# Reaction Rate

## Factors Which Influence *k*

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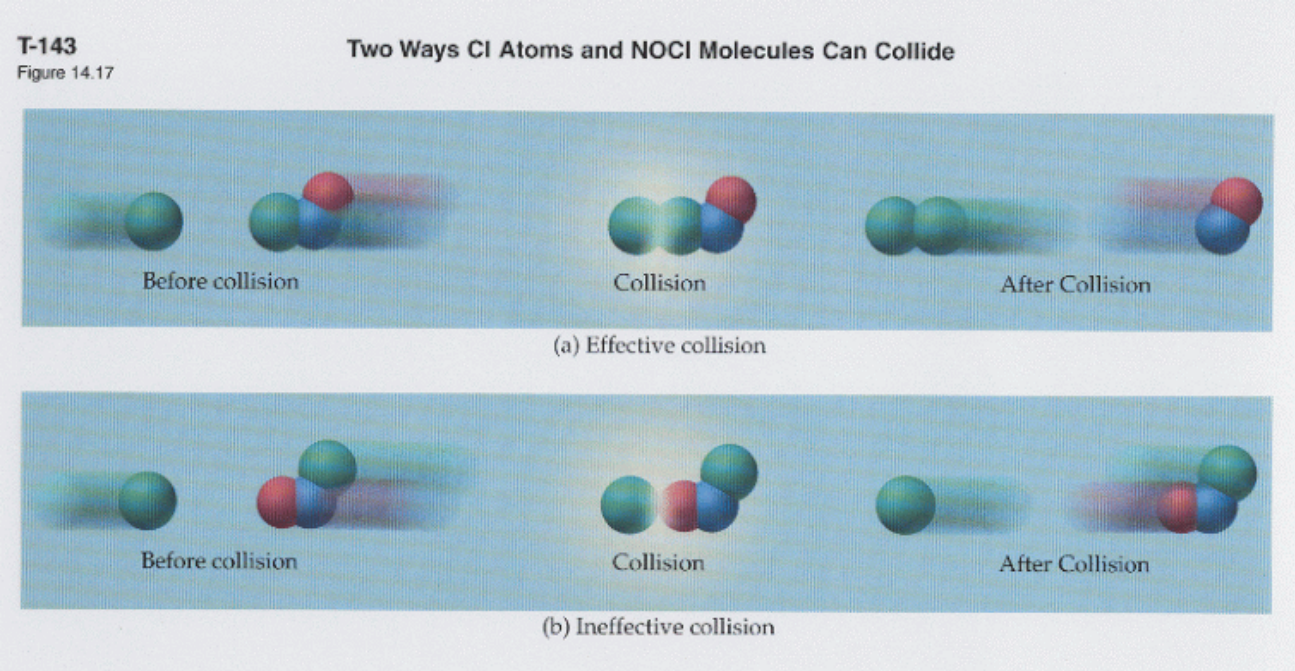
In Review

- Rate laws are the mathematical expression relating reactant concentrations to reaction rate.
- The general form is
  - Rate = $k[A]^m[B]^n$....
- Up until now we have studied the relationships between
  - Rate and Time
  - Rate and Concentration
- We are now ready to look at some of the factors that affect the values for the rate constant (*k*)

# Factors Which Influence *k*

## Orientation

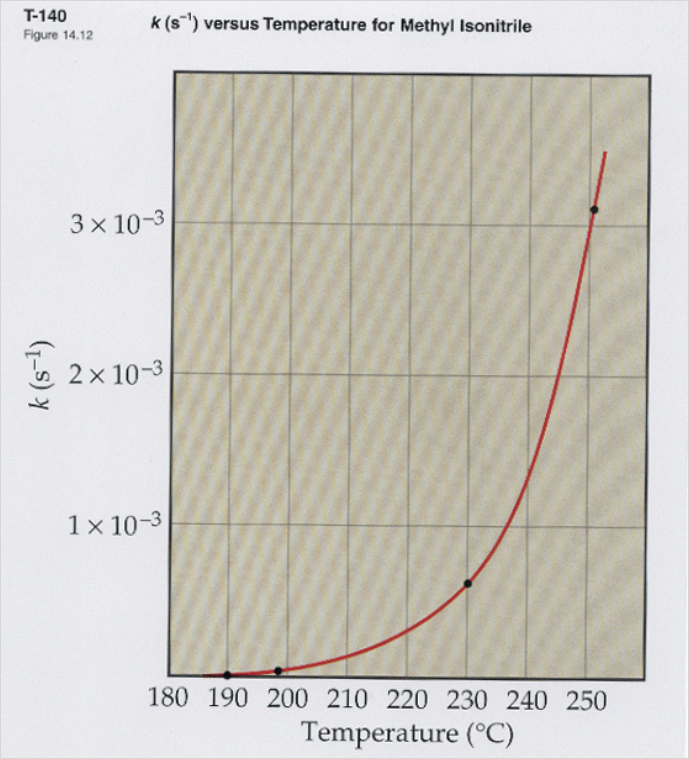
- Even if a reaction has enough energy to occur, there is still no guarantee it will occur
- The reactants must also be properly aligned
- Cl + NOCl ==> $Cl_2$ + NO



# Factors Which Influence *k*

## Temperature

- For most reactions, as the temperature increases, the rate of the reaction increases.
- We can see this fact reflected in the measured rate constant for a simple unimolecular reaction as it varies with temperature



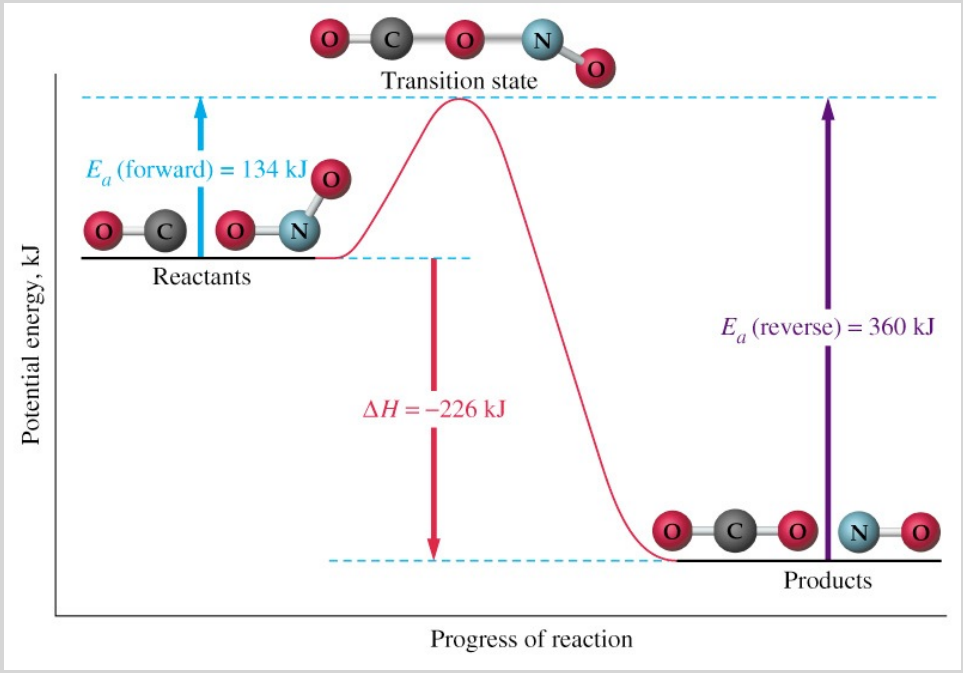
# Factors Which Influence *k*

Temperature

- As the temperature of a reaction increases, what about the reaction changes to cause an increase in reaction rate?
  - Collision Model
    - When the temperature of a substance increases its average kinetic energy increases
    - This increase in speed cause more collisions (interactions) per unit time
    - This, however, is not enough to fully explain the affects of temperature on rate
      - Not all collisions result in a reaction
      - In order for a reaction to take place, the interacting molecules must have enough energy to break and reform bonds
      - If they do not possess this minimum energy, no reaction will take place
  - Activation Energy
    - The minimum energy needed to initiate a chemical reaction
      - $E_a$
        - The energy difference between the reactants and the **activated complex** (transition state)
          - The arrangements of molecules at the apex of the reaction pathway

# Factors Which Influence *k*

## Activation Energy




- Is this reaction endothermic or exothermic?
  - This has no bearing on the reaction rate
- The lower the value for $E_a$, the faster the reaction rate

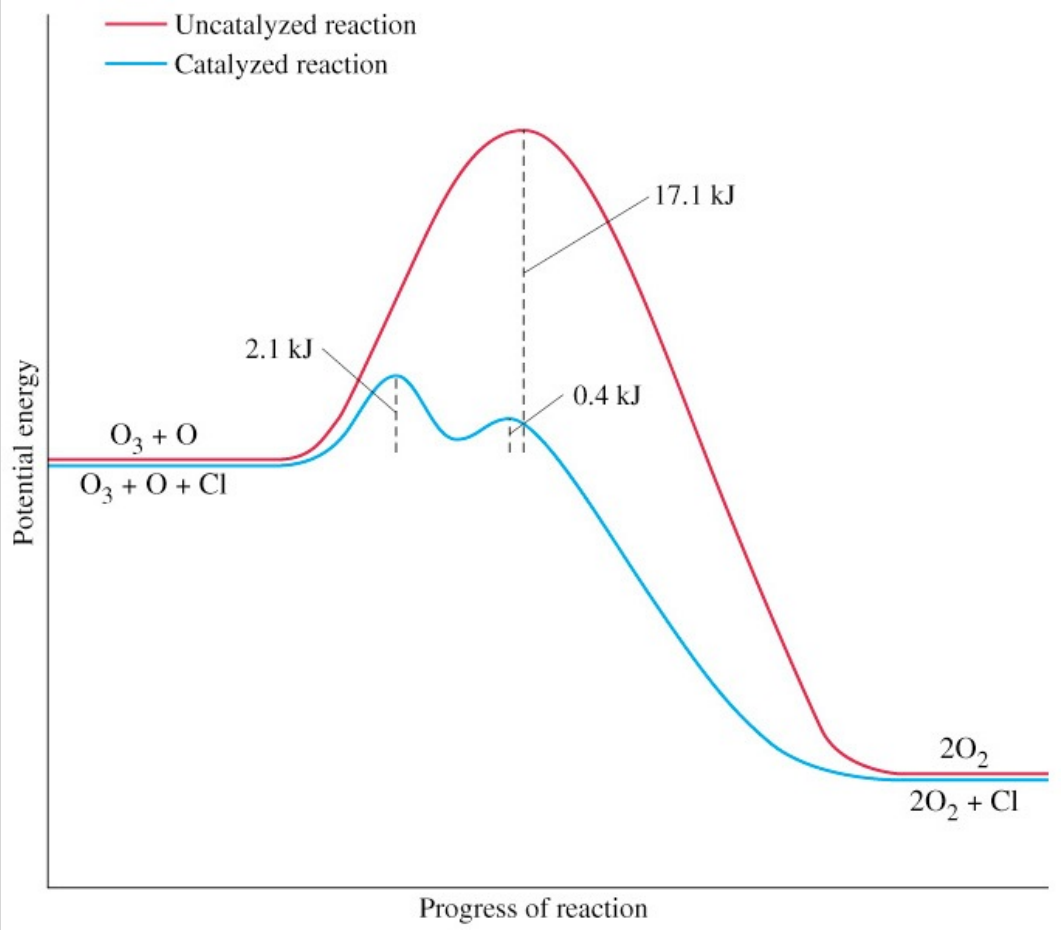
# Factors Which Influence *k*

## Catalysts

- A catalyst is a substance that changes the speed of a reaction without undergoing a permanent change
- Generally, a catalyst affects the reaction rate by decreasing the activation energy of a reaction
  - Usually, this happens by creating a totally different reaction pathway (mechanism), having a lower activation energy
  - This, in turn, increases the value of *k*
- Two Types
  - Homogeneous
    - A catalyst that exists in the same phase as the reacting molecules
    - Initially consumed by the reaction as a reactant, then released as a product
  - Heterogeneous
    - A catalyst that exist in a different phase than the reactant molecules
    - Usually a solid in contact with a liquid or gas
    - A surface on which the reaction takes place

# Factors Which Influence *k*

## Homogeneous Catalysts



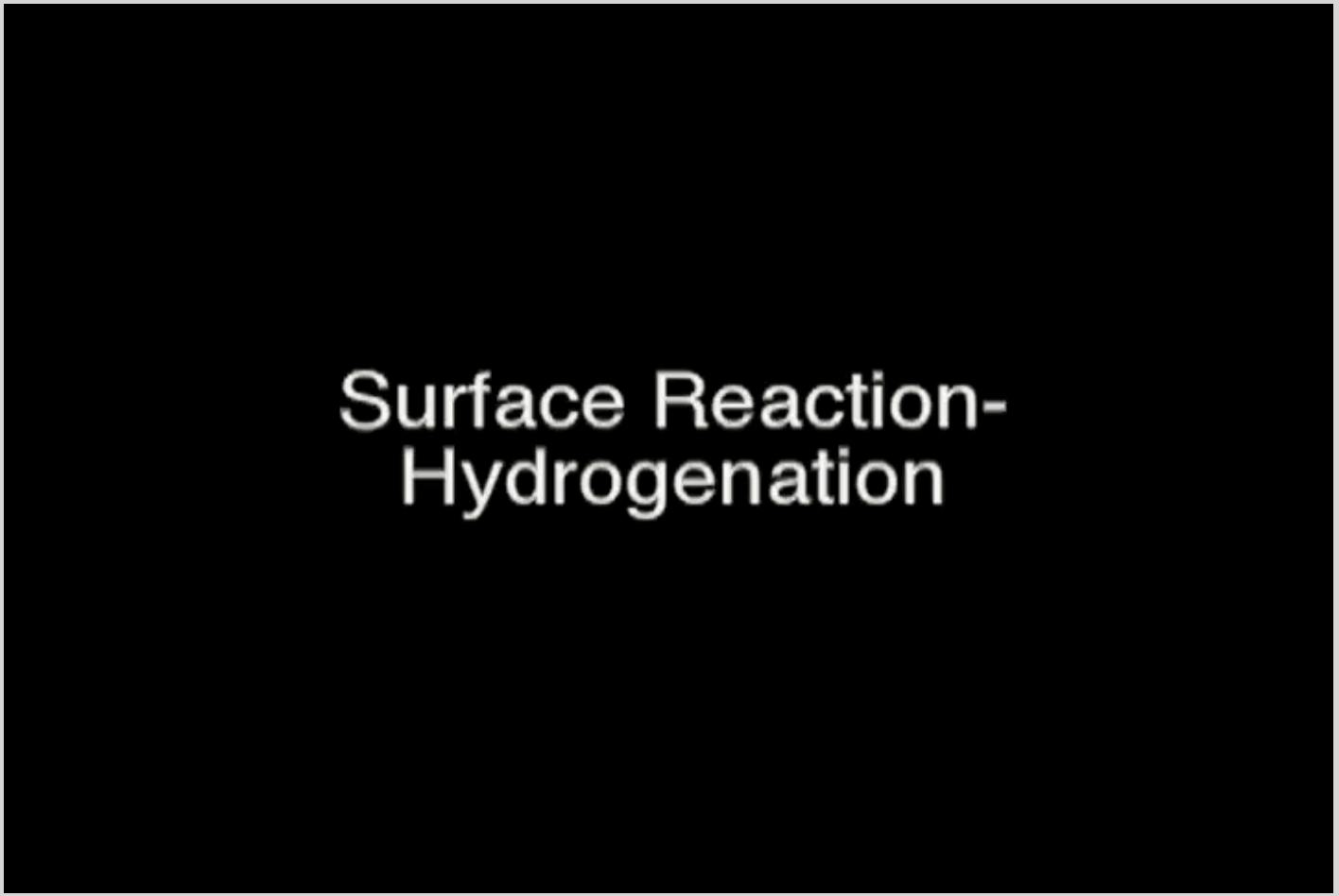
# Factors Which Influence *k*

## Heterogeneous Catalysts

- Heterogeneous Catalyst
  - The action of a heterogeneous catalyst begins with **adsorption**
    - The reactant particles bind to the surface of the catalyst
    - The locations where reactant particles bind are termed **active sites**

# Factors Which Influence *k*

Heterogeneous Catalysts



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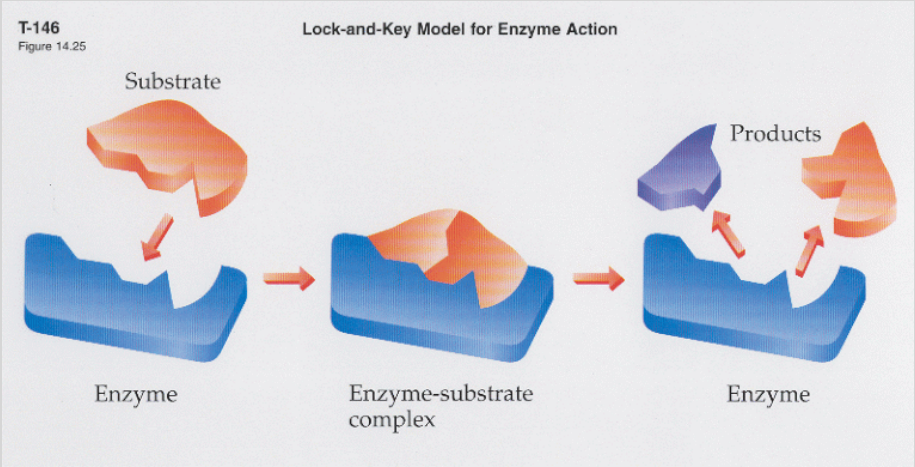
## Catalysts

- Enzymes
  - Biological catalysts
  - Generally have atomic masses ranging from 10,000 to 1,000,000 amu's
  - Two terms used in relation to enzyme activity
    - Substrate
      - The molecules undergoing a reaction in the presence of an enzyme
    - Lock-and-key model
      - A neat-fitting system in which an enzyme is specially shaped for a particular substrate to interact with it



# Factors Which Influence *k*

Catalysts

## Factors Which Influence *k*

Homework

- 14.9 / 14.11 / 14.13 / 14.14 / 14.15 / 14.51 / 14.52 / 14.55 / 14.57 / 14.59 / 14.75 / 14.76 / 14.79 / 14.82