## Essential Question

What controls how fast a reaction happens?

# What Is Reaction Rate?

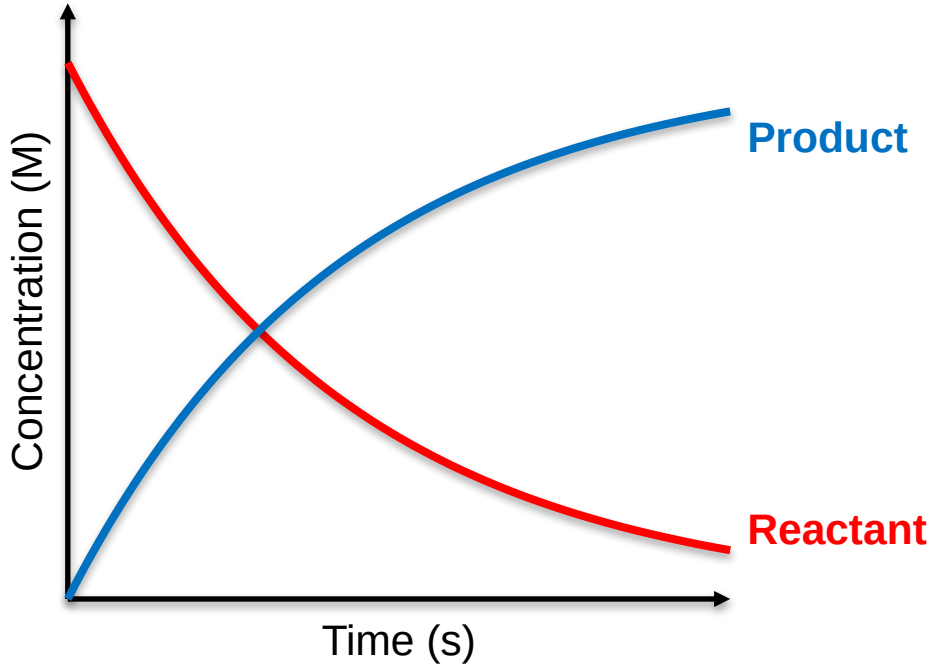
- How fast reactants turn into products
- Change in concentration per unit of time

$$\text{rate} = \Delta[\text{P}] / \Delta t = -\Delta[\text{R}] / \Delta t$$

| $[\text{P}], [\text{R}]$ | $\Delta t$ | $\text{M/s}$ |
|---|---|---|
| product, reactant (M) | change in time (s) | units of rate |

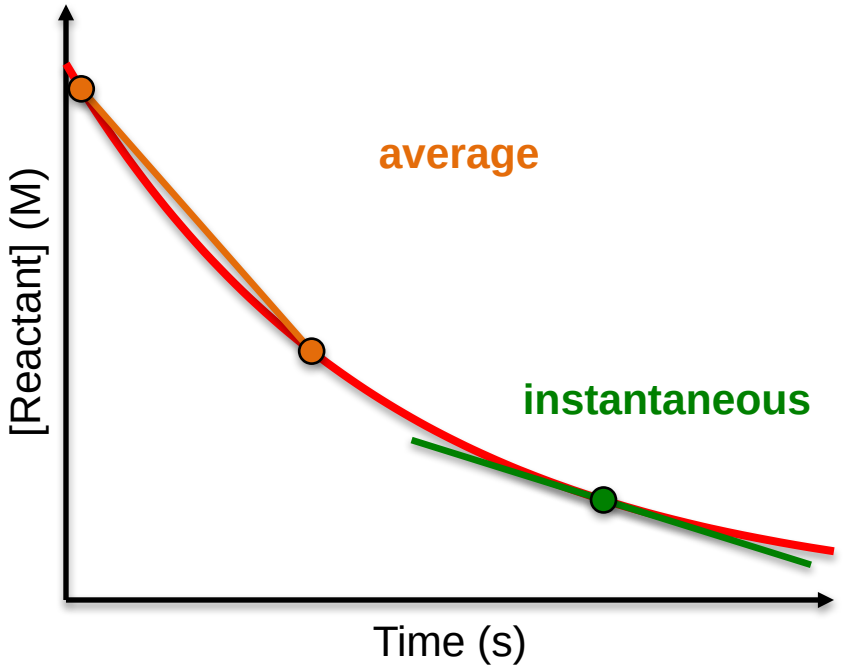
# Reactants Down, Products Up

- Reactant concentration decreases
- Product concentration increases
- Rate is fastest at the start



# Average vs. Instantaneous Rate

- Average rate: slope between two points
- Instantaneous rate: slope of the tangent line at one point



# Rates and Stoichiometry

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

| $N_2O_5$ | = | $NO_2$ | = | $O_2$ |
|---|---|---|---|---|
| $-\frac{1}{2}\,\Delta[N_2O_5]/\Delta t$ | | $\frac{1}{4}\,\Delta[NO_2]/\Delta t$ | | $\Delta[O_2]/\Delta t$ |

- Divide each rate by its coefficient
- Reactants get a negative sign

# Factors That Affect Rate

## Concentration

More particles → more collisions

## Temperature

Faster particles → more and harder collisions

## Surface Area

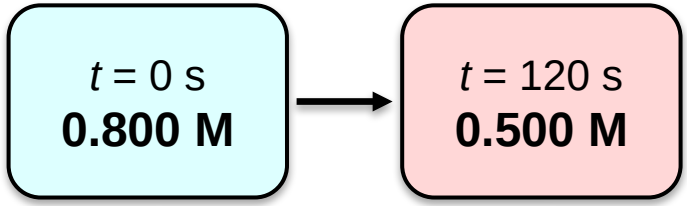
More exposed particles → more collisions

## Catalyst

Easier pathway → lower energy barrier

# Example: Average Rate

The concentration of $H_2O_2$ drops from 0.800 M to 0.500 M in 120 s. Calculate the average rate at which $H_2O_2$ is used up.



## Example: Comparing Rates

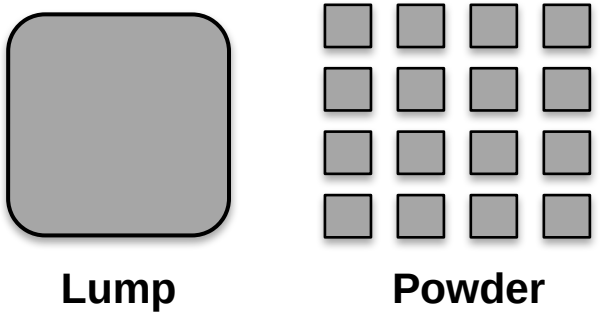
For the reaction below, $NH_3$ forms at a rate of 0.240 M/s. At what rate is $H_2$ used up?

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

| $H_2$ | $NH_3$ |
| --- | --- |
| ? M/s | 0.240 M/s |

# Example: Explaining a Rate Change

Equal masses of zinc react with the same HCl solution. Zinc powder reacts much faster than one lump of zinc. Explain why using particles.



# Reaction Rates

## Big Ideas

- Rate = change in concentration ÷ time
- Steeper graph → faster rate
- Use coefficients to compare rates
- Concentration, temperature, surface area, and catalysts change rate

