# Integrated Rate Laws and Their Half-Lives

**Zero-Order Reaction**

**rate law**

$$R = k$$

**differential rate law**

$$-\frac{d[\mathrm{A}]}{dt} = k$$

**derivation of integrated rate law**

$$d[\mathrm{A}] = -k dt$$
$$\int d[\mathrm{A}] = -k \int dt$$
$$[\mathrm{A}]_t - [\mathrm{A}]_0 = -kt$$
$$[\mathrm{A}]_t = [\mathrm{A}]_0 - kt$$

**half-life**

$$t_{1/2} = \frac{[\mathrm{A}]_0}{2k}$$

**form of linear plot and how to interpret plot and half-lives**

$[\mathrm{A}]_t$ vs $t$; slope $= -k$; $y$-intercept $= [\mathrm{A}]_0$; each successive half-life is 50% of previous half-life

**First-Order Reaction**

**rate law**

$$R = k[\mathrm{A}]$$

**differential rate law**

$$-\frac{d[\mathrm{A}]}{dt} = k[\mathrm{A}]$$

**derivation of integrated rate law**

$$\frac{1}{[\mathrm{A}]}d[\mathrm{A}] = -kdt$$
$$\int \frac{1}{[\mathrm{A}]}d[\mathrm{A}] = -k\int dt$$
$$\ln[\mathrm{A}]_t - \ln[\mathrm{A}]_0 = -kt$$
$$\ln[\mathrm{A}]_t = \ln[\mathrm{A}]_0 - kt$$

**half-life**

$$t_{1/2} = \frac{0.693}{k}$$

**form of linear plot and how to interpret plot and half-lives**

$\ln[\mathrm{A}]_t$ vs $t$; slope $= -k$; $y$-intercept $= \ln[\mathrm{A}]_0$; each successive half-life equals previous half-life

**Second-Order Reaction**

**rate law**

$$R = k[\mathrm{A}]^2$$

**differential rate law**

$$-\frac{d[\mathrm{A}]}{dt} = k[\mathrm{A}]^2$$

**derivation of integrated rate law**

$$\frac{1}{[\mathrm{A}]^2}d[\mathrm{A}] = -kdt$$
$$\int \frac{1}{[\mathrm{A}]^2}d[\mathrm{A}] = -k\int dt$$
$$-\frac{1}{[\mathrm{A}]_t} + \frac{1}{[\mathrm{A}]_0} = -kt$$
$$\frac{1}{[\mathrm{A}]_t} = \frac{1}{[\mathrm{A}]_0} + kt$$

**half-life**

$$t_{1/2} = \frac{1}{k[\mathrm{A}]_0}$$

**form of linear plot and how to interpret plot and half-lives**

$\frac{1}{[\mathrm{A}]_t}$ vs $t$; slope $= +k$; $y$-intercept $= \frac{1}{[\mathrm{A}]_0}$; each successive half-life is $2\times$ previous half-life