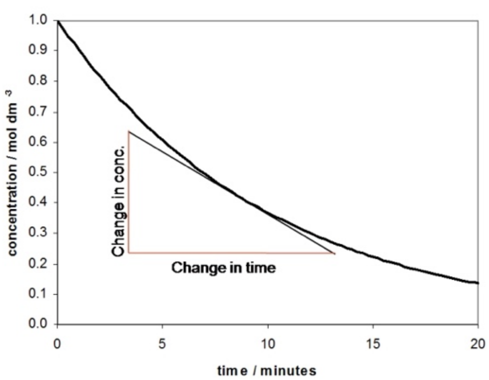
Chemical Kinetics: Rates of Reaction

STUDY LIST From Paul Groves

Reaction Rates:

I can…

- ☐ give the correct units to describe the rate of a reaction.
  $\text{rate} = \dfrac{\Delta[\text{chemical}]}{\Delta \text{ time}}$ units = $\dfrac{M}{s}$ or $mol \cdot L^{-1} \cdot s^{-1}$
- ☐ discuss the rate as the rate of **disappearance** of reactant or the rate of **appearance** of product Watch your signs because $-\Delta[\text{Reactants}] = \Delta[\text{Products}]$.
- ☐ use **coefficients** to change one rate to another
  Example reaction: $2A + 3B \rightarrow 4C$
  $$-\tfrac{1}{2}\frac{\Delta[A]}{\Delta t} = -\tfrac{1}{3}\frac{\Delta[B]}{\Delta t} = \tfrac{1}{4}\frac{\Delta[C]}{\Delta t}$$
- ☐ list three ways to speed up a reaction
  --increase the **concentration** of reactants
  --increase the **temperature** of the reaction
  --add a **catalyst**
- ☐ determine the **average rate** of a reaction as well as the **instantaneous rate** of a reaction from a graph of [ ] vs. time.

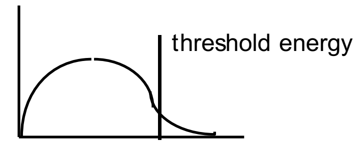


This graph shows how to determine the instantaneous rate at 8 minutes. Take the slope of the tangent line at 8 min.

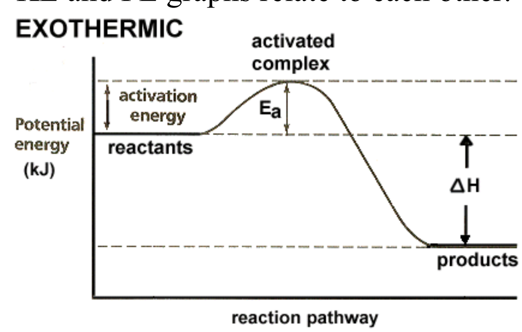
- ☐ describe a catalyst as a substance that speeds up a reaction without getting used up and cite examples of catalysts we have used in class (ester lab & elephant toothpaste demo).

KE & PE Diagrams:

- ☐ draw the kinetic energy distribution for a sample of any reactants (as during the light stick activity).



- ☐ sketch the change that occurs in the KE distribution if the reactants are warmed or cooled.
- ☐ state that the only thing that moves the threshold energy is the addition of a catalyst. Temperature does not shift the threshold energy.
- ☐ sketch the potential energy profile for a reaction showing the energy barrier between the reactants and products and show how the KE and PE graphs relate to each other.



- ☐ explain that a catalyst lowers the activation energy by changing the way the reaction occurs.

Half Life:

- ☐ determine the half-life of a chemical from graphical data or information in a word problem.
- ☐ use the integrated rate law to solve half-life problems involving in-between times.
  - $\ln\dfrac{[A]_o}{[A]_t} = kt$
  - the special case of half-life
    $\ln(2) = 0.693 = kt_{½}$

Rate Laws:

- ☐ write the rough rate law to show how the rate of a reaction depends on concentration.
  Ex: $N_2 + 3H_2 \rightarrow 2NH_3$
  Rate = k $[N_2]^x[H_2]^y$
- ☐ determine the order of reaction with respect to a chemical using the method of initial rates by inspection.
- ☐ determine orders of reactions using the mathematical method of initial rates.
- ☐ solve for the specific rate constant, k, and determine the correct units.

Reaction Mechanisms:

- ☐ explain that a reaction often occurs in several "elementary steps" that often involve only two particles at a time.
- ☐ combine the elementary steps in a mechanism to identify the overall reaction, the intermediates, and a catalyst.
- ☐ state that the slowest step in a mechanism is called the "rate determining step" and is linked to the rate law.
- ☐ give an example of a chain reaction mechanism for $H_2 + Cl_2$ or for the destruction of ozone (O_3) by stratospheric chlorine atoms.
- ☐ label steps in a chain reaction mechanism as initiation, propagation, and termination steps.

Reaction Order--Graphical Method:

- ☐ identify the integrated rate laws for zero, first, and second order reactions.
- ☐ explain that the integrated rate laws can be set into the form "y = mx + b" which means that a graph indicate the order of reaction and the value of the rate constant, k.
- ☐ state the straight-line graph that is identified with each reaction order.
- ☐ use the slope of the straight-line graph to determine the value of k.

Arrhenius Equation:

- ☐ use the Arrhenius equation to calculate the rate constant, k, using R = 8.31 J/mol K.
- ☐ graphically or algebraically determine the activation energy, E_a, from rate or k data at different temperatures.
- ☐ explain that a rate increase with temperature means that the rate constant, k, has increased proportionately.
- ☐ explain that the slope of a graph of ln k vs. 1/T = $-E_a/R$.

Chain Reaction Mechanisms:

- ☐ cite two examples of chain reaction mechanisms and label the elementary steps as initiation, propagation, and termination steps.

From the AP Exam:

$$\ln[A]_t - \ln[A]_0 = -kt$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$$

$$\ln k = \frac{-E_a}{R}\left(\frac{1}{T}\right) + \ln A$$

Gas constant, $R = 8.31 \text{ J mol}^{-1}\text{ K}^{-1}$
$= 0.0821 \text{ L atm mol}^{-1}\text{ K}^{-1}$
$= 62.4 \text{ L torr mol}^{-1}\text{ K}^{-1}$
$= 8.31 \text{ volt coulomb mol}^{-1}\text{ K}^{-1}$