AP CHEMISTRY

TOPIC 8: KINETICS, PART B, EXAMPLES, PART III

Day 102:

- First-Order Reactions
- Half-Life
- Second-Order Reactions

Example #1. A certain first-order reaction is 73.0% complete in 110 seconds. Determine the rate constant and the half-life for this process.

If the reaction is 73% complete,then 73% of the original concentration is consumed, leaving 27%.

[A]$_t$ = 27% of [A]$_0$ or [A]$_t$ = 0.27 [A]$_0$; $\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$, $\ln\left(\frac{0.27}{1.00}\right) = -k\,(\,110 \text{ sec}\,)$

ln (0.27) = - k (110 sec), - 1.309 = - k (110 sec)

$$k = \frac{-1.309}{-110 \text{ sec}} = 1.19\times10^{-2} \text{ sec}^{-1}$$

Half – life

$$t_{1/2} = \frac{\ln\,(0.5)}{k} = \frac{-0.693}{-k} \quad ; \quad t_{1/2} = \frac{0.693}{\left(\frac{1.19\times10^{-2}}{\text{sec}}\right)} = \frac{0.693(\text{sec})}{1.19\times10^{-2}} = 58.2 \text{ sec}$$

Example #2. A first-order reaction is 20.5% complete in 200 seconds.

a) Calculate the rate constant.
b) What is the value (amount of time) at the half-life.
c) How long will it take for the reaction to go to 45%, and 85% completion?

a) *If the reaction is 20.5% complete,then 20.5% of the original concentration is consumed, leaving 79.5%.*

[A]$_t$ = 79.5% of [A]$_0$ or [A]$_t$ = 0.795 [A]$_0$; $\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$, $\ln\left(\frac{0.795}{1.00}\right) = -k\,(200 \text{ sec})$

ln (0.795) = - k (200 sec), - 0.229 = - k (200 sec)

$$k = \frac{-0.229}{-200 \text{ sec}} = 1.145\times10^{-3} \text{ sec}^{-1}$$

b) $$t_{1/2} = \frac{-0.693}{-k} \quad ; \quad t_{1/2} = \frac{-0.693(\text{sec})}{-1.15\times10^{-3}} = 604 \text{ sec}$$

c) *If the reaction is 45% complete, then 55% of the original concentration is consumed, leaving 55%.*

[A]$_t$ = 55% of [A]$_0$ or [A]$_t$ = 0.55 [A]$_0$; $\ln\left(\frac{[A]_t}{[A]_0}\right) = -kt$, $\ln\left(\frac{0.55}{1.00}\right) = -\left(1.15\times10^{-3}\right) t$

$$t = \frac{-0.598(\text{sec})}{-1.15\times10^{-3}} = 520 \text{ sec}$$

$$\boxed{t = \frac{-1.897(\text{sec})}{-1.15\times10^{-3}} = 1650 \text{ sec} \quad (\text{ 85 \% answer })}$$

Example #3. A certain second-order reaction is 67.0% complete in 27.3 seconds. Determine the rate constant and the half-life for this process.

If the reaction is 67% complete, then 67% of the original concentration is consumed, leaving 33%.

$[A]_t = 33\%$ *of* $[A]_0$ *or* $[A]_t = 0.33\,[A]_0$; $\quad \dfrac{1}{[A]_t} - \dfrac{1}{[A]_0} = kt$

the equation then becomes:

$$\frac{1}{0.33\ M} - \frac{1}{1.00\ M} = k(27.3\ \text{sec})$$

then subtract alike terms:

$$\frac{3.\overline{03}}{M} - \frac{1}{M} = k(27.3\ \text{sec}) = \frac{2.\overline{03}}{M}$$

the equation then becomes:

$$\frac{2.\overline{03}}{(27.3\ \text{sec})(M)} = k = 0.07437\ \text{sec}^{-1}\ M^{-1}$$

Now, that you know k, solve for the half-life period:

$$\frac{1}{[A]_0} = kt_{1/2}\ ;\ t_{1/2} = \frac{1}{[A]_0(k)} = \frac{1(\text{sec}\ M)}{(1.00\ M)(0.07437)} = 13.4\ \text{sec}$$