(1) ✓

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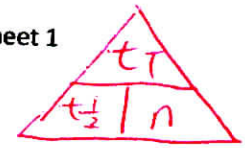
Honors Chemistry

Half-Life Practice Worksheet 1



$A_t = A_0(0.5)^n$

$A_t = A_0(\frac{1}{2})^n$

Determine Half-Life ($t_{1/2}$):

1. If 100.0 g of carbon-14 decays until only 25.0 g of carbon is left after 11 460 y, what is the half-life of carbon-14?

a. Calculate how many half-lives have passed during the decay of the 100.0 g sample. (2)

$A_0 = 100.0\,g$
$A_t = 25\,g$
$t_T = 11460\,yrs$
$t_{\frac{1}{2}} = ?$

$n = ?$ | $100/2 \xrightarrow{①} 50/2 \xrightarrow{②} 25$

$\Rightarrow$ n = 2 half lives

b. Solve for the half-life. (5730 yrs)

$t_{\frac{1}{2}} = ?$ | $t_{\frac{1}{2}} = \frac{t_T}{n} = \frac{11460\,yr}{2} =$ 5730 yrs $\Rightarrow$ half-life of carbon-14

2. What is the half-life of a 100.0 g sample of nitrogen-16 that decays to 12.5 g of nitrogen-16 in 21.6 s? (7.2 s)

$A_0 = 100\,g$
$A_t = 12.5\,g$
$t_T = 21.6\,s$
$t_{\frac{1}{2}} = ?$

$100/2 \xrightarrow{①} 50/2 \xrightarrow{②} 25/2 \xrightarrow{③} 12.5 \Rightarrow n = 3$ half lives

$t_{\frac{1}{2}} = \frac{t_T}{n} = \frac{21.6\,s}{2} =$ 7.2 seconds $\Rightarrow$ half life of nitrogen-16

3. All isotopes of technetium are radioactive, but they have widely varying half-lives. If an 800.0 g sample of technetium-99 decays to 100.0 g of technetium-99 in 639 000 yrs, what is its half-life? (213000 yrs)

$A_0 = 800\,g$
$A_t = 100\,g$
$t_T = 639000\,yr$
$t_{\frac{1}{2}} = ?$

$800/2 \xrightarrow{①} 400/2 \xrightarrow{②} 200/2 \xrightarrow{③} 100 \Rightarrow n = 3$ half lives

$t_{\frac{1}{2}} = \frac{t_T}{n} = \frac{639000\,yr}{3} =$ 213000 yrs

4. A 208 g sample of sodium-24 decays to 13.0 g of sodium-24 within 60.0 hrs. What is the half-life of this radioactive isotope? (15 hrs)

$A_0 = 208\,g$
$A_t = 13.0\,g$
$t_T = 60\,hr$
$t_{\frac{1}{2}} = ?$

$208/2 \xrightarrow{①} 104/2 \xrightarrow{②} 52/2 \xrightarrow{③} 26 \xrightarrow{④} 13$

$\Rightarrow n = 4$ half lives

$t_{\frac{1}{2}} = \frac{t_T}{n} = \frac{60\,hr}{4} =$ 15 hrs

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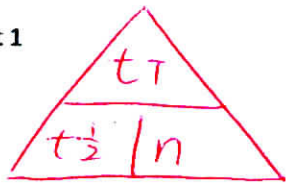

Determine Total Time elapsed (t_T):

5. Thallium-208 has a half-life of 3.053 min. How long will it take for 120.0 g to decay to 7.50 g?

$A_0 = 120.0\ g$
$A_t = 7.5\ g$
$t_{\frac{1}{2}} = 3.053\ min$
$t_T = ?$

a. Calculate how many half-lives have passed during the decay of the 120.0 g sample. (4)

$n = ?$

$120/2 \xrightarrow{①} 60/2 \xrightarrow{②} 30/2 \xrightarrow{③} 15/2 \xrightarrow{④} 7.5$

$\Rightarrow$ n = 4 half lives

b. Solve for the total time elapsed. (12.212 min)

$t_T = ?$

$t_T = (t_{\frac{1}{2}})(n) = (3.053\ min)(4) = 12.212\ min$ (time taken for thallium-208 to decay from 120g to 7.50g)

6. If the half-life of iodine-131 is 8.10 days, how long will it take a 50.00 g sample to decay to 6.25 g? (24.3 day

$A_0 = 50.0\ g$
$A_t = 6.25\ g$
$t_{\frac{1}{2}} = 8.10\ day$
$t_T = ?$

$50/2 \xrightarrow{①} 25/2 \xrightarrow{②} 12.5 \xrightarrow{③} 6.25$

$\Rightarrow n = 3$ half lives

$t_T = (t_{\frac{1}{2}})(n) = (8.10\ day)(3) =$ **24.3 days**

~~7.~~ **The half-life of hafnium-156 is 0.025 s. How long will it take a 560 g sample to decay to one-fourth its original mass?** (0.05 seconds)

$A_0 = 560\ g$
$A_t = 560(\frac{1}{4}) = 140\ g$
$t_{\frac{1}{2}} = 0.025\ s$
$t_T = ?$

$560/2 \xrightarrow{①} 280/2 \xrightarrow{②} 140\ g$

$\Rightarrow n = 2$

$t_T = (t_{\frac{1}{2}})(n) = (0.025\ s)(2) =$ **0.05 seconds**

8. Chromium-48 has a short half-life of 21.6 h. How long will it take 360.00 g of chromium-48 to decay to 11.25 g? (108 hrs)

$A_0 = 360.0\ g$
$A_t = 11.25\ g$
$t_{\frac{1}{2}} = 21.6\ h$
$t_T = ?$

$360/2 \xrightarrow{①} 180/2 \xrightarrow{②} 90/2 \xrightarrow{③} 45/2 \xrightarrow{④} 22.5/2 \xrightarrow{⑤} 11.25$

$\Rightarrow n = 5$

$t_T = (t_{\frac{1}{2}})(n) = (21.6\ h)(5) =$ **108 hrs**

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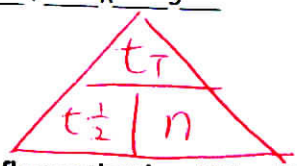
Determine the Age of an Artifact or Sample (t_T)



9. The half-life of Carbon-14 is 5730 years. A scientist finds a fossil of a flower that has 300 million atoms of Carbon-14 remaining. If a living sample of this flower has 4800 million atoms of Carbon-14, how old is the fossil? (22920 yrs old)

A_o = 4800 million atoms

A_t = 300 million atoms

$t_{\frac{1}{2}}$ = 5730 yrs

t_T = ?

4800/2 ① → 2400/2 ② → 1200/2 ③ → 600/2 ④ → 300

⇒ n = 4

$t_T = (t_{\frac{1}{2}})(n) = (5730\text{ yr})(4) = 22920$ yrs old = the age of the fossil

10. An ancient artifact is found to have a ratio of carbon-14 to carbon-12 that is 1/8 of the ratio of carbon-14 to carbon-12 found in a similar object today. How old is the artifact? (17145 yrs old)

Fraction of Remaining = $\frac{A_t}{A_o} = \frac{1}{8}$

$t_{\frac{1}{2}}$ of carbon-14 = 5715 yrs

t_T = ?

$\frac{1}{8} = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \Rightarrow n = 3$ half lives

or 1 ① → 1/2 ② → 1/4 ③ → 1/8

$t_T = (t_{\frac{1}{2}})(n) = (5715)(3) =$ 17145 yrs old

11. Assuming that a half-life of radium-226 is 1599 years, how old is an ancient sample if it is found to have a ratio of radium-226 to radium-228 that is 1/16 of the ratio found in a similar object today? (6396 yrs old)

$t_{\frac{1}{2}}$ = 1599 yrs

Fraction of Remaining = $\frac{A_t}{A_o} = \frac{1}{16}$

t_T = ?

$\frac{1}{16} = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \Rightarrow n = 4$ half lives

or 1 ① → 1/2 ② → 1/4 ③ → 1/8 ④ → 1/16

$t_T = (t_{\frac{1}{2}})(n) = (1599)(4) =$ 6396 yrs old

12. The half-life of polonium-218 is 3.0 min. If you start with 16 mg of polonium-218 and only 1.0 mg is remained after using to find the age of a sample, how old is the sample? (12 min old)

A_o = 16 mg

A_t = 1.0 mg

$t_{\frac{1}{2}}$ = 3 min

t_T = ?

Method A

16/2 ① → 8/2 ② → 4/2 ③ → 2/2 ④ → 1.0 ⇒ n = 4

$t_T = (t_{\frac{1}{2}})(n) = (3\text{ min})(4) =$ 12 min

Method B

Fraction of Remaining = $\frac{A_t}{A_o} = \frac{1.0}{16} = \frac{1}{16}$

$\frac{1}{16} = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$

⇒ n = 4

$t_T = (t_{\frac{1}{2}})(n) = (3\text{ min})(4) =$ 12 min

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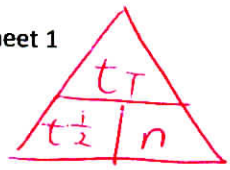

Determine Amount Remaining (A_t):

13. Gold-198 has a half-life of 2.7 days. How much of a 96 g sample of gold-198 will be left after 8.1 days?

$A_o = 96g$
$A_t = ?$
$t_{\frac{1}{2}} = 2.7$ days
$t_T = 8.1$ days

a. Calculate how many half-lives have passed during the decay of the 96 g sample. (3)

$n = ?$ | $n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{8.1 \text{ days}}{2.7 \text{ days}} =$ **3 half lives**

b. Calculate how much of the sample will remain after 3.0 half-lives. (12g)

$A_t = ?$ | $96/2 \xrightarrow{(1)} 48/2 \xrightarrow{(2)} 24/2 \xrightarrow{(3)} 12$

$\Rightarrow$ **12g will remain**

14. Potassium-46 has a half-life of 12.4 hours. How much of an 848 g sample of potassium-46 will be left after 62.0 hours? (26.5 g)

$A_o = 848g$
$A_t = ?$
$t_{\frac{1}{2}} = 12.4$ hr
$t_T = 62$ hr.

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{62}{12.4} = 5$ half lives

$848/2 \xrightarrow{(1)} 424/2 \xrightarrow{(2)} 212/2 \xrightarrow{(3)} 106/2 \xrightarrow{(4)} 53/2 \xrightarrow{(5)} 26.5g$

26.5g will remain

15. Carbon-14 has a half-life of 5730 yrs. How much of a 144 g sample of carbon-14 will remain after 17190yrs? (18 g)

$A_o = 144g$
$A_t = ?$
$t_{\frac{1}{2}} = 5730$ yrs
$t_T = 17190$ yrs

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{17190}{5730} = 3$ half lives

$144/2 \xrightarrow{(1)} 72/2 \xrightarrow{(2)} 36 \xrightarrow{(3)} 18$

$\Rightarrow$ **18 g will remain**

16. The half-life of iodine-131 is 8 days. If a hospital receives a shipment of 200 g of iodine-131, how much I-131 will remain after 32 days? (12.5g)

$A_o = 200g$
$A_t = ?$
$t_{\frac{1}{2}} = 8$ days
$t_T = 32$ days

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{32}{8} = 4$ half lives

$200/2 \xrightarrow{(1)} 100/2 \xrightarrow{(2)} 50/2 \xrightarrow{(3)} 25/2 \xrightarrow{(4)} 12.5$

$\Rightarrow$ **12.5g will remain**

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Determine Amount Original (A_o):

17. If the half-life of uranium-235 is 704000000 yrs and 12.5 g of uranium-235 remain after 2820000000 yrs, how much of the radioactive isotope was in the original sample? (200g)

$A_o = ?$
$A_t = 12.5g$
$t_{\frac{1}{2}} = 704000000 yrs$
$t_T = 2820000000 yrs$

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{2820000000}{704000} = 4$ half lives

Working Backwards:

$12.5 \times 2 \xrightarrow{(1)} 25 \times 2 \xrightarrow{(2)} 50 \times 2 \xrightarrow{(3)} 100 \times 2 \xrightarrow{(4)} 200$

$\Rightarrow$ 200g original amt

18. The half-life of Potassium-44 is 10 days. If after 50 days you end up with 15 grams of Potassium-44, how many grams did you start with? (480g)

$A_o = ?$
$A_t = 15g$
$t_{\frac{1}{2}} = 10$ days
$t_T = 50$ days

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{50}{10} = 5$ half lives

$15 \times 2 \xrightarrow{(1)} 30 \times 2 \xrightarrow{(2)} 60 \times 2 \xrightarrow{(3)} 120 \times 2 \xrightarrow{(4)} 240 \times 2 \xrightarrow{(5)} 480$

$\Rightarrow$ 480 g original amt

19. The half-life of Magnesium-26 is 30 days. How many milligrams of polonium-210 start with if there is 200 milligrams left after 150 days? (6400 mg)

$A_o = ?$
$A_t = 200 mg$
$t_{\frac{1}{2}} = 30$ days
$t_T = 150$ days

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{150}{30} = 5$ half lives

$200 \times 2 \xrightarrow{(1)} 400 \times 2 \xrightarrow{(2)} 800 \times 2 \xrightarrow{(3)} 1600 \times 2 \xrightarrow{(4)} 3200 \times 2 \rightarrow 6400$

$\Rightarrow$ 6400 mg original amt

20. The half-life of Potassium-42 is 1600 years. If after 4800 years you end up with 20 grams of Potassium-42, how many grams did you start with? (160g)

$A_o = ?$
$A_t = 20g$
$t_{\frac{1}{2}} = 1600 yrs$
$t_T = 4800 yrs$

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{4800}{1600} = 3$ half lives

$20 \times 2 \xrightarrow{(1)} 40 \times 2 \xrightarrow{(2)} 80 \times 2 \xrightarrow{(3)} 160$

$\Rightarrow$ 160 g original amt

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Determine the Fraction of the original amount remaining (A_t/A_o):

21. Fluorine-21 has a half-life of 5 seconds. What fraction of the original nuclei would remain after 1 minute? (1/4096)

$t_{\frac{1}{2}} = 5$ sec

$t_T = 1$ min $= 60$ sec

$\frac{A_t}{A_o} = ?$

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{60}{5} = 12$ half lives

$\frac{A_t}{A_o} = \left(\frac{1}{2}\right)^n = \frac{1}{2^{12}} = \frac{1}{2^3 \cdot 2^3 \cdot 2^3 \cdot 2^3} = \frac{1}{8 \times 8 \times 8} = \boxed{\frac{1}{4096}}$

22. Iodine-131 has a half-life of 8 days. What fraction of the original sample would remain at the end of 32 days? (1/16)

$t_{\frac{1}{2}} = 8$ days

$t_T = 32$ days

$\frac{A_t}{A_o} = ?$

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{32}{8} = 4$ half lives

$\frac{A_t}{A_o} = \left(\frac{1}{2}\right)^n = \frac{1}{2^4} = \boxed{\frac{1}{16}}$

23. Chromium-48 decays. After 6 half-lives, what fraction of the original nuclei would remain? (1/64)

$n = 6$

$\frac{A_t}{A_o} = ?$

$\frac{A_t}{A_o} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^6 = \frac{1}{(2)^6} = \boxed{\frac{1}{64}}$

24. The half-life of iodine-125 is 60 days. What fraction of iodine-125 nuclides would be left after 360 days? (1/64)

$t_{\frac{1}{2}} = 60$ days

$t_T = 360$ days

$\frac{A_t}{A_o} = ?$

$n = \frac{t_T}{t_{\frac{1}{2}}} = \frac{360}{60} = 6$ half lifes

$\frac{A_t}{A_o} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^6 = \frac{1}{2^6} = \frac{1}{64}$