Integrated Rate Laws and Half-Life

1. Dimethyl ether, CH_3OCH_3, decomposes at 525.0 °C. The rate constant is $7.6 \times 10^{-4}\ s^{-1}$.

   $CH_3OCH_3\ (g) \rightarrow CH_4\ (g) + H_2\ (g) + CO\ (g)$

   If the initial pressure of CH_3OCH_3 is 143 mmHg, what is its pressure after 1126 seconds?

   From the units of k, this is first order.

   $ln\left(\frac{[CH_3OCH_3]_t}{[CH_3OCH_3]_o}\right) = -kt$ $[CH_3OCH_3]_t$ = ? $[CH_3OCH_3]_o$ = 143 mmHg

   T = 1126 s k = $7.6 \times 10^{-4}\ s^{-1}$

   Solve equation for $\ln[CH_3OCH_3]_t$

   $ln[CH_3OCH_3]_t = -kt + ln[CH_3OCH_3]_o$

   $ln[CH_3OCH_3]_t = -7.6 \times 10^{-4} s^{-1} \times 1126 s + \ln(143\ mmHg) = 4.107$

   $ln[CH_3OCH_3]_t = 4.107$ take antilog of both sides of equation

   $[CH_3OCH_3]_t = e^{4.107} = \mathbf{60.8\ mmHg}$

2. The decomposition of NO_2 at 310°C has a rate constant of $0.544\ M^{-1}s^{-1}$. If the initial concentration of NO_2 was 0.0480 M, what is the concentration after 0.250 hr?

   According to the units of k, this is second order.

   $\frac{1}{[A]_t} = kt + \frac{1}{[A]_o}$ k = $0.544\ M^{-1}s^{-1}$ $[A]_o$ = 0.0489 M t = 900 s

   $\frac{1}{[A]_t} = 0.544\ M^{-1}s^{-1} \times 900\ s + \frac{1}{0.0489\ M} = 510\ M^{-1}$

   $[A]_t = 1/510\ M^{-1} = \mathbf{1.96 \times 10^{-3}\ M}$

3. The half-life for the first order dissociation of I_2 at 352 °C is 2.56 s. If we start with 0.0450 M I_2, how much will remain after 4.52 s?

   Find k using half-life. $t_{1/2} = \frac{0.693}{2.56\ s} = 0.2707\ /s$

   $ln\left(\frac{[I_2]_t}{[I_2]_o}\right) = -kt$ $[I_2]_o$ = 0.0450 M $[I_2]_t$ = ? t = 4.52 s k = 0.2707/s

   $ln\left(\frac{[I_2]_t}{0.0450\ M}\right) = -0.2707\ s^{-1} \times 4.52\ s = -1.22$ take antilog of both sides

   $\frac{[I_2]_t}{0.0450\ M} = e^{-1.22}$ $[I_2]_t = e^{-1.22} \times 0.0450\ M = \mathbf{0.0133\ M}$