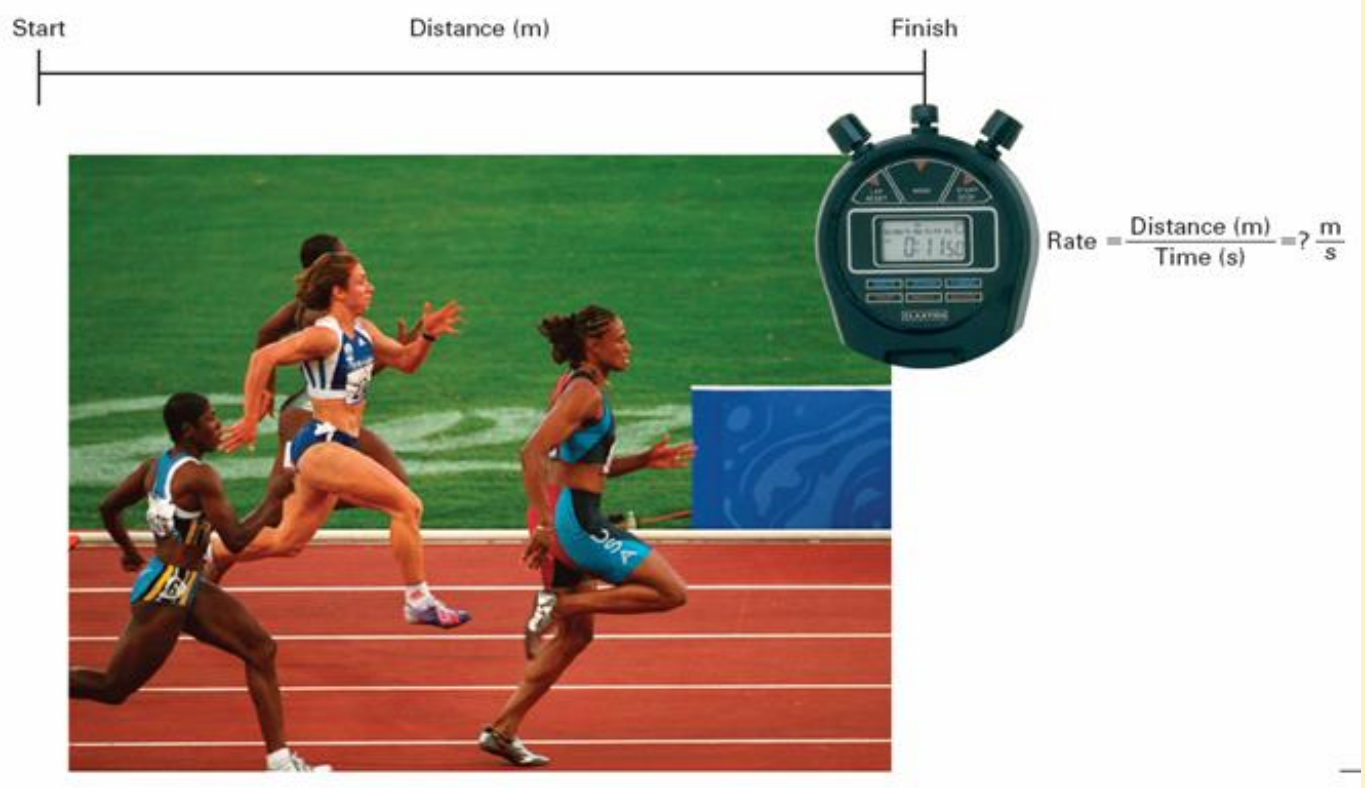
# Chapter 17 *Reaction Rates*


**Thermodynamics** – does a reaction take place?

**Kinetics** – how fast does a reaction proceed?

# Rates

The speed of a chemical reaction is called its **reaction rate**.



# Rates…

- **Reaction Rate**:
  change in concentration of **reactants and products** over time.

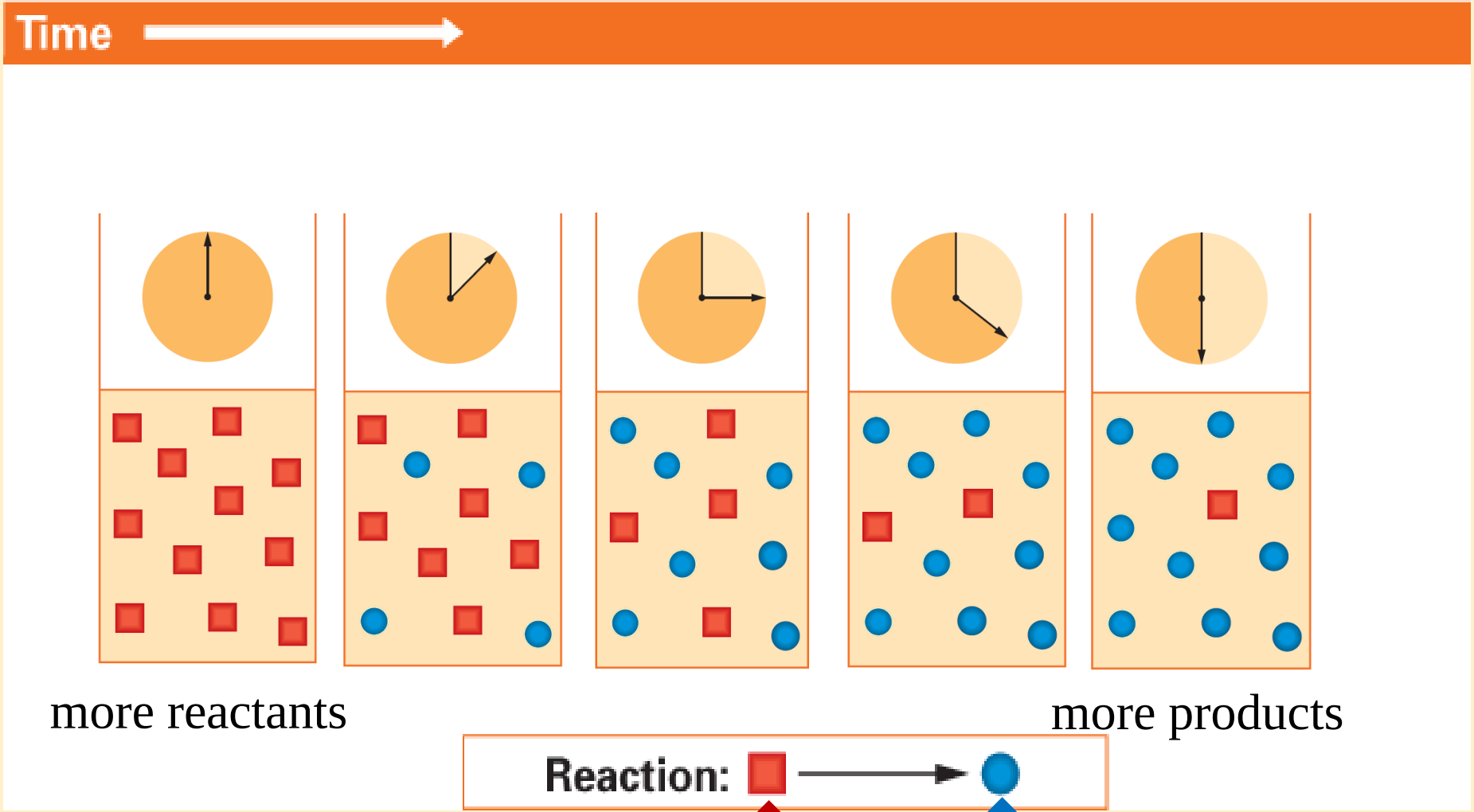
**reactants → products**

get consumed get formed

- (**tell how fast** a reaction is going)

Example: TNT & leaves changing

# Rates…


Time
more reactants
more products
Reaction:
reactants
products

# Calculating Average Reaction Rates

- ***Reaction rate*** is the change in the *concentration* of a reactant or a product with time (*M*/s)

$$\text{Average rate} = -\frac{\Delta[A]}{\Delta t}$$

- $\Delta$ = change *(final-initial)*
- $\Delta[A]$ = change in concentration of A
  *[ ] represent M *(Molarity)* and A is the substance
- t= time expressed in seconds (s)

Since M is mol/L the final unit is expressed as **mol/(L·s)**

# Practice Problem

1) Data for the reaction between butyl chloride and water is given. What is the average reaction rate over this time period expressed as moles of $C_4H_9Cl$ consumed per liter per second?

**Molar Concentration of Butyl Chloride ($C_4H_9Cl$)**

| $[C_4H_9Cl]$ at t=0.00 s | $[C_4H_9Cl]$ at t=0.00 s |
|---|---|
| **0.220 M** | **0.100 M** |

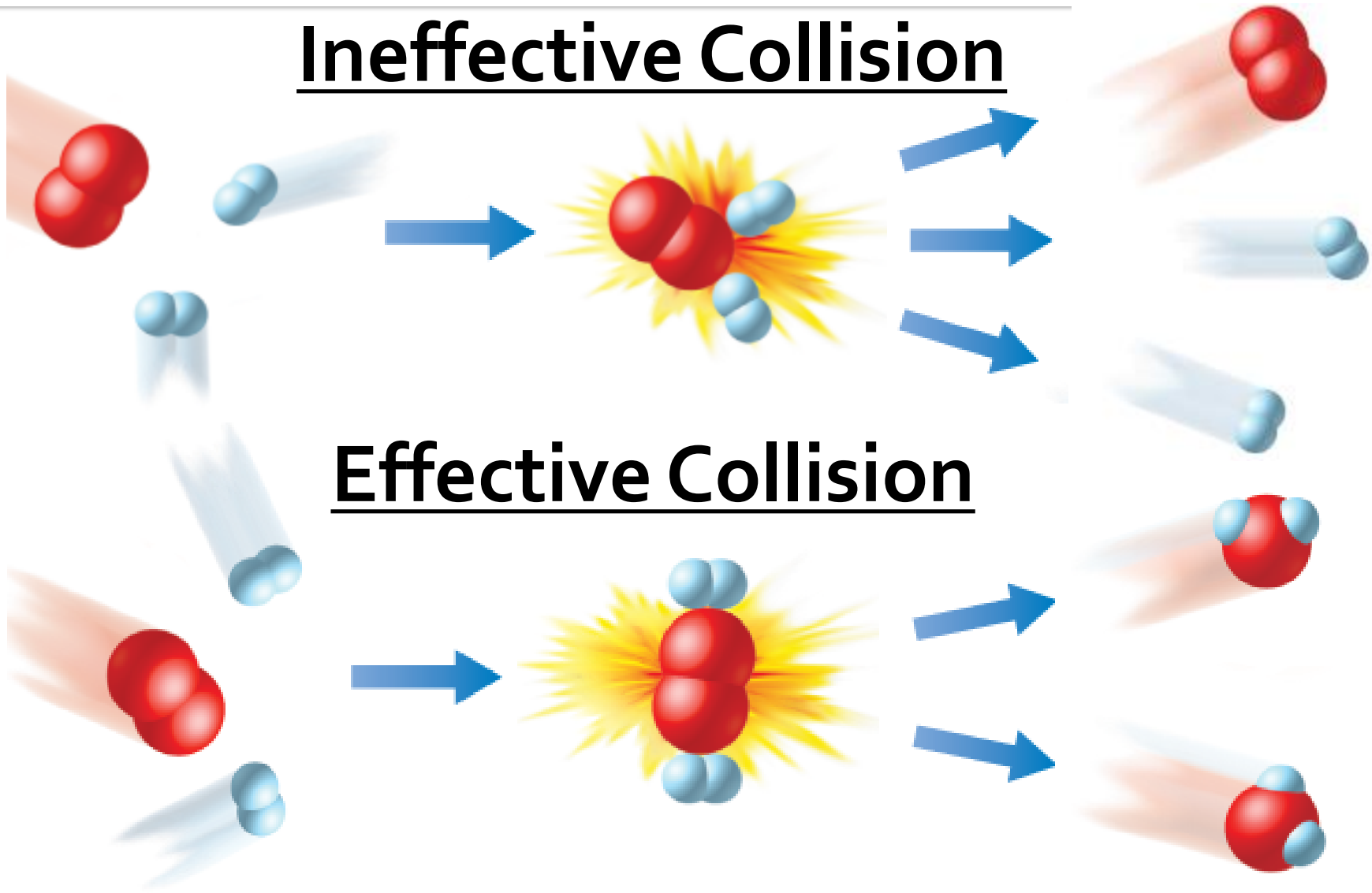
# Practice Problem

| Time | $[NaN_3]$ |
|---|---|
| 0 s | 0.500 M |
| 1 s | 0.473 M |
| 5 s | 0.378 M |
| 10 s | 0.286 M |
| 15 s | 0.216 M |
| 20 s | 0.163 M |

2) Given the following rate data concerning the decomposition of sodium azide into nitrogen gas, determine its average rate expressed in moles of $NaN_3$ consumed per liter per second between the start and after 5 seconds.

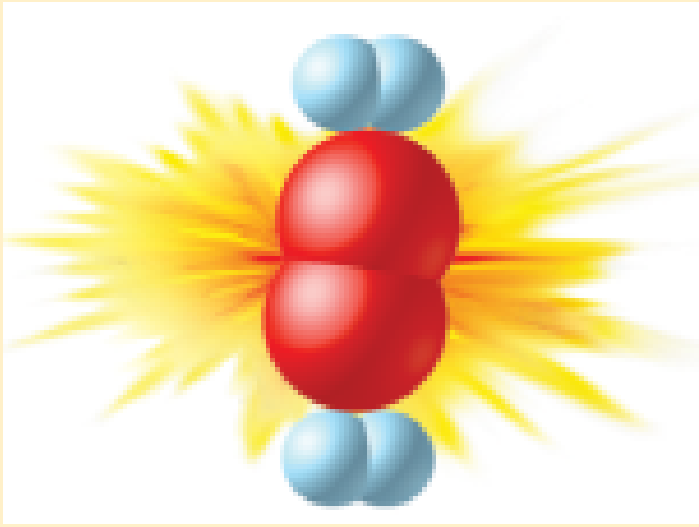
3) Calculate the average reaction rate at the start to 20 seconds.

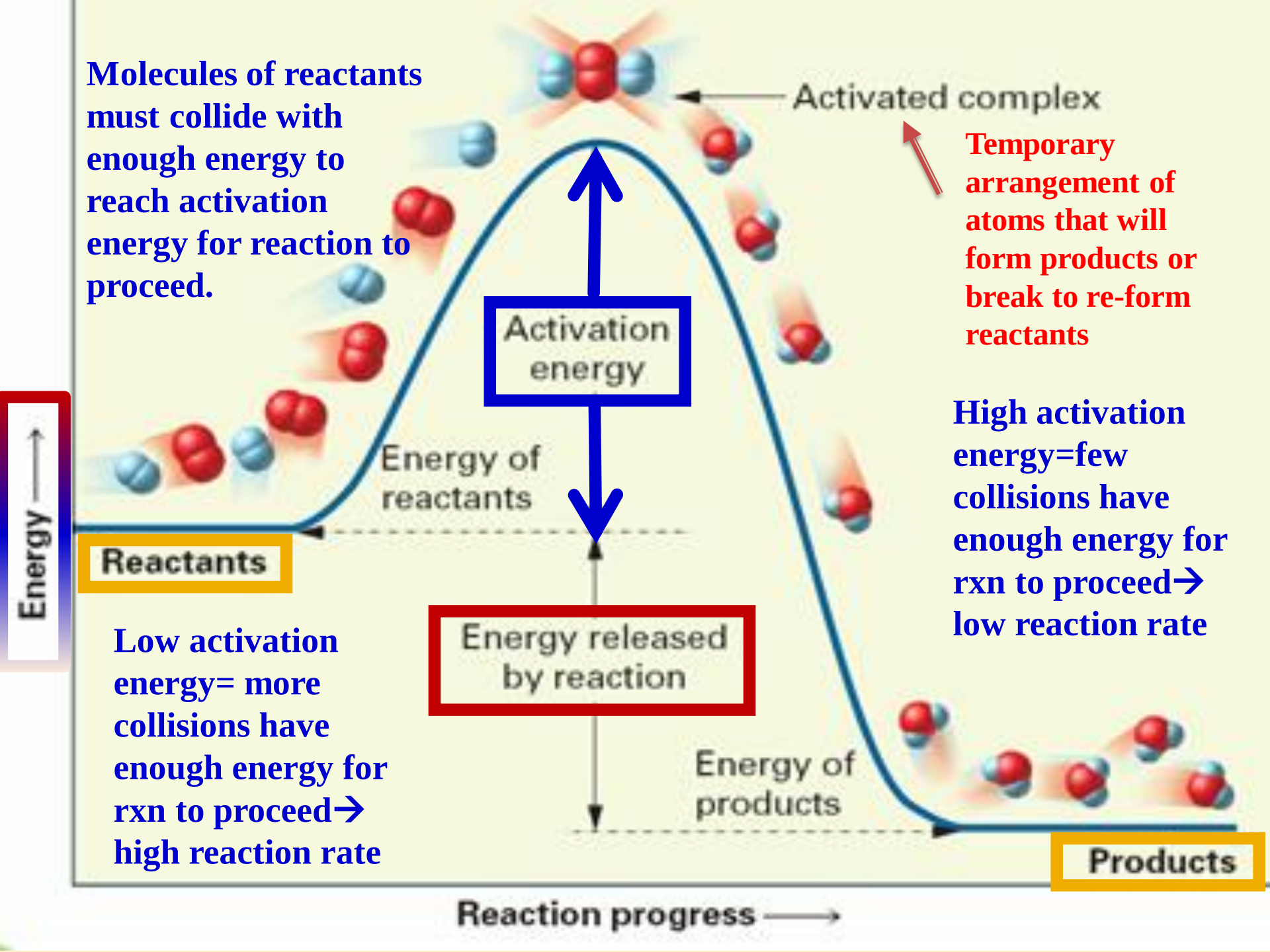
# Collision Theory-atoms, ions, and molecules must collide in order to react



# Collision Theory.

- **For rxn to occur, collision must have:**
  - **proper orientation**
    (position)
  - **minimum energy**
    needed **to react** called
    **Activation Energy**




Molecules of reactants must collide with enough energy to reach activation energy for reaction to proceed.
Activated complex
Temporary arrangement of atoms that will form products or break to re-form reactants
Activation energy
Energy of reactants
Reactants
High activation energy=few collisions have enough energy for rxn to proceed→ low reaction rate
Energy released by reaction
Low activation energy= more collisions have enough energy for rxn to proceed→ high reaction rate
Energy of products
Products
Energy
Reaction progress

# 5 Factors Affecting Rates

- The speed that a reaction takes place can be affected by:
    - Nature of Reactants
    - Temperature
    - Surface Area
    - Concentration
    - Catalysts

# 1) Nature of Reactants

- Some substances are more reactive than others.

**Which is faster and why?**

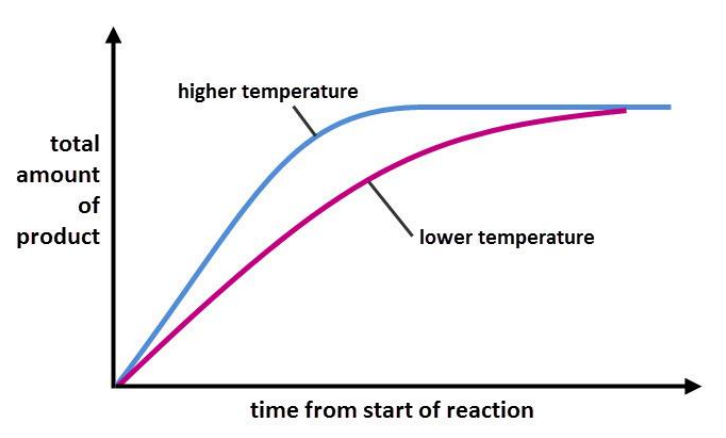
$Ca + 2H_2O \rightarrow H_2 + Ca(OH)_2$

$2Na + 2H_2O \rightarrow H_2 + 2Na(OH)_2$

# 2) Temperature

- Why does milk last longer in the fridge?

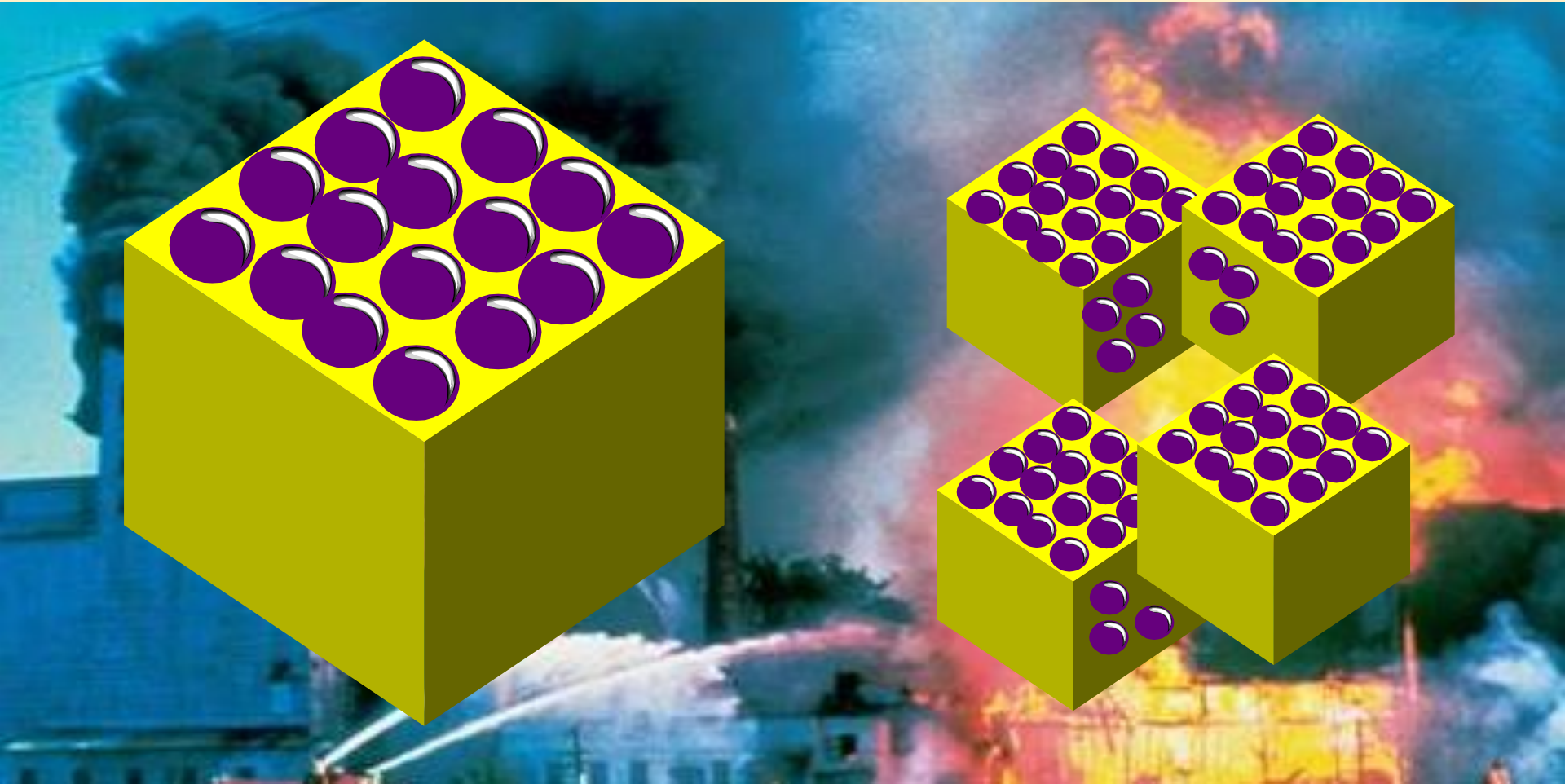
- ↑Temp. ↑Rate




- **more energy, more collisions**

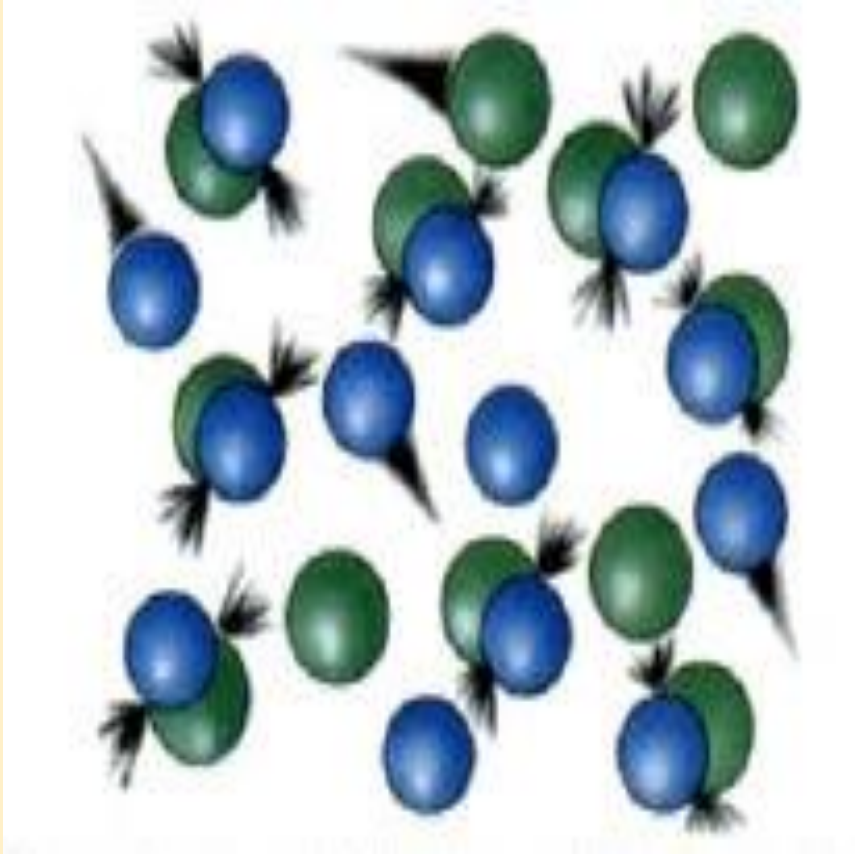
# 3) Surface Area

- ↑ Surf. Area ↑ Rate
- more collisions



# 4) Concentration

- ⇧Conc. ⇧Rate
  - more collisions

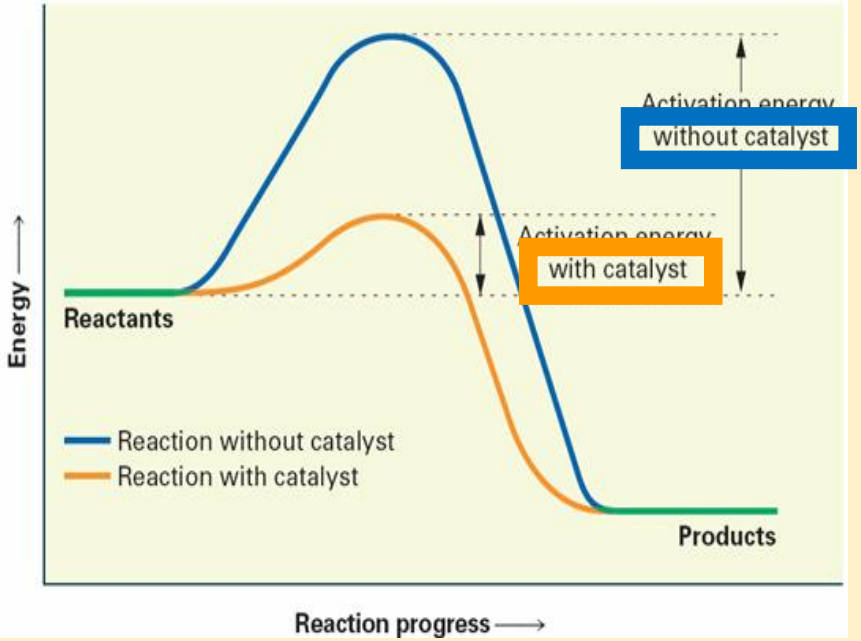


# Concentration Continued…

- ↑ Conc. ↑ Rate


# 5) Catalysts

- **speed up** a reaction **without** being **consumed**.
- **lower** the **activation energy**.




**How does a catalyst affect collisions?**

More collisions have sufficient energy to initiate reaction!

# Practice Problem

3) Nitrogen monoxide reacts with chlorine gas to form nitrosyl chloride according to the following equation:

$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$

| Time (s) | $[Cl_2]$ (M) |
|---|---|
| 0.0 | 0.00640 |
| 30.0 | 0.00295 |

:

Calculate the average rate of the reaction over this time in terms of disappearance of chlorine.