[TP] In a process, 90.% of a substance has decayed. This corresponds to the following number of half-lives.

0%	1.	9.0
0%	2.	4.5
0%	3.	3.3
0%	4.	2.5

Response Counter

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Lecture 37 CH102 A1 (MWF 9:05 am)

Monday, May 30, 2018

- Half-life calculations
- First law, second law, equilibrium, and kinetics

Next lecture: Evaluation; Complete: First law, second law, equilibrium, and kinetics

Please bring laptop or tablet to carry out course online course evaluation.

Types of first-order decay calculations

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Types of first-order decay calculations

Given amount consumed in time t, how many half-lives have elapsed?

Given how many half-lives have elapsed in time t, what is t_{half}?

Given t_{half}, how much remains after time t?

Given amount consumed in time t, what is the rate constant k?

In n half-lives, $[A]_0$ is reduced to $\frac{1}{2}\times\frac{1}{2}\times\cdots\times\frac{1}{2}[A]_0 = \left(\frac{1}{2}\right)^n [A]_0 = [A]_n$

So, the fraction remaining tells us the number of half-lives n,

$$\frac{[A]_n}{[A]_0} = \left(\frac{1}{2}\right)^n$$

This is true even if n is not an integer!

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Finding the half-lives elapsed, *n*

In a process, a 60.% of a substance has decayed. This means …

$$\left(\frac{1}{2}\right)^n = [A]_n/[A]_0 = 0.40$$

The number of half-lives elapsed is …

$$n = \log(0.40)/\log(1/2) = -\log(0.40)/\log(2) \approx 1.3$$

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[TP] In a process, 90.% of a substance has decayed. This corresponds to the following number of half-lives.

0% 1. 9.0
0% 2. 4.5
0% 3. 3.3
0% 4. 2.5

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Types of first-order decay calculations

Given amount consumed in time t, how many half-lives have elapsed?

Given how many half-lives have elapsed in time t, what is t_{half}?

Given t_{half}, how much remains after time t?

Given amount consumed in time t, what is the rate constant k?

Given $[A]_n/[A]_0$ at time t,

solve $[A]_n/[A]_0 = \left(\frac{1}{2}\right)^n$ for n, and then …

use $n \times t_{\text{half}} = t$ to calculate $t_{\text{half}} = t/n$

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Types of first-order decay calculations

87.0% decay in 180. min. What is the half-life?

$$\left(\frac{1}{2}\right)^n = (1 - 0.870) = 0.130$$

$$n = -\log(0.130)/\log(2) = 2.94$$

$$t_{\text{half}} = 180./2.94 \text{ min} = 61.2 \text{ min}$$

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[TP] In a first order process, 90.% of a substance has decayed in 33. minutes. The half-life for the process is ...

0%	1.	10 min
0%	2.	11 min
0%	3.	17 min
0%	4.	None of these

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Types of first-order decay calculations

Given amount consumed in time t, how many half-lives have elapsed?

Given how many half-lives have elapsed in time t, what is t_{half}?

Given t_{half}, how much remains after time t?

Given amount consumed in time t, what is the rate constant k?

Given t_{half} and elapsed time t,

get the number of half-lives and ...

then evaluate $\left(\frac{1}{2}\right)^n = [A]_n/[A]_0$

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Types of first-order decay calculations

$t_{half} = 74$ minutes. How much remains after 13 minutes?

$n = 13$ min / 75 min = 0.17

$\left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^{0.17} = 0.89$

Therefore 89 % remains and $(1 - 0.89) \times 100$ % = 11% has decayed.

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Types of first-order decay calculations

Given amount consumed in time t, how many half-lives have elapsed?

Given how many half-lives have elapsed in time t, what is t_{half}?

Given t_{half}, how much remains after time t?

Given amount consumed in time t, what is the rate constant k?

Given $[A]_n/[A]_0$ at time t,

solve $\ln([A]_n/[A]_0) = -kt$ to get k

special case: solve $\ln(1/2) = -kt_{half}$ to get k

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Types of first-order decay calculations

In a first order process, 90.% of a substance has decayed in 33. minutes. What is the rate constant?

$k = -\ln(1 - 0.90)/(33\ \text{min}) = 0.070/\text{min}$

Check:

$e^{-kt} = e^{-(0.070 \times 33)} = 0.10$

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[Quiz] In a first order process, 69. % of a substance has decayed in 17. minutes. What % would have decayed if instead only 8.5 minutes elapsed?

0% 1. 37. %
0% 2. 63. %
0% 3. 44. %
0% 4. 56. %
0% 5. None of the above

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Types of first-order decay calculations

In a first order process, 69.0% of a substance has decayed in 17. minutes. What % would have decayed if instead only 8.5 minutes elapsed?

$\left(\frac{1}{2}\right)^n = 0.310$, so $n = -\frac{\log(0.310)}{\log(2)} = 1.69$

$t_{half} = \frac{17.0}{1.69}\ \text{min} = 10.1\ \text{min}$

$\left(\frac{1}{2}\right)^{8.5/10.1} = 0.56$, so 44 % would have decayed in 8.5 min

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Types of first-order decay calculations

In a first order process, 69.0% of a substance has decayed in 17. minutes. What % would have decayed if instead only 8.5 minutes elapsed?

$\ln(0.310) = -k \times 17\ \text{min}$

$\ln(x) = -k \times 8.5\ \text{min}$

$\ln(x) = \ln(0.310)\ 8.5/17 = -0.586$

$x = e^{-0.586} = 0.56$, so 44 % would have decayed in 8.5 min

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Types of first-order decay calculations

The essential equations of half-life are

$$\left(\frac{1}{2}\right)^n = \frac{[\mathrm{A}]_n}{[\mathrm{A}]_0}$$

$$\ln\left(\frac{[\mathrm{A}]_t}{[\mathrm{A}]_0}\right) = -kt$$

$$nt_{\mathrm{half}} = t$$

Get as much practice as you can using these to carry out the various kinds of half-life calculations.

