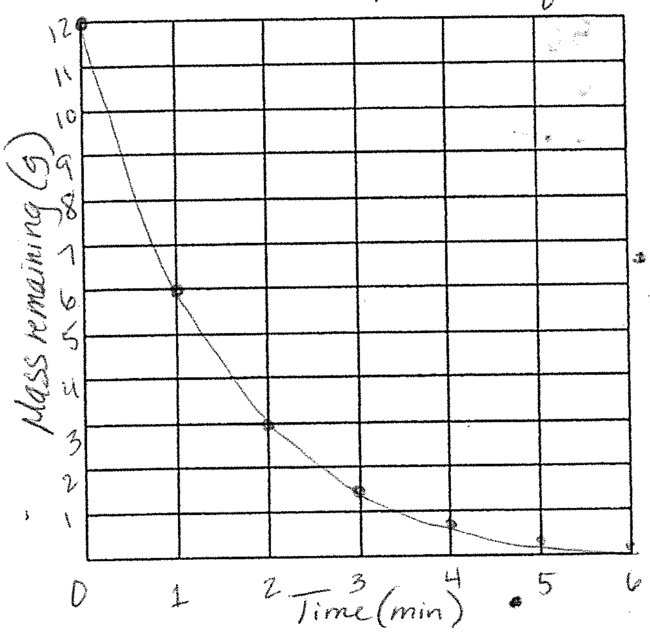
CHAPTER 26 Skip 2b, c, d Text Reference: Section 26-3

Practice Problems

1. A radioisotope's half-life is 1.000 min.

a. Given that the initial mass of a sample of this radioisotope is 12.00 g, calculate the mass of the radioisotope *that has not decayed* after 1.00 min, 2.00 min, 3.00 min, 4.00 min, 5.00 min, and 6.00 min.

b. Use the information you have just calculated to draw a graph of mass of radioisotope remaining *versus* time.



c. By interpolation of this graph, estimate the grams of radioisotope left after 1.5 min. $12g \times \left(\frac{1}{2^{1.5}}\right) = 4.24g$

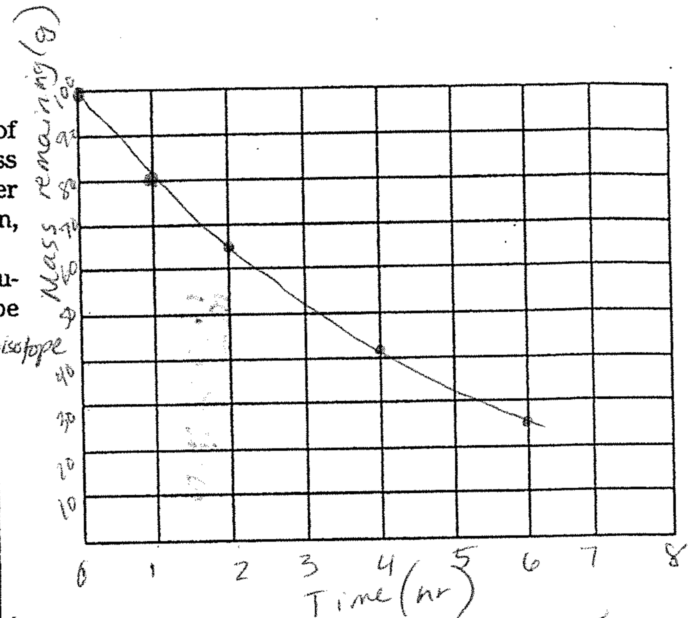
d. By interpolation, estimate the amount of time that must elapse in order for 1.0 g of the radioisotope to be present. ≈ 3.5 min

2. The initial mass of a sample of a certain radioisotope is 100.0 g. After 1.0 hour, 80.0 g of it remains; after 2.0 hours, 64.0 g remains; after 4.0 hours, 41.0 g remains; and after 6.0 hours, 26.2 g remains.

a. On the grid at the top of the next column, use this information to draw a graph of mass of radioisotope remaining versus time.

b. ~~Use the graph to estimate the half-life of the radioisotope. (Hint: Find the x-value at which half of the initial mass of the radioisotope remains.)~~

Half-life of Radioisotope



c. ~~Use your answer to **b** to calculate the amount of time required for 25 g of the radioisotope to remain. Determine the same quantity by interpolation.~~

d. ~~By extrapolation of the graph, find the mass of radioisotope remaining after 8.0 hours.~~

For questions 3–8, calculate the mass number and atomic number of the missing particle (X), given that each of these quantities must be conserved in order to produce a balanced nuclear equation. Then, referring to a table of atomic numbers of the elements, determine the chemical symbol of the missing particle. Finally, indicate whether alpha or beta decay is occurring.

3. $^{234}_{90}Th \rightarrow X + {}^{0}_{-1}e$ β — 3) $X = {}^{234}_{91}Pa$
4. $X \rightarrow {}^{214}_{82}Pb + {}^{4}_{2}He$ α — 4) $X = {}^{218}_{84}Po$
5. $^{210}_{83}Bi \rightarrow {}^{210}_{84}Po + X$ β — 5) $X = {}^{0}_{-1}e$
6. $^{226}_{88}Ra \rightarrow X + {}^{4}_{2}He$ α — 6) $X = {}^{222}_{86}Rn$
7. $^{230}_{90}Th \rightarrow {}^{226}_{88}Ra + X$ α — 7) $X = {}^{4}_{2}He$
8. $X \rightarrow {}^{234}_{92}U + {}^{0}_{-1}e$ β — 8) $X = {}^{234}_{91}Pa$

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D. Half-Life Determinations

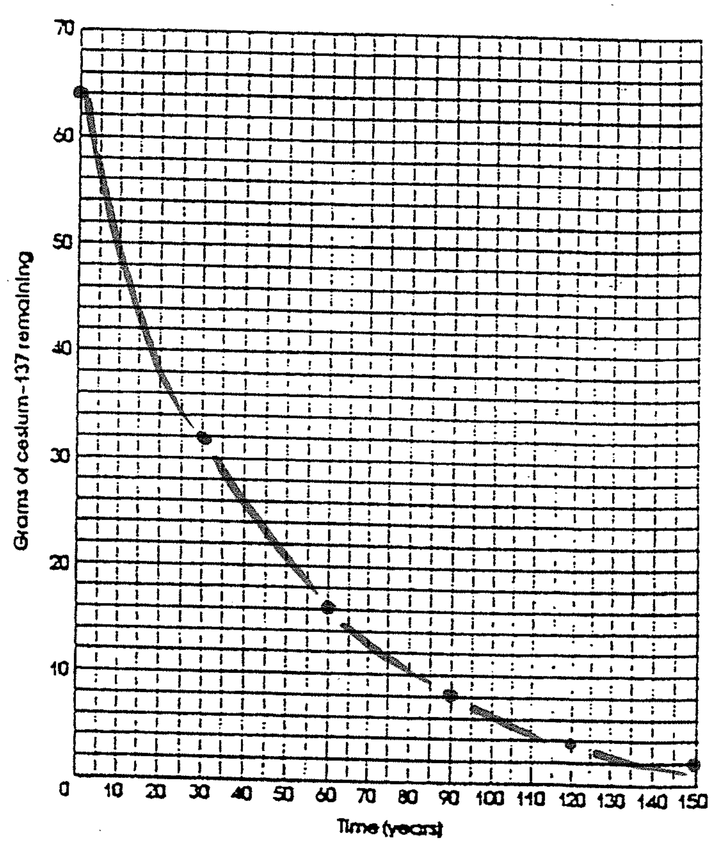
Cesium-137 is a radioactive isotope produced during fission reactions. It undergoes beta decay into barium-137, as illustrated below.

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

The half-life for this disintegration is approximately 30 years. This is the amount of time required for half the atoms in a sample to undergo decay. Assume that a 64-gram sample of Cs-137 is analyzed every 30 years for a 150-year period. Determine the grams of cesium and barium present in each sample and record these data in the table below. (Assume that the two nuclides have equal atomic mass.)

TIME	GRAMS OF CESIUM-137	GRAMS OF BARIUM-137
0 years	64 grams	0 grams
30 years	32	32
60 years	16	48
90 years	8	56
120 years	4	60
150 years	2	62

Plot the above data on the following grid.



1. How long will it take for all the cesium-137 to decay into barium-137?

Not all will decay completely – approaches Ø

Name: ______________________ Date: __________

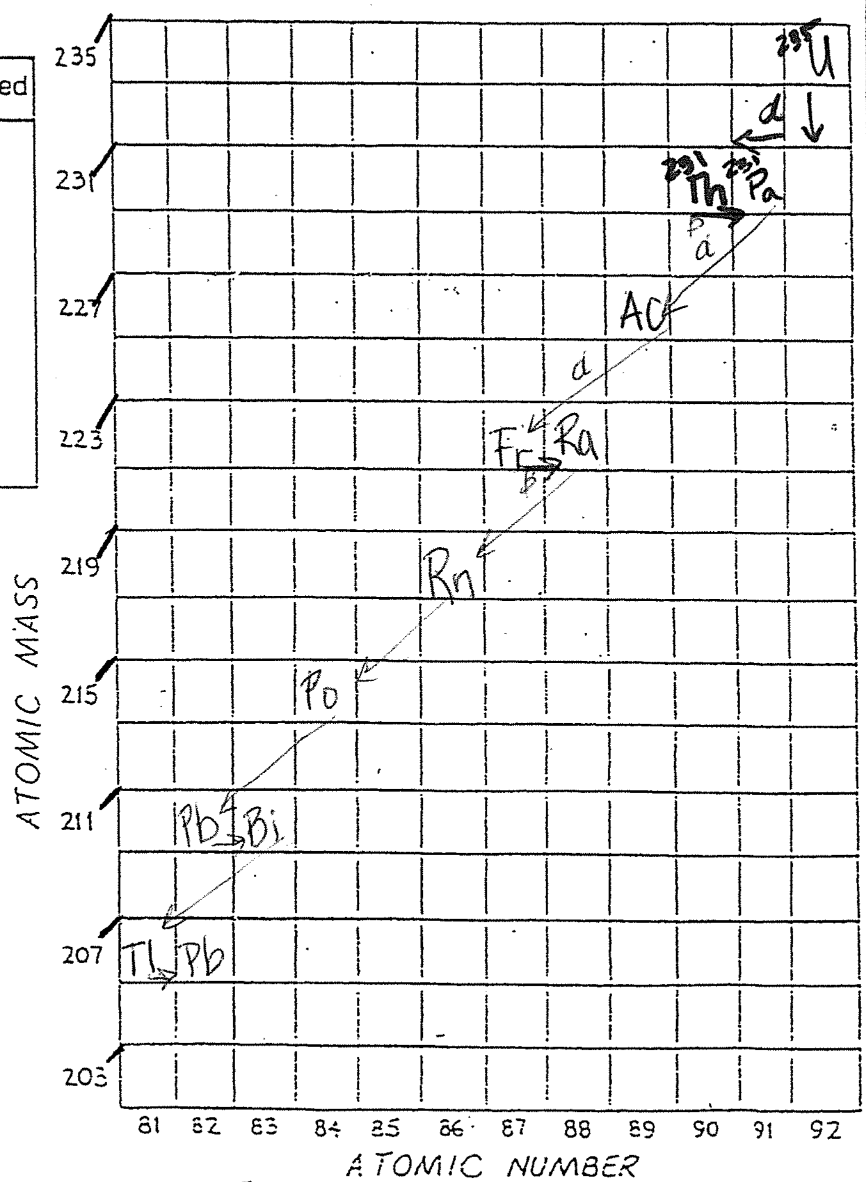
CONCEPTUAL **Physical Science** PRACTICE SHEET

Chapter 15: Radioactivity

Natural Transmutation

Draw in a decay-scheme diagram below, similar to the one on page 603 of your text. In this case you begin at the upper right with U-235 and end up with a different isotope of lead. Use the table at the left and identify each element in the series by its chemical symbol.

Step	Particle Emitted
1	Alpha
2	Beta
3	Alpha
4	Alpha
5	Beta
6	Alpha
7	Alpha
8	Alpha
9	Beta
10	Alpha
11	Beta
12	Stable



What isotope is the final product? $^{207}_{82}Pb$

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Writing Nuclear Equations

Chem Worksheet 4-4

Name ________________

In the early 1900s scientists discovered that various isotopes will undergo nuclear decay. During this process the unstable nucleus of an atom gives off radiation. When scientists studied this radiation they discovered three types of particles: alpha, beta, and gamma. The **alpha particle** is composed of two protons and two neutrons, so it has a mass of 4 amu and a charge of 2+. A **beta particle** is a high energy electron emitted from the nucleus. A **gamma ray** often accompanies the other decay processes. Gamma radiation has no charge and no mass.

Radiation Type	Symbol	Mass (amu)	Charge
Alpha	${}^{4}_{2}He$ or ${}^{4}_{2}\alpha$	4	2+
Beta	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	$\frac{1}{1840}$	1–
Gamma	${}^{0}_{0}\gamma$	0	0

Equations can be written to show how a nucleus changes during a nuclear decay process. With these nuclear equations we track the atomic number and the mass number. For this reason it is important to correctly write the symbols for each particle involved. A nuclear equation is written for an alpha decay and a beta decay below. Notice that the sum of the atomic numbers is equal on both sides of the arrow. The sum of the mass numbers is also the same on both sides.

$${}^{206}_{84}Po \rightarrow {}^{202}_{82}Pb + {}^{4}_{2}\alpha \quad \textbf{alpha decay}$$

$${}^{124}_{51}Sb \rightarrow {}^{124}_{52}Te + {}^{0}_{-1}\beta \quad \textbf{beta decay}$$

Rewrite the following equations. Fill in all the missing information.

1. ${}^{129}_{53}I \rightarrow {}^{0}_{-1}e +$ __?__ ${}^{129}_{54}Xe$
2. ${}^{216}_{86}Rn \rightarrow {}^{4}_{2}\alpha +$ __?__ ${}^{212}_{84}Po$
3. __?__ $\rightarrow {}^{4}_{2}\alpha + {}^{239}_{97}Bk$ ${}^{243}_{99}Es$
4. __?__ $\rightarrow {}^{0}_{-1}e + {}^{52}_{23}V$ ${}^{52}_{22}Ti$
5. ${}^{255}_{104}Rf \rightarrow {}^{4}_{2}\alpha +$ __?__ ${}^{251}_{102}No$
6. ${}^{85}_{35}Br \rightarrow$ __?__ ${}^{0}_{-1}e$ $+ {}^{85}_{36}Kr + {}^{0}_{0}\gamma$
7. __?__ ${}^{32}_{15}P$ $\rightarrow {}^{0}_{-1}e + {}^{32}_{16}S + {}^{0}_{0}\gamma$
8. ${}^{257}_{101}Md \rightarrow {}^{4}_{2}\alpha + {}^{4}_{2}\alpha +$ __?__ ${}^{249}_{97}Bk$

Write nuclear equations that describe the following processes.

9. Uranium-235 undergoes an alpha decay to produce thorium-231. ${}^{235}_{92}U \rightarrow {}^{231}_{90}Th + {}^{4}_{2}He$
10. Lanthanum -144 becomes cerium-144 when it undergoes a beta decay. ${}^{144}_{57}La \rightarrow {}^{144}_{58}Ce + {}^{0}_{-1}e$
11. Neptunium-233 is formed when americium-237 undergoes a nuclear decay process. ${}^{237}_{95}Am \rightarrow {}^{233}_{93}Np + {}^{4}_{2}He$
12. When protactinium-229 goes through two alpha decays, francium-221 is formed. ${}^{229}_{91}Pa \rightarrow {}^{4}_{2}He + {}^{4}_{2}He + {}^{221}_{87}Fr$
13. Uranium-238 undergoes an alpha decay and produces two gamma rays. ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He + {}^{0}_{0}\gamma + {}^{0}_{0}\gamma$
14. The neon-22 nucleus is formed when an element undergoes a beta decay. ${}^{22}_{9}F \rightarrow {}^{22}_{10}Ne + {}^{0}_{-1}e$
15. Samarium-146 is produced when an element undergoes an alpha decay. ${}^{150}_{64}Gd \rightarrow {}^{146}_{62}Sm + {}^{4}_{2}He$
16. The beta decay of dysprosium-165 creates a new element. ${}^{165}_{66}Dy \rightarrow {}^{165}_{67}Ho + {}^{0}_{-1}e$

Answer the following questions. Include the mass number when naming isotopes.

17. What atom produces scandium-47 when it goes through a beta decay? ${}^{47}_{20}Ca$
18. What new element is formed when curium-244 emits two alpha particles and three gamma rays? ${}^{236}_{92}U$

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Name ______________________ Date __________

Nuclear Decay

$^{4}_{2}He$

The following atoms all undergo alpha particle emission. Write the complete nuclear equation.

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

$^{238}_{92}U \rightarrow$ $^{234}_{90}Th$ + $^{4}_{2}He$

$^{238}_{90}Th \rightarrow$ $^{234}_{88}Ra$ + $^{4}_{2}He$

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

$^{0}_{-1}e$

The following atoms all undergo beta decay. Write the complete nuclear equation.

$^{14}_{6}C \rightarrow$ $^{14}_{7}N$ + $^{0}_{-1}e$

$^{90}_{38}Sr \rightarrow$ $^{90}_{39}Y$ + $^{0}_{-1}e$

$^{40}_{19}K \rightarrow$ $^{40}_{20}Ca$ + $^{0}_{-1}e$

$^{13}_{7}N \rightarrow$ $^{13}_{8}O$ + $^{0}_{-1}e$