general all purpose eqns: ① amt. remaining = original mass × $\frac{1}{2^{\#\ 1/2\ lives}}$ ← exponent

Half-Life Calculations Workshop ② # half lives = $\frac{\text{elapsed time}}{\text{half life length}}$

Answers

Table 2: Half-lives of some radioisotopes

Radioisotope	Radiation type	Half-life	Use
barium-131	γ	11.6 days	detection of bone tumors
carbon-14	β	5730 yr	carbon dating
chromium-51	γ, X-rays	27.8 days	measuring blood volume
cobalt-60	β, γ	5.3 yr	food irradiation, cancer therapy
iodine-131	β	8.1 days	hyperthyroid treatment
uranium-238	α, β, γ	4.47×10^9 yr	dating igneous rocks

The time required for half of a sample of a radioactive isotopes to decay is called the half-life ($t_{1/2}$).

Critical Thinking Questions:

10. Consider a 100-gram sample of radioactive cobalt-60.

    a. How much time will it take before half the sample has decayed? **5.3 years**

    (This does not mean the sample decreases in mass per se – just that the radioactivity has halved.)

    b. Approximately how many grams of radioactive cobalt-60 will remain after 11 years?

    Divide: $\frac{11\ \text{years}}{5.3\ \text{years}} = 2.1$ half-lives have passed; amount remaining $= 100\,g \cdot \frac{1}{2^{2.1}} \cong$ **20 g**

    (actually about 23 g)

11. Consider a sample of iodine-131.

    a. How many half-lives would it take for the sample to decay until less than 1% of the original isotope remained?

    We start at 100% remaining: **100%** →(1) 50% →(2) 25% →(3) 12.5% →(4) 6.25% →(5) 3.125% →(6) 1.56% →(7) **.78125%**

    ∴ It takes **7 half-lives**

    b. How many days would this be?

    7 half-lives × $\frac{8.1\ \text{days}}{\text{half-life}}$ = **57 days**

12. Considering only the half lives of uranium-238 and iodine-131, which would be more appropriate for internal usage (ingestion) for medical tests? Explain.

    I-131 It's more desirable for radiation to decay quickly from the body. I-131 has a much shorter half-life than U-238.

Practice Problems

The half-life of tritium (^3_1H) is 12.3 years. If 48.0 mg (→ orig. amount) of tritium is released from a nuclear power plant during the course of a mishap, what mass of the nuclide will remain after 49.2 years?

Divide: $\frac{49.2\ \text{yrs}}{12.3\ \text{yrs}}$ = 4 half-lives pass

(12.3 yrs → one ½-life)

Amt. remaining $= 48.0\,mg \times \frac{1}{2^4} =$ **3.00 mg**

Half-Life Calculations Workshop

Technetium-104 has a half-life of 18.0 minutes. How much of a 165.0 g sample remains after 90.0 minutes?

$\frac{90.0\ \text{min}}{18.0\ \text{min}} = 5$ half-lives; amt. remaining $= 165.0\ g \times \frac{1}{2^5}$

$= \boxed{5.156\ g}$

Manganese-56 decays by beta emission and has a half-life of 2.6 hours.

A. How many half-lives are there in 24 hours? $\frac{24\ \text{hrs}}{2.6\ \text{hrs}} = \boxed{9.2\ \text{half-lives}}$

B. How many mg of a 20.0 mg sample will remain after five half-lives?

amt. remaining $= 20.0\ mg \times \frac{1}{2^5} = \boxed{0.625\ mg}$

A 20.0 g sample of thorium-234 has a half-life of 25 days. How much will remain as a percentage of the original sample after 90 days?

$\frac{90\ \text{days}}{25\ \text{days}} = 3.6$ half lives ; amt. remaining $= 20.0\ g \times \frac{1}{2^{3.6}}$

$= 1.65\ g$

amt. remaining as % $= \frac{1.65\ g}{20.0\ g} \times 100\% = \boxed{8.25\%}$

If gallium-68 has a half-life of 68.3 minutes, how much of a 10.0 mg sample is left after one half-life? Two half-lives? Three half-lives?

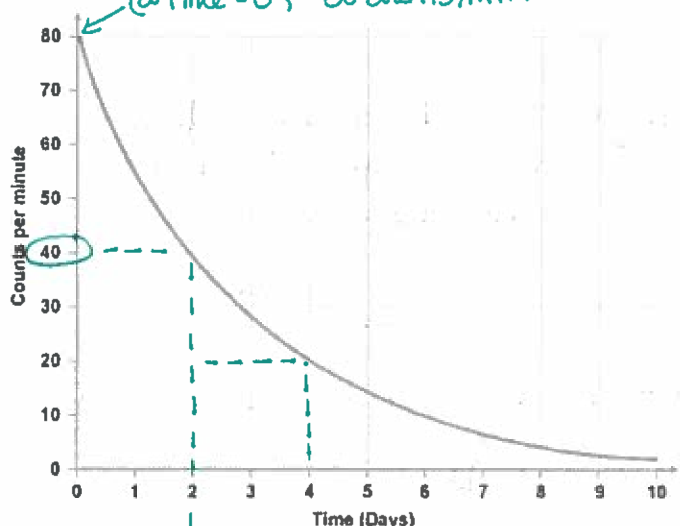
one ½ life: $\boxed{5.00\ mg\ \text{left}}$

two ½ lives: $\boxed{2.50\ mg\ \text{left}}$

three ½ lives: $\boxed{1.25\ mg\ \text{left}}$

What is the half-life of the following substance?

@time = 0, 80 counts/min



$\frac{80}{2} = 40$

Half-life is constant – it does not change rate!

$\boxed{2\ \text{days}}$