Name: KEY Official Class: ________ Date: ____________
Teacher: ______________________________ Period: ________ Class: ____________

Half-Lives of Radioactive Isotopes

Transmutation

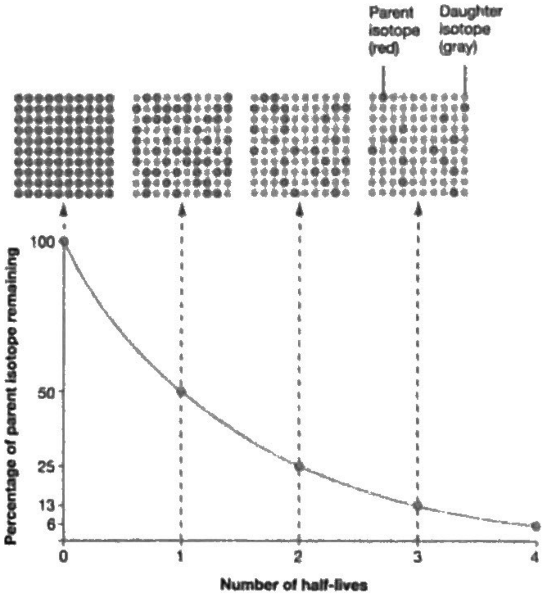
- In (natural) transmutation, the nucleus spontaneously decays into a new element.

$$^{226}_{88}Ra \rightarrow \, ^{222}_{86}Rn + \, ^{4}_{2}He$$

- In artificial transmutation, the nucleus is first bombarded with high energy particles, then decays and changes into a new element.

$$^{27}_{13}Al + \, ^{4}_{2}He \rightarrow \, ^{30}_{15}P + \, ^{1}_{0}n$$

Half-Life



- Every radioisotope has a rate of decay.
- Half-life is the time it takes for half of a sample to decay into new elements
- Table N lists half-life, decay mode (particles emitted during decay), nuclide (radioisotope, and name of nuclide.
- The half-life of Ra-226 is 1600 years; meaning, in 1600 years half of Ra-226 will decay, and in another 1600 years half of what was remaining will decay.
- After 3200 years, how many half-lives has Ra-226 gone through? 2 Half lives

Common Radioisotopes

- Carbon-14 (C-14) has a half-life of 5700 years and is used to date once living (organic) material
- Uranium-238 (U-238) has a half-life 4.5 billion years and is used to determine the age of rock
- Iodine-131 (I-131) has a half-life 8.021 days and is used for treatment of thyroid disorders
- Cobalt-60 (Co-60) has a half-life 5.271years and is used for cancer treatments

Fraction Remaining

- $^{131}_{53}I$ has a half-life of 8.07 days. A 10 gram sample was allowed to decay for 32 days. What fraction will remain?

$\frac{32}{8.07} = 4$ H.L

$1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4} \rightarrow \frac{1}{8} \rightarrow \frac{1}{16}$

1H.L 2H.L 3H.L 4H.L

$\frac{1}{16}$ remains

What is the Half-Life?

- 100 grams of a radioisotope decayed to 12 ½ grams after 90.7 years. What was the half-life?

100g → 50g → 25g → 12.5g

90.7 years

3 H.L in 90.7 years

$\frac{90.7}{3}$ = 30.2 years = 1 H.L.

What was the Initial Amount (Original Amount)

- A radioisotope has a half-life of 10 days. 1 gram remains after 40 days. What was the initial amount of the radioisotope?

HL= 10 days

$\frac{40 \text{ days}}{10 \text{ days}}$ = 4 H.L.

16 → 8 → 4 → 2 → 1

4.HL 3H.L 2HL 1HL

16g = initial amount

(work backward)

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More - Mixed Half-Life Practice

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

HL = 3.823 day (Table N) | 30 → 15 → 7.5 (1 H.L, 2 H.L) | 2 H.L | 2(3.823) = **7.646 days**

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

HL = 7.13 s (Table N) $\frac{21.6}{7.13}$ = 3 H.L 16g → 8g → 4g → 2g (1 H.L, 2 H.L, 3 H.L) **2 grams**

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

50g → 25g → 12.5g → 6.25g (1 H.L, 2 H.L, 3. H.L) **3 Half lives**

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

H.L = 14.28 days (Table N) $\frac{42.9}{14.28}$ = 3 H.L $1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4} \rightarrow \frac{1}{8}$ (1 H.L, 2 H.L, 3 H.L) **$\frac{1}{8}$ remains**

Regents Questions

1. Which radioisotopes have the same decay mode and have half-lives greater than 1 hour?

TABLE N (B)

a. Au-198 and N-16 Au = 2.695d / β- N = 7.13s / β-
b. I-131 and P-32 8.021 d / β- 14.28d / β-
c. Ca-37 and Fe-53
d. Tc-99 and U-233 2.13×10⁵y / β- 1.592×10⁵y / α

c. Ca-37 & Fe-53
Ca = 182 ms / β+
Fe = 8.51 min / β+

2. After decaying for 48 hours, 1/16 of the original mass of a radioisotope sample remains unchanged. What is the half-life of this radioisotope?

(C)

a. 3.0 h
b. 9.6 h
c. 12 h
d. 24 h

48 hours: $1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4} \rightarrow \frac{1}{8} \rightarrow \frac{1}{16}$ (1 HL, 2 HL, 3 HL, 4 HL)

48 hours
4 H.L.
$\frac{48}{4}$ = 12 hours