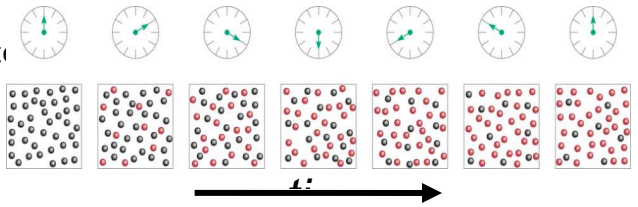
Ch. 11 - Kinetics (Reaction Rat



Kinetics/Reaction Rates

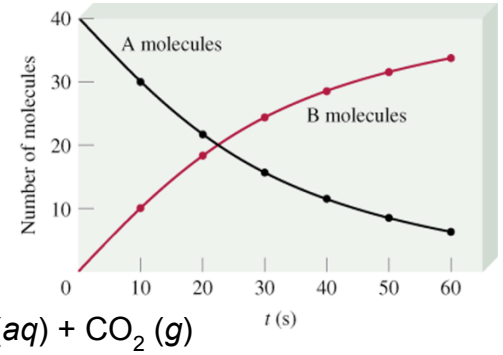
I. Kinetics:

A. Reaction (rxn) rate: , namely, for the reaction A → B, :

1.

2.

3.



II. Units:

A. Rxn rate is found by the

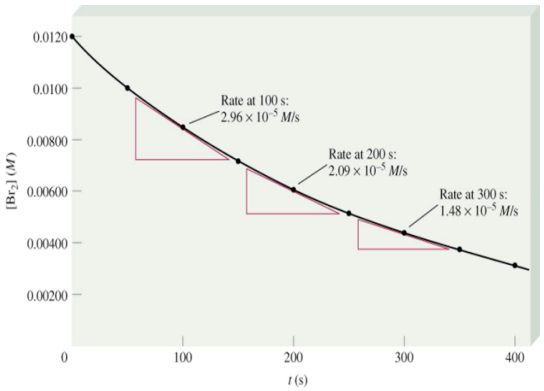
1.

2.

3.

$Br_2\ (aq) + HCOOH\ (aq) \longrightarrow 2Br^-\ (aq) + 2H^+\ (aq) + CO_2\ (g)$

Time (s)	$[Br_2]$ (*M*)
0.0	0.0120
50.0	0.0101
100.0	0.00846
150.0	0.00710
200.0	0.00596
250.0	0.00500
300.0	0.00420
350.0	0.00353
400.0	0.00296



Average rate:

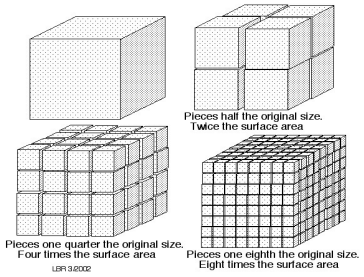
Instantaneous rate:

III. Graph:

A. For eq: $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$,

1. What happens to the conc. of products and the reactant as the reaction progresses?

Factors Affecting Reaction Rates



I. :

A. A reaction happens if occur.

B. Collisions must have AND

1. is called

II. The factors (all relationships):

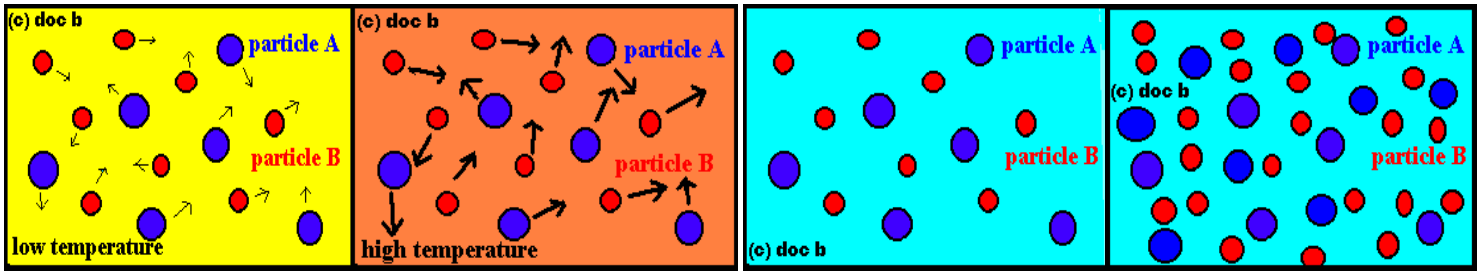
A. Temperature:

B. Reactant concentration:

C. Surface area of a solid:

D. Pressure (only for gases):

E. Catalysts: More on this later.

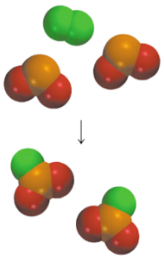


Ch. 11 - Kinetics (Reaction Rates)

Rate Laws

I. How rate laws are determined
 A. ALWAYS
 B. ALWAYS using
 C. Initial rates are used because

II. Two types of rate laws:
 A.



$$F_2 + 2ClO_2 \rightarrow 2FClO_2$$

$$\text{rate} = k[F_2][ClO_2]$$

  1.
   a. k=
   b. [A] and [B] =
   c. x,y =
   d.
  2. Order of reaction:
   a.
    i. k[A]
    ii. k[A][B]
    iii. $k[A]^2$
    iv. $k[A][B]^2$
    v. k
   b. We will only be focusing on
  3. Units of k
   a. depends on the (remember:)
    i. 0 order:
    ii. 1st order:
    iii. 2nd order:
  4. Finding the rate law: Steps:
   a. You will be given a table of data showing different experiments
    i. Choose two experiments. so that all but one of the variables cancels when divided.
    ii. Use this eq.:

    iii. Cancel all but one to find x then repeat to find y
    iv. Use the rate law for one (or the average of all) of the experiments to find k.
    v. Use dimensional analysis to find the units of k.

Ch. 11 - Kinetics (Reaction Rates)

Integrated Rate Law

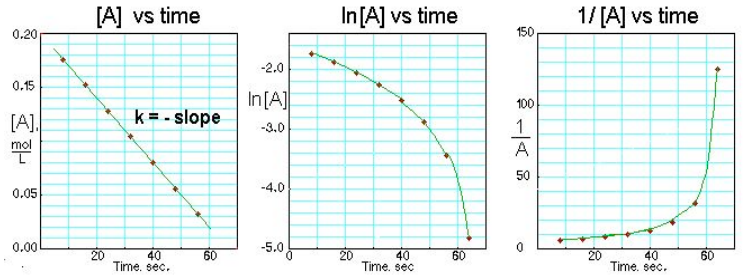
I. takes the form of
   A. y=
   B. x= m= b=

II. Affect of order on integrated rate law:
   A. 0 order:

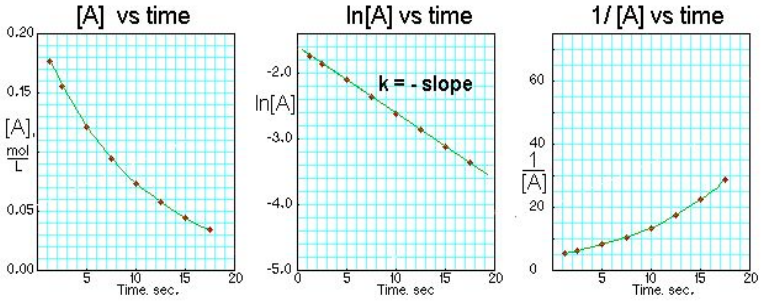
   B. 1st order:

   C. 2nd order:

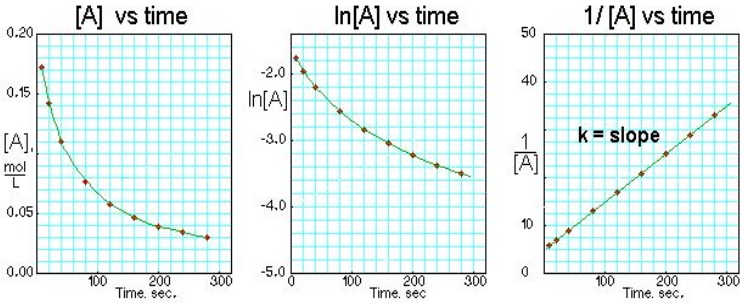
III. Used when the plot of conc. v. time is used.
   A. 0 order: $[A] = -kt + [A_0]$
      1. If is plotted, you will get a straight line.



   B: 1st order: $\ln[A] = -kt + \ln[A_0]$.
      1. If you will get a straight line.



   C: 2nd order: $(1/[A]) = kt + (1/[A_0])$
      1. If , you will get a straight line.
      2. Note



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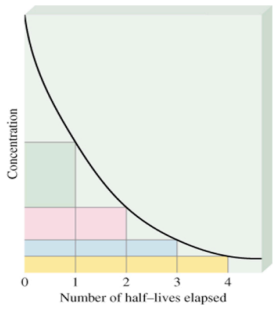
IV. Using the integrated rate law…
1. If given conc. data v. time, use this law.
2. Plot [A], ln[A] and 1/[A] v. time.
3. Draw a line through the points.
4. The graph that gives the straightest line is the order of the reaction.
5. To find the rate constant, k, find the slope of the line (Δy/Δx).
6. Use a generic rate law to find the units of k.



First-order reaction

A ⟶ product

# of half-lives	$[A] = [A]_0/n$
1	2
2	4
3	8
4	16

Rate Laws and Half-Life

I. Half-life ( ):

A. When

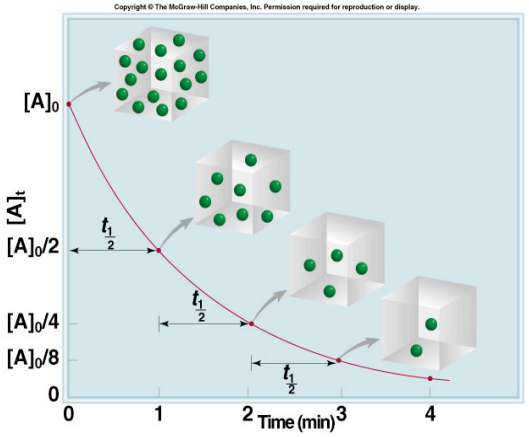
B. For a 1st order reaction, you can find half life using
1. If you plug in

2. You get

C. For a 2nd order reaction…
1. Plugging

2. You get….

13.3



D. For a zero order reaction…
1. Plugging

2. You get….

II. If half-life is involved, you can use these equations to find the half-life, concentration or the rate constant.
A.
B.
C. These equations will not be given so make sure you know how to

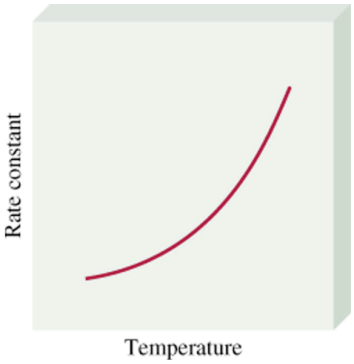
Rate and Temperature

I. Re: Collision Model
A. For a rxn, you need the and
B. When
C. Boltzmann Distribution:
1. As temperature increases,
increases.
2. Because of this,
3. This relation gives rise to the

D. At the high point ( ) of the energy diagram of the reaction, the reactants are in a . They have collided with

E. The reactants at transition state is known as the

F. The energy gap between the reactants and the activated complex is the



II. The equation:

A.

B. E_a , R T and k

C. A This is the

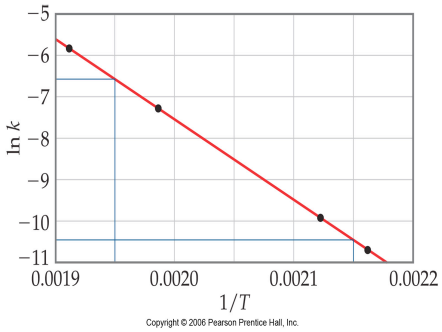
D. Taking the natural logarithm of the equation, you get an equation with the

E.

F. Thus, if k is found at several temperatures, you can find

G. This will be the equation that you will use.

H. To find activation energy you can use this derived equation:



I. Activation energy is usually in

J. Refer to Braviroff study guide, p. 7

Reaction Mechanisms

I. Not all reactions happen as written

A. Example: $NO_2 + CO \rightarrow NO + CO_2$

B. This reaction happens in two steps:

$NO_2 + NO_2 \rightarrow NO_3 + NO$ (1)

$NO_3 + CO \rightarrow NO_2 + CO_2$ (2)

C. The written process whereby a reaction occurs is known as the

D. When you , you will arrive at the original chemical equation.

E. NO_3 is in the overall equation yet it is . These species are known as

F.

II. <u>Elementary Reaction (or Process)</u>: Defined as a

A. For the previous example, there were two elementary reactions.

III.

A. One molecule:

B. Two molecules:

C. Three molecules:

IV. Rate laws for elementary reactions:

A. If a reaction happens in a single step, the rate law can be found

B. Examples:

A → products

2A → products

A+B → products

A +2B → products

C. Find the rate law for $H_2 + Br_2 \rightarrow 2HBr$, assuming that it occurs in a single elementary step.

1. rate = $k[H_2][Br_2]$
2. The correct rate law is actually rate=
3. Why? The reaction involves
   . This is why you have to find the rate law experimentally.

V. Multi-step reactions.

A. We must first define the

B. The rate-determining step is
   . Every reaction will have one.

C. The other steps

D. Finding the rate law for a multi-step rxn:

1. (just like we did for the elementary rxns).
2. The rate law
3. Example:

E. What if the rate-determining step contains an intermediate as a reactant?

1. Write the rate law for the rate-determining step.
2. Find the step that contains the intermediate (should be an equilibrium reaction).
3. Replace the intermediate with the corresponding reactants.
4. Combine like terms if necessary.
5. Example:

F. To have a plausible mechanism, the mechanism MUST:

1.
2.

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Catalysts

I. A catalyst must fit two criteria:
  A.
  .
  B.
II. Catalysts affect reaction mechanisms by or
III. Finding a catalysts in a reaction mechanism.
  A. Find the substance that is ( ).
  B. If this reactant is (
  ), it is a catalyst.
IV. There are three types of catalysts:
  A. Homogeneous:
  B. Heterogeneous:

  C. Biological catalysts: