Half-Lives of Common Rate Laws for R → P

The table below shows how to derive the half-life expression for the three common types of rate laws. In addition, there also are some observations about how to use the pattern of successive half-lives to identify a reaction's rate law. You are responsible for knowing the half-life equations (although they are relatively easy to derive if needed).

	Zero-Order Reaction	First-Order Reaction	Second-Order Reaction
Begin by writing the linear form of the rate law	$[R]_t = [R]_o - kt$	$\ln[R]_t = \ln[R]_o - kt$	$\frac{1}{[R]_t} = \frac{1}{[R]_o} + kt$
Next, substitute $[R]_t = \frac{1}{2}[R]_o$ at time $t = t_{1/2}$	$\frac{1}{2}[R]_o = [R]_o - kt_{1/2}$	$\ln(\frac{1}{2}[R]_o) = \ln[R]_o - kt_{1/2}$	$\frac{1}{\frac{1}{2}[R]_o} = \frac{1}{[R]_o} + kt_{1/2}$
Then, solve for $t_{1/2}$	$kt_{1/2} = [R]_o - \frac{1}{2}[R]_o$ $kt_{1/2} = \frac{1}{2}[R]_o$ $t_{1/2} = \frac{[R]_o}{2k}$	$kt_{1/2} = \ln[R]_o - \ln(\frac{1}{2}[R]_o)$ $kt_{1/2} = \ln\frac{[R]_o}{\frac{1}{2}[R]_o}$ $kt_{1/2} = \ln 2$ $t_{1/2} = \frac{0.693}{k}$	$kt_{1/2} = \frac{1}{\frac{1}{2}[R]_o} - \frac{1}{[R]_o}$ $kt_{1/2} = \frac{2}{[R]_o} - \frac{1}{[R]_o}$ $kt_{1/2} = \frac{1}{[R]_o}$ $t_{1/2} = \frac{1}{k[R]_o}$
How to use information about half-lives to determine the rate law for a reaction	For a zero-order reaction, each successive half-life is exactly ½ of the previous half-life. Thus, if the first half-life is 50 seconds, then the next two half-lives are 25 seconds and 12.5 seconds	For a first-order reaction, each successive half-life is exactly the same as the preceding half-life. Thus, if the first half-life is 50 seconds, then the second and third half-lives also are 50 seconds	For a second-order reaction, each successive half-life is exactly twice as large as the previous half-life. For example, if the first half-life is 50 seconds, then the second half-life is 100 seconds and the third half-life is 200 seconds.