HALF-LIFE PROBLEMS

Name_____ Block _____

1. An isotope of cesium (cesium-137) has a half-life of 30 years. If 1.0 g of cesium-137 disintegrates over a period of 90 years, how many g of cesium-137 would remain?

$\frac{90}{30} = 3$ ½ L.

1
0.5
.25
.125 g

2. Actinium-226 has a half-life of 29 hours. If 100 mg of actinium-226 disintegrates over a period of 58 hours, how many mg of actinium-226 will remain?

$\frac{58}{29} = 2$ h.l

100
50
25 mg

3. Sodium-25 was to be used in an experiment, but it took 3.0 minutes to get the sodium from the reactor to the laboratory. If 5.0 mg of sodium-25 was removed from the reactor, how many mg of sodium-25 were placed in the reaction vessel 3.0 minutes later if the half-life of sodium-25 is 60 seconds?

$\frac{3.0}{1.0} = 3$ h.l

5 mg
2.5
1.25
.625 mg

4. The half-life of isotope X is 2.0 years. How many years would it take for a 4.0 mg sample of X to decay and have only 0.50 mg of it remain?

3 x 2.0 yr = 6 yr

4.0
2.0
1.0
.5
3 h.l.

5. Selenium-83 has a half-life of 25.0 minutes. How many minutes would it take for a 10.0 mg sample to decay and have only 1.25 mg of it remain?

3 x 25 = 75 min

10
5
2.5
1.25
3 h.l

6. The half-life of Po-218 is three minutes. How much of a 2.0 gram sample remains after 15 minutes? Suppose you wanted to buy some of this isotope, and it required half an hour for it reach you. How much should you order if you need to use 0.10 gram of this material?

$\frac{15}{3} = 5$ h.l

2.
1
.5
.25
.125
.0625

$\frac{30m}{3} = 10$ h.l

.1 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2

102.4 g

HALF-LIFE WORKSHEET Name _____

Use Reference Table on side to assist you in answering the following questions.

Equations:

* Number-Mass on test

½ lifes:
As-81 = 33 seconds
Au-198 = 2.69 days
C-14 = 5730 years

1 How long does it take a 100.00g sample of As-81 to decay to 6.25g?

100 → 50 → 25 → 12.5 → 6.25 4 hl

4 x 33 = 132 sec.

2. How long does it take a 180g sample of Au-198 to decay to 1/8 its original mass?

$\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}$ 3 hl

3 x 2.69 = 8.07 ✓

3. What percent of a sample of As-81 remains un-decayed after 43.2 seconds?

* $N = N_0(\frac{1}{2})^{t/t_{1/2}}$

$N = (\frac{1}{2})^{43.2/33}$

$= 0.3$ 30%

4. What is the half-life of a radioactive isotope if a 500.0g sample decays to 62.5g in 24.3 hours?

500 → 250 → 125 → 62.5 3 hl

÷ 3 8.1 hr

5. How old is a bone if it presently contains 0.3125g of C-14, but it was estimated to have originally contained 80.000g of C-14?

80 → 40 → 20 → 10 → 5 → 2.5 → 1.25 → 0.625 → 0.3125 8 hl

8 x 5730 45,840 years

HALF-LIFE CALCULATIONS

Name _____

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?

   $\frac{15.2}{3.8} = 4$ hl

   100 → 50 → 25 → 12.5 → (6.25) _____

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?

   3 hl

   70 → 35 → 17.5 → (8.75) _____

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?

   $\frac{62}{12.4} = 5$ hl

   500 → 250 → 125 → 62.5 → 31.25 → 15.625 _____

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 hl

   400 → 200 → 100 → 50

   400 _____

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?

   $\frac{40.35}{8.07} = 5$ hl

   500 → 250 → 125 → 62.5 → 31.25

   500 _____

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

   100 → 50 → 25 → 12.5 → 6.25 (4 hl)

   $\frac{10.8}{4} = 2.16$ _____

Name_____ Half-life Worksheet

Half-life Worksheet

1. What is radioactivity?_____

2. What is nuclear radiation?_____

3. What is half-life?_____

4. If we start with 400 atoms of a radioactive substance, how many would remain after one half-life? _____ after two half-lives? _____ after three half-lives? _____ after four half-lives?

5. If we start with 48 atoms of a radioactive substance, how many would remain after one half-life? _____ After two half-lives? _____ after three half-lives? _____ after four half-lives? _____

6. If we start with 16 grams of a radioactive substance, how much will remain after three half-lives? _____

7. If we start with 120 atoms of a radioactive substance, how many will remain after three half-lives? _____

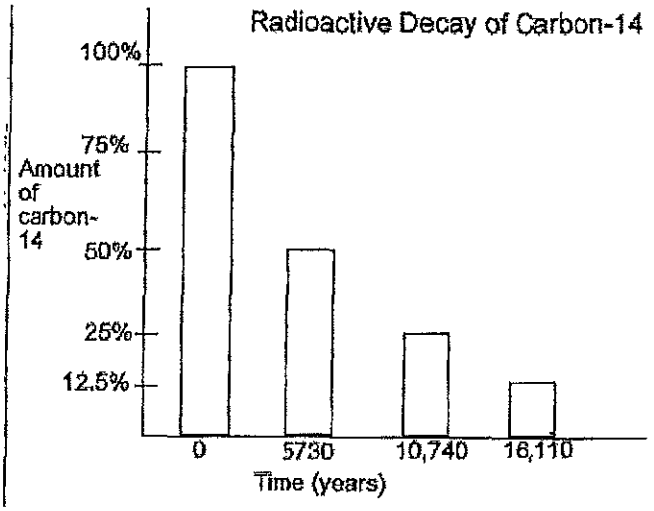
8. Which type of radiation (beta particles, gamma rays, or alpha particles) can be blocked by...

a) a piece of paper _____

c) a piece of lead _____

d) a large block of lead _____

Use the following graph to answer questions9-12...



9. How long is a half-life forcarbon-14?_____

10. If only 25% of the carbon-14remains, how old is the material containing the carbon-14?_____

11. If a sample originally had120 atoms of carbon-14, how many atoms will remain after 16,110 years?_____

12. If a sample known to be about 10,740 years old has 400 carbon-14 atoms, how many atoms were in the sample when the organism died? _____

Use the following chart to answer questions 13-16.

Radioactive Substance	Approximate half-life
Radon-222	4 days
Iodine-131	8 days
Radium-226	1600 years
Carbon-14	5,730 years
Plutonium-239	24,120 years
Uranium-238	4,470,000,000

13. If we start with 8000 atoms of radium-226, how much would remain after 3,200 years? _____

14. If we start with 20 atoms of plutonium-239, how many would remain after 48,240 years? _____

15. If we start with 60 atoms of uranium-238, how many remain after 4,470,000,000 years? _____

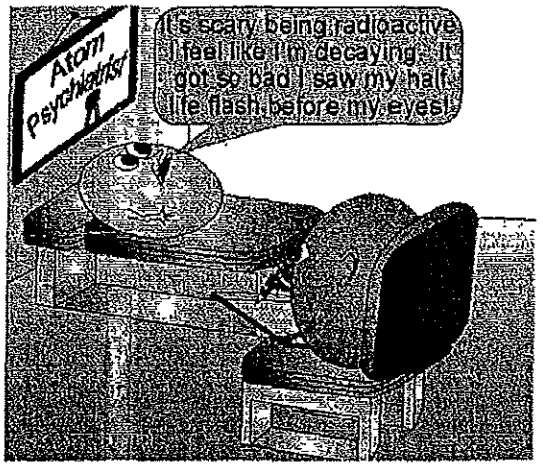
16. If we start with 24 atoms of Iodine-131, how many remain after 32 days? _____

Chemistry: Form WS12.6.1A Name _____

NUCLEAR CHEMISTRY Date _____ Period _____

Working With Half-Life

When radioactive materials decay they release high speed particles that bang into other unstable radioactive atoms, hastening their decay. As the process proceeds, the amount of radioactive material decreases. This causes the number of high speed emissions to decrease. The fewer emissions there are, the slower the decay process becomes. As a result, large samples of radioactive material decay at a faster rate than small samples. In fact, as the sample size decreases, the rate of decay slows in such a way that the amount of time it takes for half the sample to decay is constant regardless of the sample size. In other words, it takes 500 g of uranium the same amount of time to decay into 250 g of uranium as it does for 2 g of uranium to decay into 1 g of uranium. The amount of time it takes for a radioactive sample to decay to half its original mass is called the half-life.



The easiest way to solve half life problems is to set up a table.

Sample Problem

How much ^{42}K will be left in a 320 g sample after 62 h?

Step 1: Look up the half life in *Table N*, the table of Selected Radioisotopes
12.4 h

Step 2: Set up a table showing the mass, time elapsed, the fraction remaining, and number of half lives starting with the initial conditions and ending when the full time has elapsed. For each half life elapsed, cut the mass in half, increase the time by an amount equal to the half life, cut the fraction in half, and add one to the number of half lives.

Mass	Time	Fraction	Half lives
320	0	1	0
160	12.4	½	1
80	24.8	1/4	2
40	37.2	1/8	3
20	49.6	1/16	4
10	62	1/32	5

Following this procedure it is possible to determine the final mass, the time elapsed, the fraction of the original sample, or the number of half lives elapsed.

Answer the questions below using data from *Table N*, the table of *Selected Radioisotopes*.

1. How long will it take for 30 g of ^{222}Rn to decay to 7.5 g?

30
15
7.5
2 h l

2 x 3.82 d
= 7.64

2. How many grams of ^{16}N will be left from a 16 g sample after 21.6 s?

h l = 7.2 sec

21.6 / 7.2 = 3 h l

16
8
4
(2 g)

Continue ☞

3. How many half lives will it take for 50 g of ^{99}Tc to decay to 6.25 g?

4. What fraction of a sample of ^{32}P will be left after 42.9 d?

5. How long will it take for a 28 g sample of ^{226}Ra to decay to 3.5 g?

6. How long will it take for 50% of a sample of ^{131}I to decay?

7. After 9.8×10^{10} y, how many grams will be left from a 256 g sample of ^{232}Th?

8. How long will it take for 500 g of ^{90}Sr to decay to 125 g?

9. What fraction of a sample of ^{3}H will be left after 36.78 y?

Table N
Selected Radioisotopes

Nuclide	Half-Life	Decay Mode	Nuclide Name
^{198}Au	2.69 d	β^-	gold-198
^{14}C	5730 y	β^-	carbon-14
^{37}Ca	175 ms	β^+	calcium-37
^{60}Co	5.26 y	β^-	cobalt-60
^{137}Cs	30.23 y	β^-	cesium-137
^{53}Fe	8.51 min	β^+	iron-53
^{220}Fr	27.5 s	α	francium-220
^{3}H	12.26 y	β^-	hydrogen-3
^{131}I	8.07 d	β^-	iodine-131
^{37}K	1.23 s	β^+	potassium-37
^{42}K	12.4 h	β^-	potassium-42
^{85}Kr	10.76 y	β^-	krypton-85
^{16}N	7.2 s	β^-	nitrogen-16
^{19}Ne	17.2 s	β^+	neon-19
^{32}P	14.3 d	β^-	phosphorus-32
^{239}Pu	2.44×10^4 y	α	plutonium-239
^{226}Ra	1600 y	α	radium-226
^{222}Rn	3.82 d	α	radon-222
^{90}Sr	28.1 y	β^-	strontium-90
^{99}Tc	2.13×10^5 y	β^-	technetium-99
^{232}Th	1.4×10^{10} y	α	thorium-232
^{233}U	1.62×10^5 y	α	uranium-233
^{235}U	7.1×10^8 y	α	uranium-235
^{238}U	4.51×10^9 y	α	uranium-238

ms = milliseconds; s = seconds; min = minutes;
h = hours; d = days; y = years