Chemical Kinetics
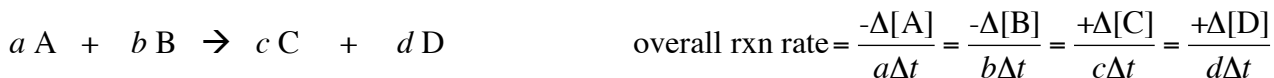
All rates written as $\frac{\Delta conc}{\Delta time}$ or $\frac{\Delta[A]}{\Delta t}$. Instantaneous rate is the slope of a concentration vs time plot and is shown by the differential equation: $\frac{d[A]}{dt}$. Overall rates for forward reactions are shown as POSITIVE rates, therefore, all reactants (which have negative rate of change) must have their rates negated $\left(\frac{-d[A]}{dt}\right)$.

In general for the overall reation:

$$a\,A \ + \ b\,B \ \rightarrow \ c\,C \ + \ d\,D \qquad\qquad \text{overall rxn rate} = \frac{-\Delta[A]}{a\Delta t} = \frac{-\Delta[B]}{b\Delta t} = \frac{+\Delta[C]}{c\Delta t} = \frac{+\Delta[D]}{d\Delta t}$$

Note that each individual rate is divided by it's coefficient in the balanced chemical equation.

Rate Laws for: $a\,A \rightarrow$ products

Zero Order	First Order	Second Order
rate = k	rate = $k[A]$	rate = $k[A]^2$
$[A]_0 - [A]_t = akt$	$\ln[A]_0 - \ln[A]_t = akt$ $\ln\left(\frac{[A]_0}{[A]}\right) = akt$	$\frac{1}{[A]_t} - \frac{1}{[A]_0} = akt$
$[A]_t = -akt + [A]_0$	$\ln[A]_t = -akt + \ln[A]_0$	$\frac{1}{[A]_t} = akt + \frac{1}{[A]_0}$
$t_{1/2} = \frac{[A]_0}{2ak}$	$t_{1/2} = \frac{\ln 2}{ak}$	$t_{1/2} = \frac{1}{ak[A]_0}$

half-life ($t_{1/2}$) is the time it takes for the concentration to drop to one half its current value.

Temperature dependence of rate (Arrhenius) $k = A e^{-(Ea/RT)}$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \qquad\qquad \ln\left(\frac{t_1}{t_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Note this is the typical Arrhenius Equation where you have 2 specific rate consants at 2 specific temperatures. Remember they come in pairs. Also note how the Arrhenius factor A, has factored OUT of the equation.

This is still the Arrhenius Equation, EXCEPT we now show TIME in place of rate constant. Time is inversely proportional to rate so the positions are switched. Any common timed event will work – half-life is the most common.

Electrochemistry

$$E_{cell} = E_{reduction} + E_{oxidation} \qquad\qquad \Delta G = -nFE \qquad\qquad \frac{I \cdot t}{n \cdot F} = moles$$

$$E = E° - \frac{RT}{nF}\ln Q \qquad\qquad E = E° - \frac{0.0257}{n}\ln Q \qquad\qquad E = E° - \frac{0.05916}{n}\log Q$$