**Chemical Kinetics** Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*AP Chemistry Lecture Outline*

**Factors that Govern Rates of Reactions**

Generally... (1) ...as the concentration of reactants increases, rate \_\_\_

 (2) ...as temperature increases, rate \_\_\_

 (3) ...with a catalyst, rate \_\_\_

 (4) ...as reactant surface area increases, rate \_\_\_

Reaction rates are usually expressed in M/s.

**Conc. of Substance x v. Time**

 [x] is (–) if x is a…

 [x] is (+) if x is a…

**Conc. of Substance x v. Time**

 instantaneous rate: the reaction rate

 at any given time

 -- it is equal to the slope of the

 [ ] – time curve at any point

For point P, one finds

 the instantaneous rate by:

 -- constructing a tangent line

 -- picking two points on the line

 -- finding their coordinates

 -- calculating the slope as…

Coeff. in bal. eq. are used when comparing rates for substances in a rxn.

EX. At a given time, the instantaneous rate of appearance of nitrogen dioxide is

3.2 x 10–6 M/s. Find the instantaneous rates of disappearance of nitrogen monoxide

and oxygen at that time.

Generally, reaction rates are proportional to the [ ] of reactants.

 rate law:

 -- contains a rate constant, k

 -- A rate law has the form…

where m and n are...

 -- Usually, reaction orders are 0, 1, or 2, but some are fractions or are (–).

If a reaction is zero order in a particular reactant, changing its concentration...

 1st order:

2nd order:

The rate constant k is NOT affected by concentration, but it **IS** affected by...

|  |  |  |
| --- | --- | --- |
| **[H2] (M)** | **[Cl2] (M)** | **Init. rate of HCl formation (M s–1)** |
| 0.100 | 0.100 | 0.340 |
| 0.100 | 0.200 | 0.680 |
| 0.200 | 0.200 | 2.720 |

EX. H2(g) + Cl2(g) 2 HCl(g) Find... (1) rxn order of each reactant (2) overall reaction order

(3) units of rate constant

Rate laws can be converted into equations that give the concentrations of substances at any time during the course of a reaction.

 ***First-Order Reactions***

 -- Rate laws for 1st order rxns have the form:

 -- To find rxn [ ]s over time, use…

 Plotting ln [A]t v. t gives a straight line w/slope…

EX. (CH3)2O(g) CH4(g) + H2(g) + CO(g)

 If this is a first-order process, with k = 6.8 x 10–4 s–1 and w/the initial pressure of

(CH3)2O being 256 torr, find the partial pressure of (CH3)2O after 36.5 min.

Half-life of a reaction, t1/2: the time required for a reactant’s [ ] to drop to ½ of its orig. value

 For 1st order rxns:

For 1st order reactions:

 -- t1/2 is independent of initial concentration

 -- the concentration of reactants is cut in half...every half-life

***Second-Order Reactions*** (that are 2nd order in just one reactant)

 e.g.,

 and

 Plotting 1/[A]t v. t gives a straight line w/slope…

\*\* Above equations do NOT apply to 2nd order reactions that are 1st order in two reactants.

As temperature increases, rate increases because...

 collision model: explains how rate is affected by [ ] and by temperature

 -- greater [ ]:

 -- higher temperature:

activated complex:

Ea of reverse reaction

Ea

E

 **Energy**

 **Time**

 **R**

 **P**

 About E...

 -- it is \_\_\_ for endo.

 -- it is \_\_\_ for exo.

 --

For the reaction to occur, collisions must take place with particles oriented in a certain way.

 e.g., Cl + NOCl Cl2 + NO

For a given reaction, the Ea relates rate constants at two different temps WITH those temps.

 Ea in J/mol

 R = 8.314 J/mol-K

 T = absolute temp.

EX. Using the following information, find...

T (oC) k (s–1)

189.7 2.52 x 10–5

251.2 3.16 x 10–3

 (1) ...Ea

 (2) ...k at 430.0 K

**Reaction Mechanisms**

 -- the processes by which reactions occur

 --

 -- sometimes, mechanisms are dependent on temperature

elementary steps (or elementary reactions):

A reaction’s molecularity is defined by the number of particles that participate as

reactants in an elementary step.

 unimolecular

 bimolecular

 termolecular

For multistep mechanisms, sequences of elementary steps are needed to go from R to P.

 e.g., For the reaction NO2 + CO NO + CO2

Elem. Step 1:

 Elem. Step 2:

Above, NO3 is an intermediate. All multistep mechanisms have them.

The rate law and relative speed of each elementary step (no matter how many there are) determine the overall rate law for the reaction; that is, the mechanism gives us the overall rate law. Rate laws for the elementary steps are found as follows...

|  |  |  |
| --- | --- | --- |
| **Molecularity** | **Elementary Step** | **Rate Law for that****Elementary Step** |
| uni- | A 🡪 P |  |
| bi- | A + A 🡪 P |  |
| bi- | A + B 🡪 P |  |
| ter- | A + A + A 🡪 P |  |
| ter- | A + A + B 🡪 P |  |
| ter- | A + B + C 🡪 P |  |

 These rate laws are for elementary steps, not necessarily for the R P reaction.

Most reactions have multiple elementary steps. The slowest of these is the...

The correct rate law for a reaction must:

1. be based on…
2. have only…

EX. CHCl3(g) + Cl2(g) CCl4(g) + HCl(g) has the following elementary steps:

 E. S. 1: Cl2 2 Cl (fast, eq)

 E. S. 2: CHCl3 + Cl 🡪 CCl3 + HCl (slow)

 E. S. 3: CCl3 + Cl 🡪 CCl4 (fast)

 State the rate law and the units on the rate constant.

catalysis: the process by which a catalyst changes the rate

 and mechanism of a chemical reaction

 -- a catalyst is…

 -- Catalyzed and uncatalyzed reactions have…

Homogeneous catalysts are present in the same phase as the reacting molecules.

Heterogeneous catalysts exist in a different phase than the reacting molecules.

 --

The first step in heterogeneous catalysis is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the reactant molecules onto the metal surface – specifically, onto the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, which are the locations at which the reactants attach to the metal catalyst.

 --

 -- then, the products detach from the catalyst

enzymes:

 -- large protein molecules

 -- usually very specific

 -- names end in... “\_\_\_\_”

 -- substrates: substances (i.e., reactants) that react at the active sites of enzymes

 -- The lock-and-key model explains how an enzyme affects a substrate molecule and

 changes it into a new substance.

**Lock-and-Key Model**

turnover number:

Enzyme inhibitors bind to the active site or alter the unique shape of an enzyme

 molecule, destroying the enzyme’s activity

 e.g.,