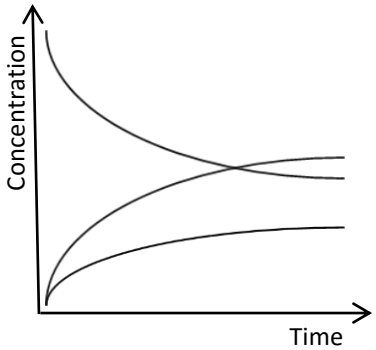
Key Concepts

How
FAST
are reactions?

Chemical reactions occur at certain speeds
The speed of a reaction…

…is measured by looking at concentration changes over time.



…depends on a reactions mechanism.

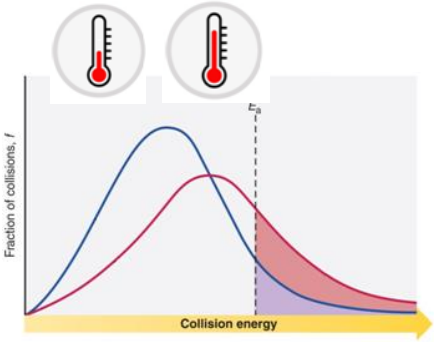
$2\ NO_2(g) \longrightarrow NO(g) + NO_3(g)$

$NO_3(g) \longrightarrow NO(g) + O_2(g)$

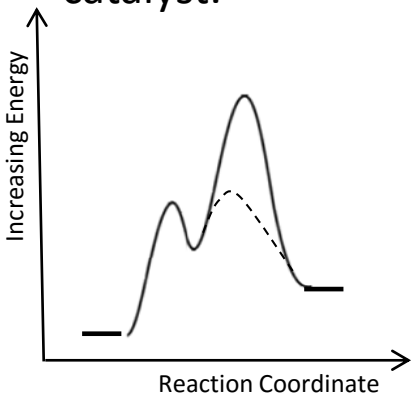
OR

$2\ NO_2(g) \longrightarrow 2NO(g) + O_2(g)$

…can be altered by changing temperature.



…can be altered by the use of a catalyst.



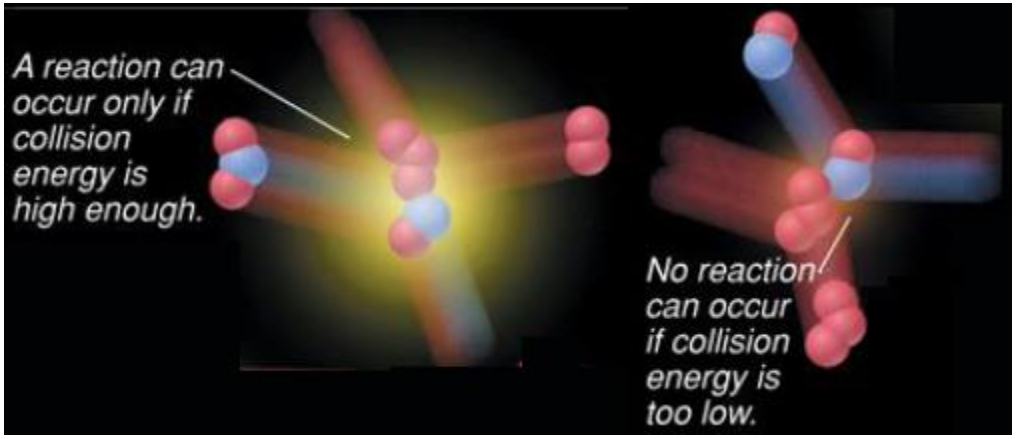
The following pages are titled with respect to the learning objectives that their content relates to.

Learning Objectives

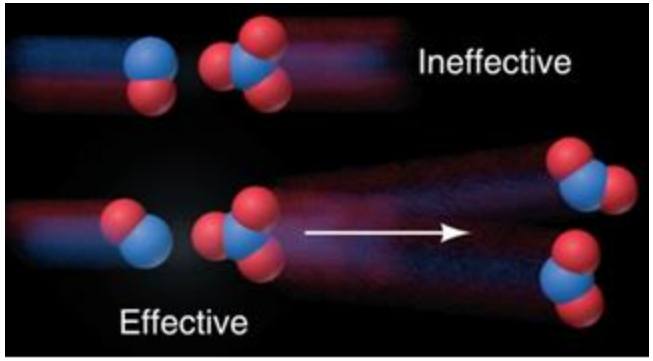
Qualitatively *describe* what the speed of a reaction depends upon.
Generate plots of concentration versus time for the chemical species of a reaction.
Determine the instantaneous and average rate of reaction from experimental data.
Relate reactant concentration to instantaneous reaction rates using rate laws.
Given experimental data, quantitatively *determine* the components of a rate law (*k* and order), using the method of initial rates.
Use integrated laws to *determine* the amount of product produced (or reactant remaining) at any given point rate within a reaction and *determine* the half-life of a reaction.
Determine the rate law given the mechanism of a reaction, and vice versa – for reactions with a slow first step only.
Draw and *interpret* a reaction energy diagram for a given reaction.
Determine the effect of changing temperature on rate and activation energy.
Explain how reaction speed can be modified using a catalyst.

Qualitatively *describe* what the speed of a reaction depends upon.

What is needed for a reaction to occur?



Modification Figure 14.4

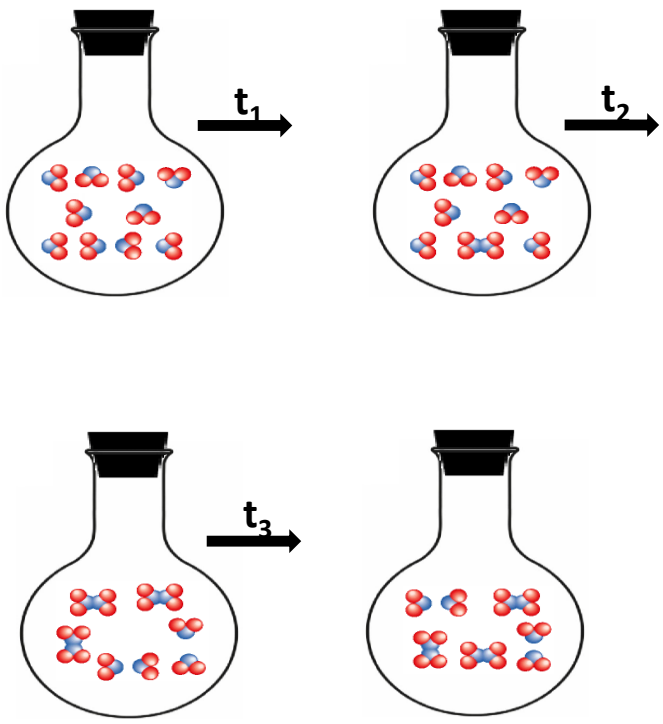


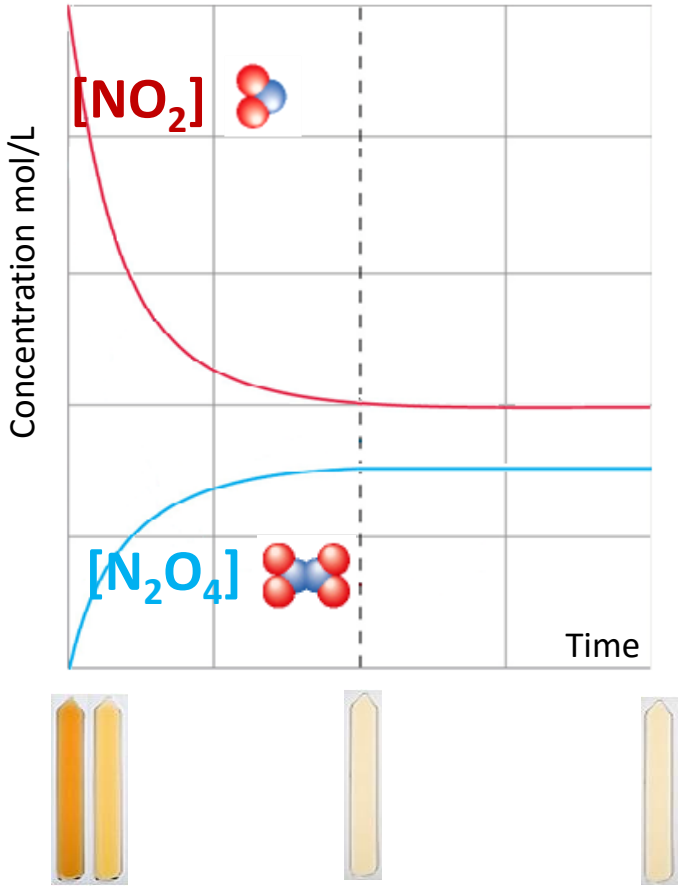
Modification Figure 14.18

Generate plots of concentration versus time for the chemical species of a reaction. e.g. $2\ NO_2(g) \longrightarrow N_2O_4(g)$

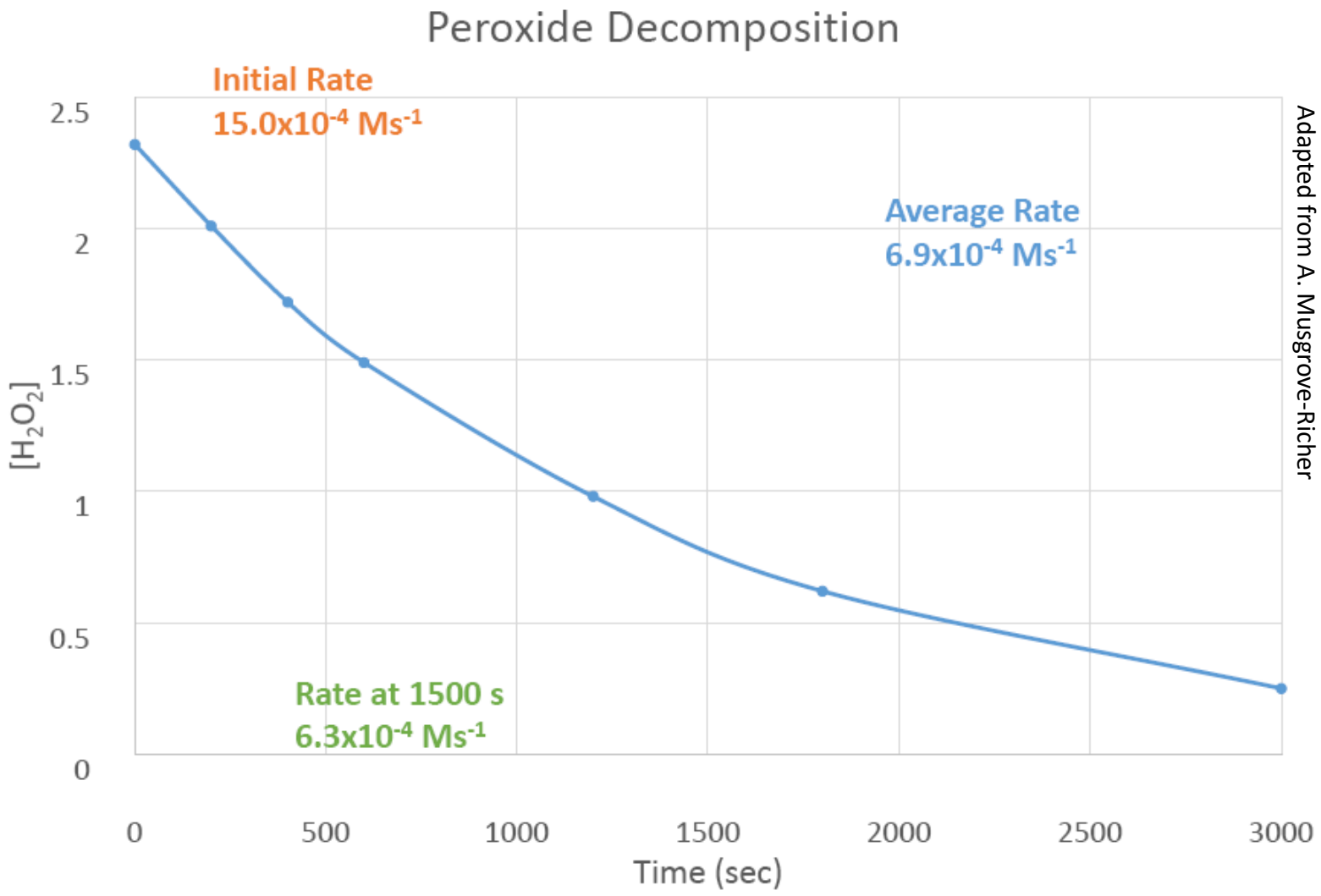
What is embedded in the plot below?

How does the plot relate to what is also known about the reaction?





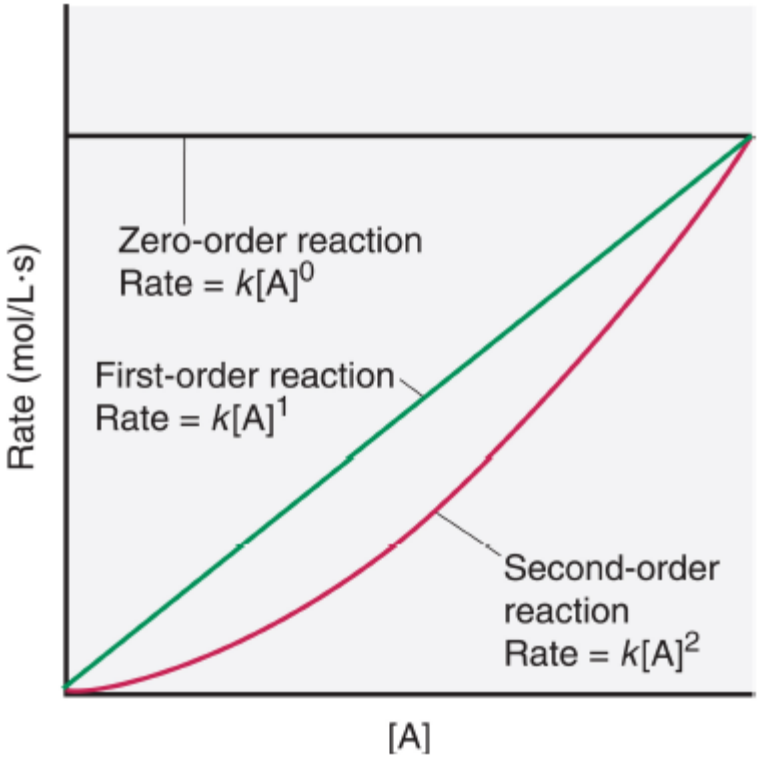
Determine the instantaneous (d) and average (Δ) rate of reaction from experimental data. e.g. $2\ H_2O_2\ (aq) \longrightarrow 2\ H_2O(l) + O_2\ (g)$



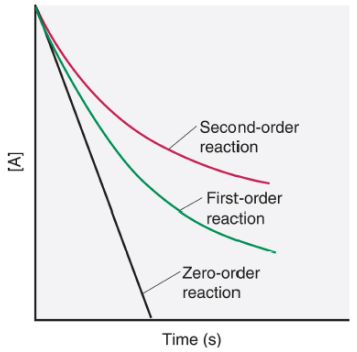
Relate reactant concentration to instantaneous reaction rates using rate laws. e.g. $2\ NO_2(g) \longrightarrow N_2O_4(g)$

How is the generic form of the rate law generated for a reaction?

Relate reactant concentration to instantaneous reaction rates using rate laws. e.g. $2\ H_2O_2\ (aq) \longrightarrow 2\ H_2O(l) + O_2\ (g)$



Modification Figure 14.8



Modification Figure 14.7

Given experimental data, quantitatively *determine* the components of a rate law (*k* and order), using the method of initial rates.

e.g. $2\ NO_2(g) \longrightarrow 2NO(g) + O_2(g)$

Expt	Initial rate (M /s)	$[NO_2]$
1	1.1×10^{-2}	0.15 M
2	4.5×10^{-2}	0.30 M
3	1.8×10^{-1}	0.60 M
4	4.0×10^{-13}	0.90 M

Given experimental data, quantitatively *determine* the components of a rate law (*k* and order), using the method of initial rates.

e.g. $2\ NO(g) + Cl_2(g) \longrightarrow 2\ NOCl(g)$

Expt	Initial rate (M/s)	$[NO]_o$	$[Cl_2]_o$
1	2.86×10^{-6}	0.250 M	0.500 M
2	11.4×10^{-6}	0.500 M	0.500 M
3	5.72×10^{-6}	0.500 M	0.250 M

Use integrated rate laws to *determine* the amount of product produced (or reactant remaining) at any given point within a reaction or the half-life of a reaction.

What is an integrated rate law?

Use integrated rate laws to *determine* the amount of product produced (or reactant remaining) at any given point within a reaction or the half-life of a reaction.

How is it used to determine the amount of product produced?

Use integrated rate laws to *determine* the amount of product produced (or reactant remaining) at any given point within a reaction or the half-life of a reaction.

How is it used to determine the half-life of a reaction?

Determine the rate law given the mechanism of a reaction.

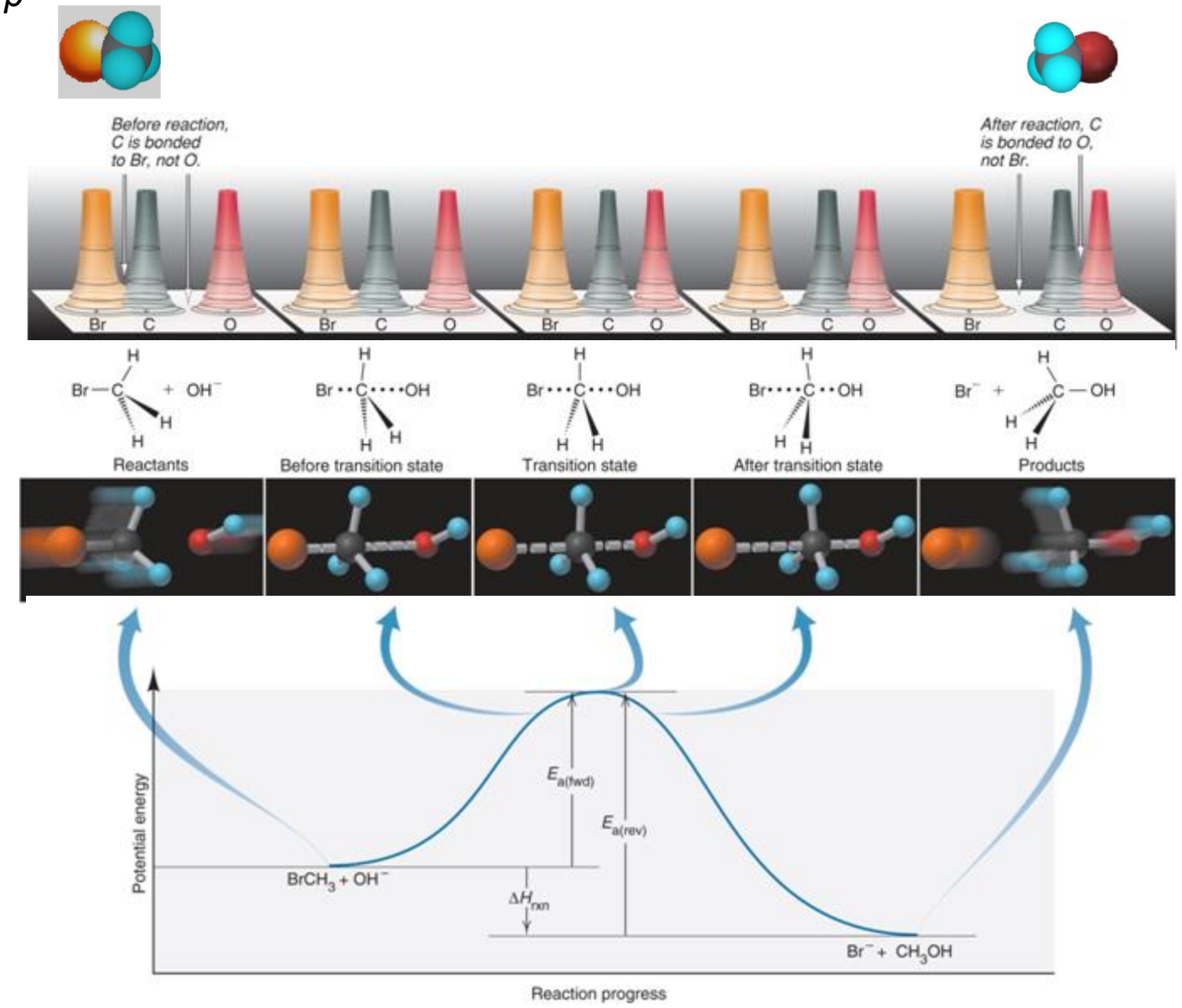
What is a mechanism?

Draw and *interpret* a reaction diagram.

How is a mechanism visualized?

One step

e.g. $BrCH_3 + OH^- \longrightarrow Br^- + CH_3OH$



Modification Figure 14.20

Draw and *interpret* a reaction diagram.

How will you decide how to draw one given a reaction?

One step

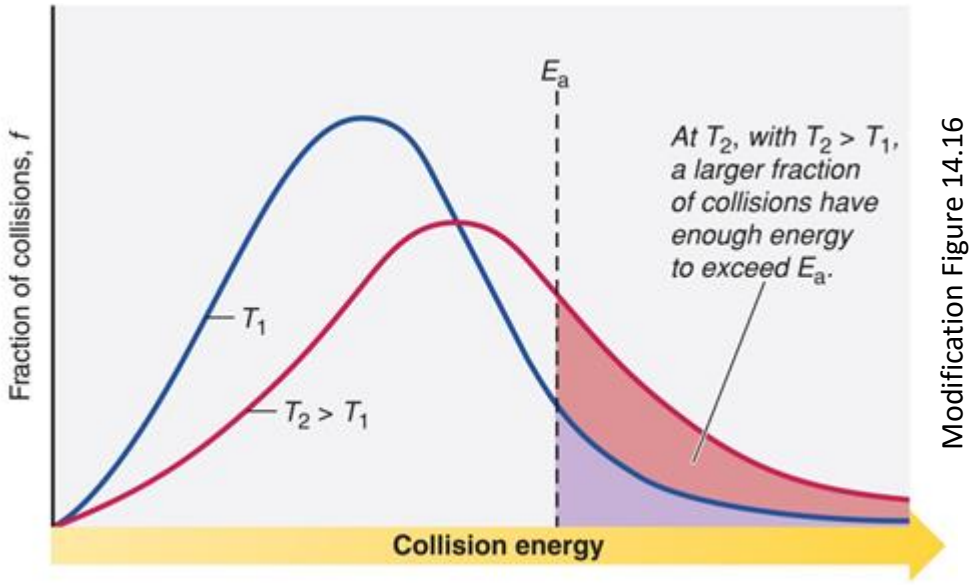
Draw and *interpret* a reaction diagram.

How will you decide how to draw one given a reaction?

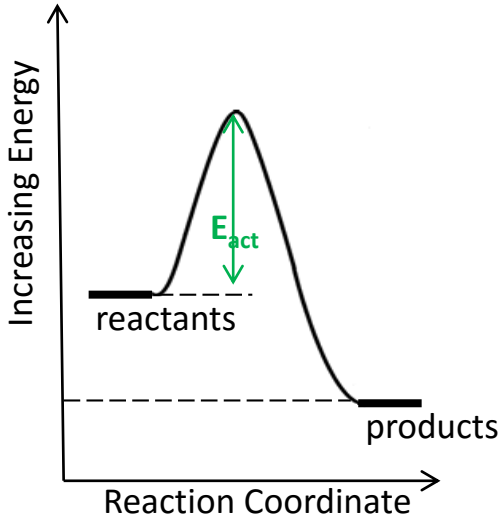
Multi-step

Determine the effect of changing temperature on rate and activation energy

What exactly is a change in temperature affecting?

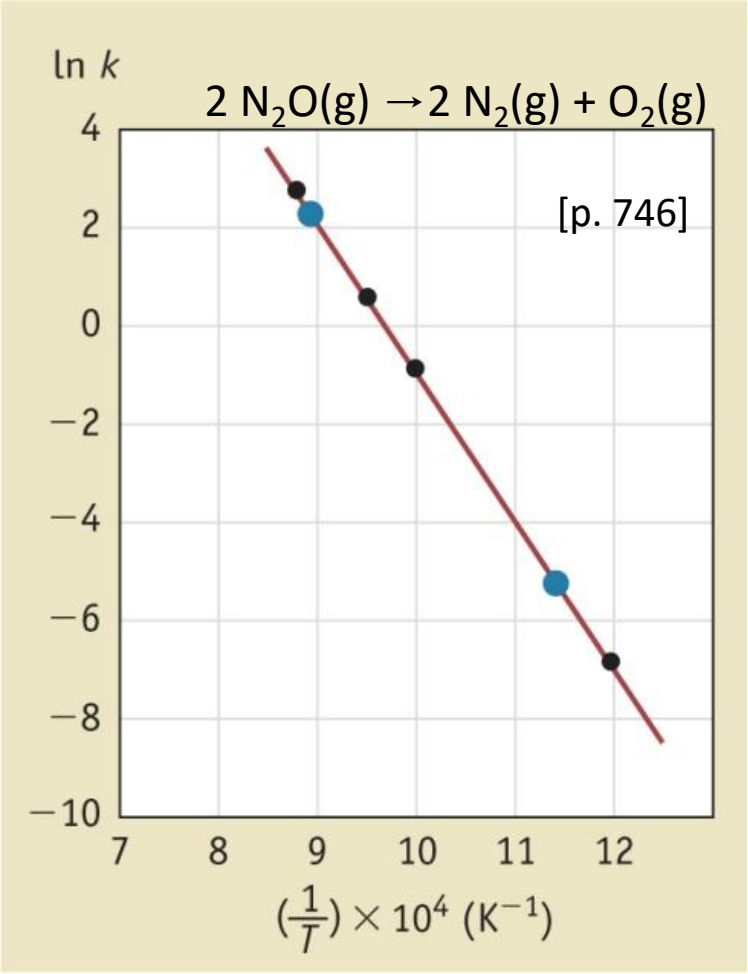


Modification Figure 14.16



Determine the effect of changing temperature on rate and activation energy

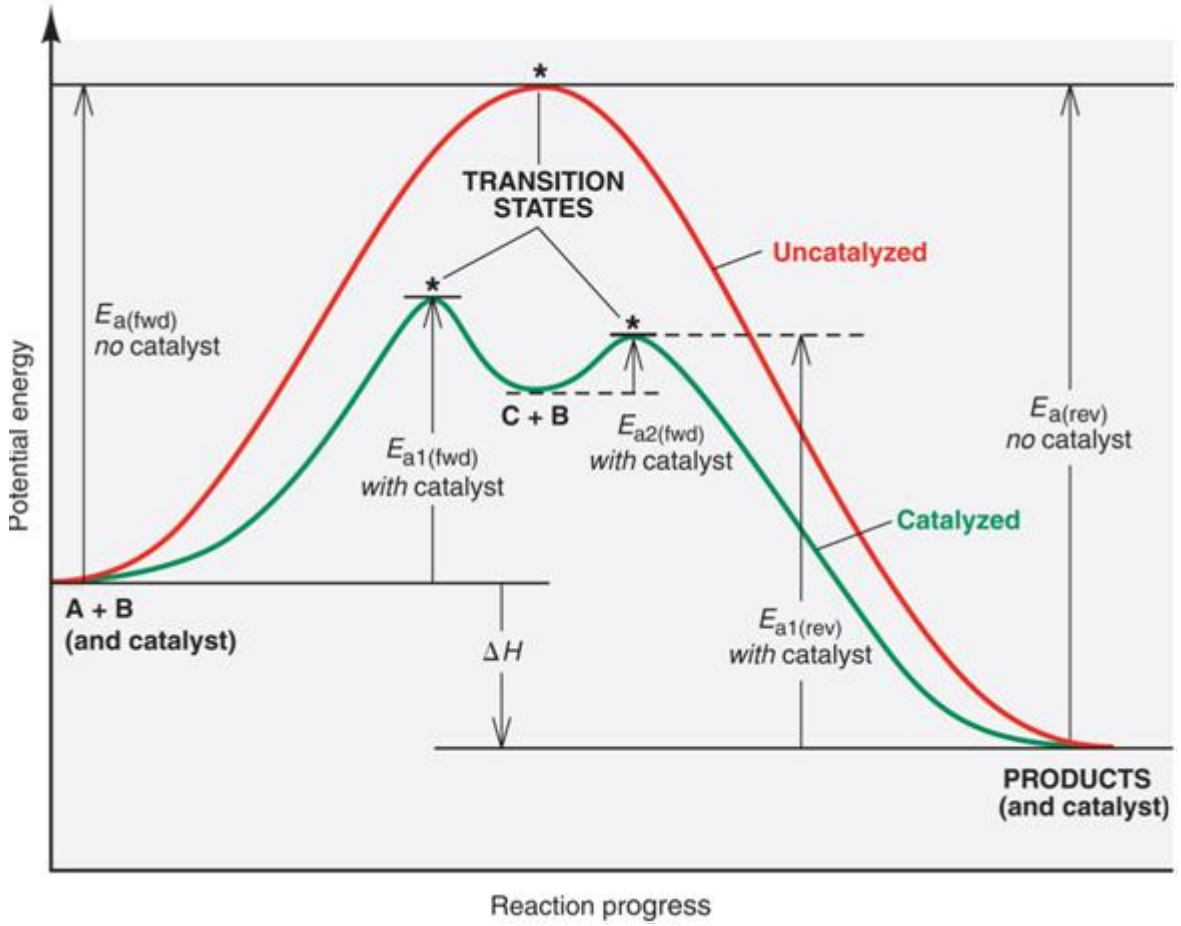
How is the affect of temperature on k quantitatively examined?



Mahaffy et al, 2nd ed, p. 746

Explain how reaction speed can be modified using a catalyst

What does a catalyst do?

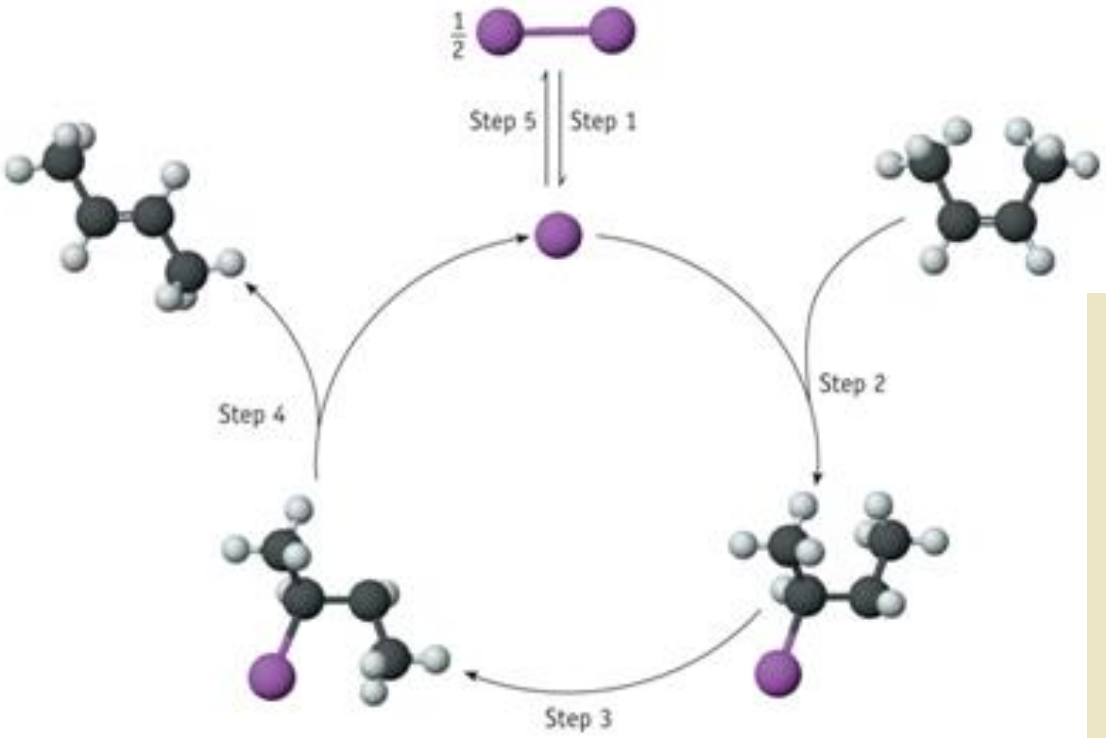


Modification of Figure 14.23

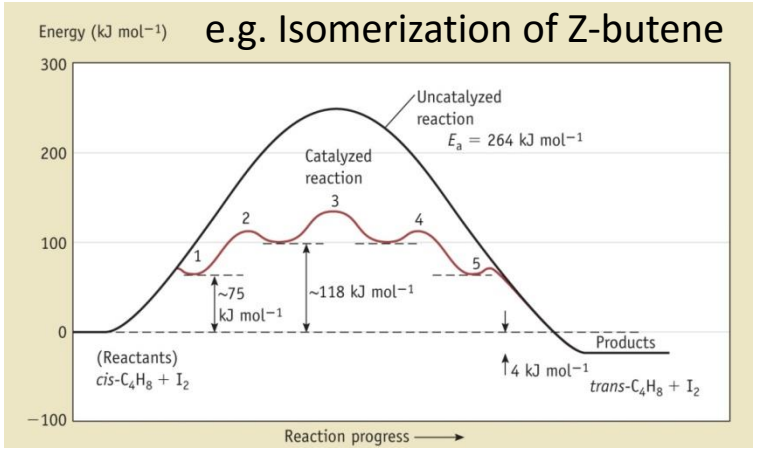
Explain how reaction speed can be modified using a catalyst

What is homogeneous catalysis?

Homogeneous catalysts are in the same phase as the reactant(s)/product(s) of a reaction



e.g. Isomerization of Z-butene



Mahaffy et al. 2nd Ed. pp. 748-749

Explain how reaction speed can be modified using a catalyst

What is heterogeneous catalysis?

e.g. Hydrogenation of Ethylene

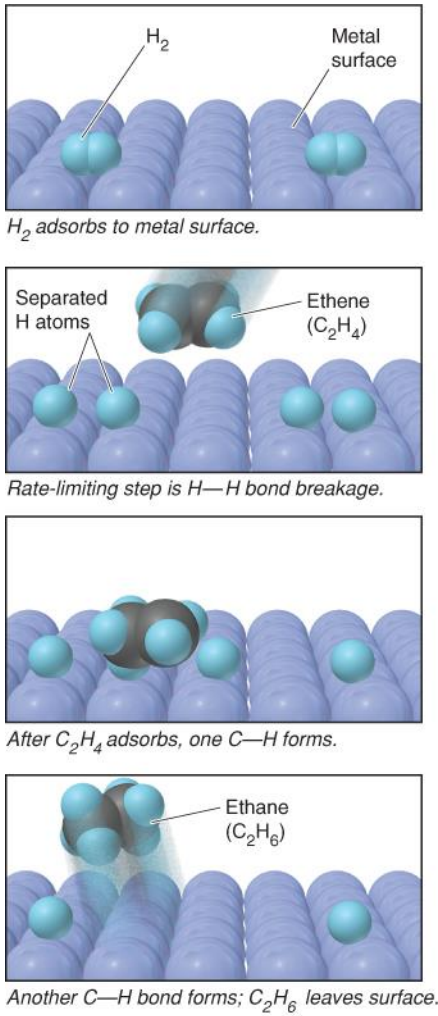


FIGURE 14.25 **The metal-catalyzed hydrogenation of ethene**