Rate Law

$Rate = k[A]^n$

rate constant

order of rxn with respect to A

reactant

Rate:

How to describe the rate of a reaction with a chemical equation:

1. Using concentration data:

   ex) $2NO_2 \rightarrow 2NO + O_2$

   The Rate of the reaction can be expressed as the **change in concentration over time**

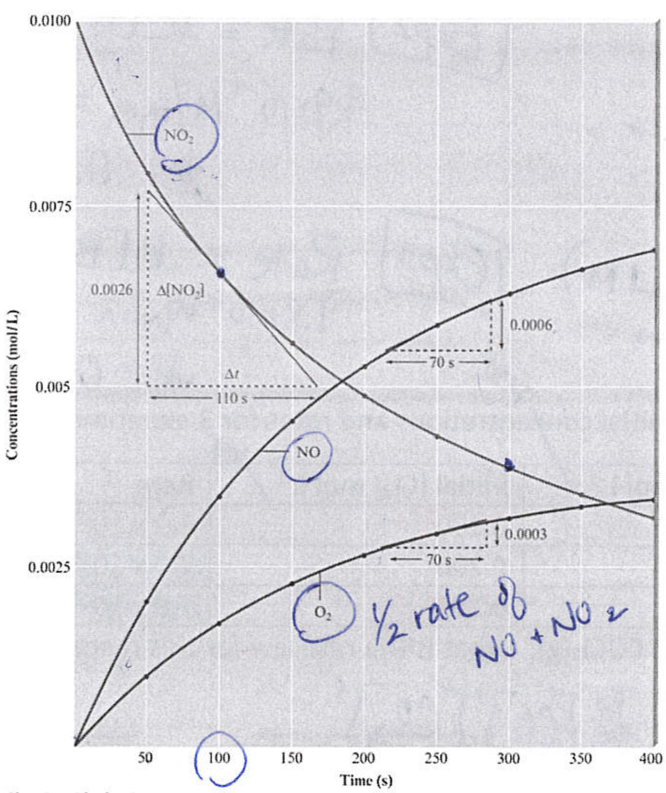
   Rate = -Δ[reactant]/Δtime OR Rate = +Δ[product]/Δtime = k[ ]^n

$$Rate = \frac{-\Delta[NO_2]}{\Delta t} = \frac{+\Delta[NO]}{\Delta t} = \frac{2 + \Delta[O_2]}{\Delta t}$$

2. Using graphical data (concentration vs. time) to find **instantaneous rate**

@ specific time (t)

use the slope of tangent line @ t



©Cengage Learning All Rights Reserved.

$A + B \rightarrow C$

Rate Law: $Rate = k[A]^{m}[B]^{n}$

m ← order with respect to A

n ← order with respect to B

overall order of rxn = m + n

rate constants can have different units

Finding the Rate Law with the **method of initial rates:**

1. **Reaction: A + B → C**

Experiment	[A] zero order	[B] first order	Rate M/min
1	1.00 M	1.00 M	4.9 x 10^{-1}
2	2.00 M	1.00 M	4.9 x 10^{-1}
3	1.00 M	2.00 M	9.8 x 10^{-1}

Write the rate law for this reaction.

$Rate = k[A]^{0}[B]^{1} = k[B]$

Solve for the rate law constant. = k

Exp1 $Rate = k[B]$

4.9×10^{-1} M/min $= k(1M)$

$k = 0.49\ min^{-1}$

Exp2 $Rate = k[B]$

4.9×10^{-1} M/min $= k(1M)$

$k = 0.49\ min^{-1}$

Exp3 $Rate = k[B]$

9.8×10^{-1} M/min $= k(2M)$

$k = 0.49\ min^{-1}$

2. The following table gives the initial concentrations and rates for 3 experiments.

Experiment	Initial [CO] mol L^{-1} 1st	Initial [Cl_2] mol L^{-1} 1st	Rate
1	0.200	0.100	3.9 x 10^{-25}
2	0.100	0.200	3.9 x 10^{-25}
3	0.200	0.200	7.8 x 10^{-25}

Reaction: CO(g) + Cl_2(g) → $COCl_2$(g). What is the rate law for this reaction?

$Rate = k[CO]^{1}[Cl_2]^{1}$

3. $2ClO_2(aq) + 2OH^{-1}(aq) \rightarrow ClO_3^{-1}(aq) + ClO_2^{-1}(aq) + H_2O(g)$

A series of experiments were conducted to study this reaction. The initial rates are recorded in the table below.

first order   2nd order   overall order = 3

Experiment	Initial $[OH^{-1}]$ M	Initial $[ClO_2]$ M	Rate M/min
1	0.030	0.020	0.166
2	0.060	0.020	0.331
3	0.030	0.040	0.661

a. Determine the order of the reaction with respect to each reactant.
b. Write the rate law.
c. Determine the value of the rate constant, making sure the units are included.
d. Determine the rate when $[OH^{-1}]$ is 0.050 M and $[ClO_2]$ is 0.050 M.

b) $Rate = k[OH^-][ClO_2]^2$

c) $0.166\ M/min = k\underset{M}{(0.030)}\underset{M}{(0.020)}^2$

$\boxed{k = 13{,}800\ M^{-2}\ min^{-1}}$

watch the units

d) $Rate = k[OH^-][ClO_2]^2$

$= (13{,}800\ M^{-2} min^{-1})(0.050\ M)(0.050\ M)^2$

$Rate = 1.\cancel{725}$

$\boxed{1.73\ M/min}$