N8 - KINETICS

Quick Review

Link to YouTube Presentation: https://youtu.be/c3JlH98mA0U

N8 - KINETICS

Quick Review

Target: I can refresh my memory from Honors Chem about how we measure reaction rates.

Kinetics

Study of

- reaction rates
- reaction mechanisms

Reaction Rate

Reaction Rate - The speed of a chemical reaction

How fast products are made **or**
How fast reactants are used.

The ability to control the speed of a chemical reaction is important! Speeding them up is sometimes good, slowing them down is sometimes good.

Defining Rate

Rate

How much a quantity changes in a given period of time.

Example:

Speed of a car — distance the car travels (miles) in a given period of time (1 hour).

So, the rate of your car has units of mi/hr.

$$\text{Rate} = -\frac{\Delta[I_2]}{\Delta t}$$

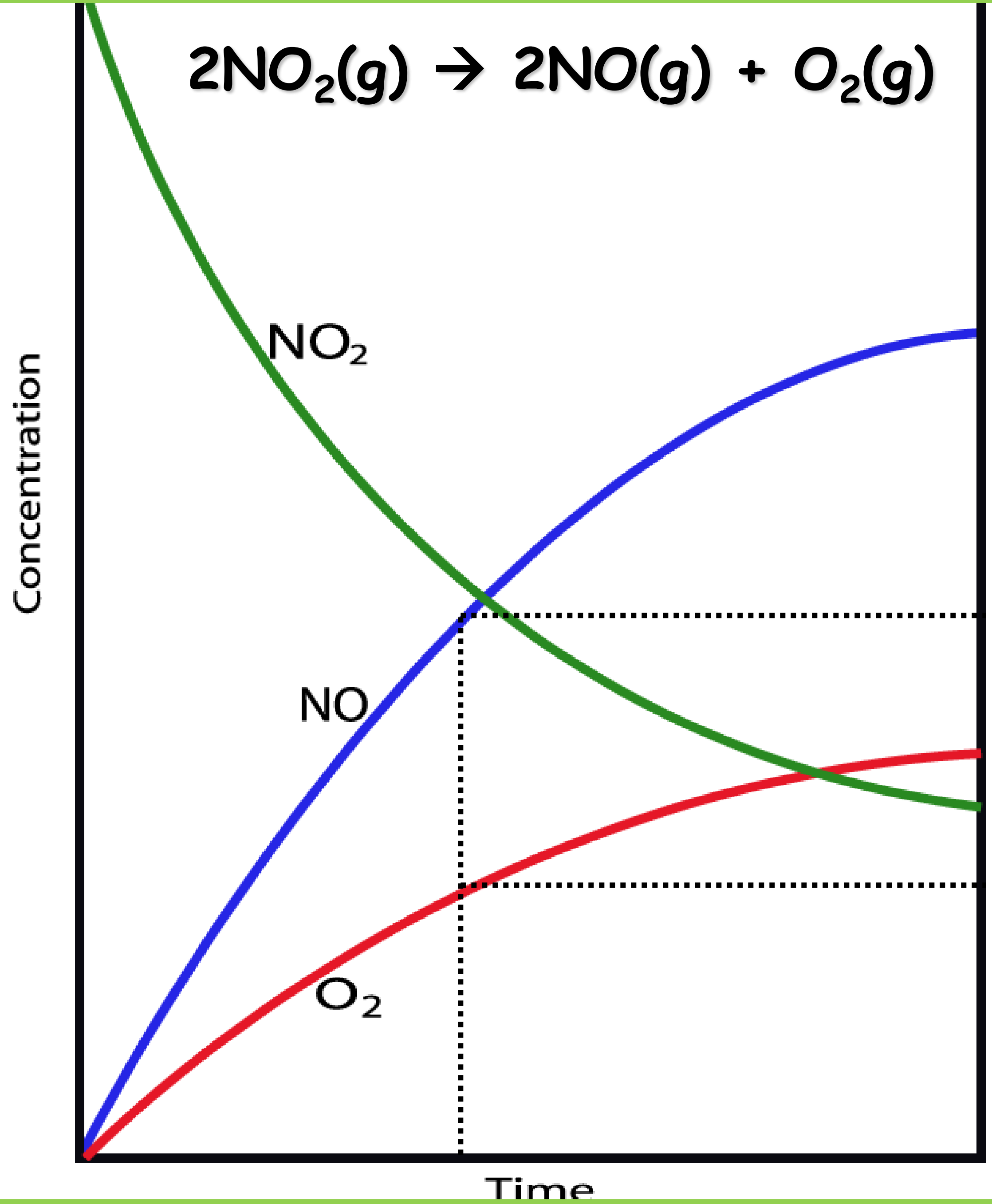
Defining Reaction

Rate for a chemical reaction – change in concentration in a given amount of time.

- Could be how fast products are made = +
- Could be how fast reactants are used up = -

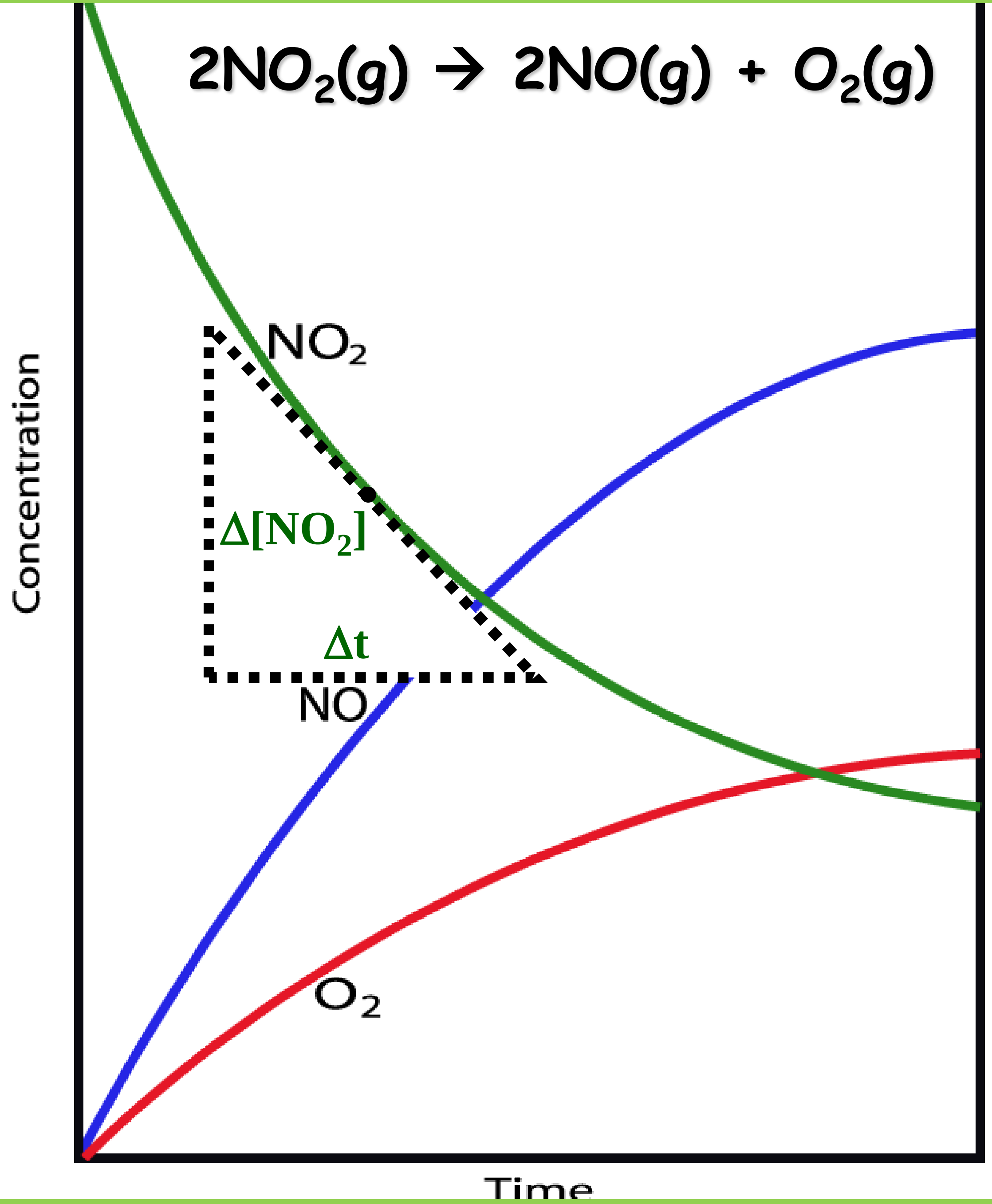
For reactants, a negative sign is placed in front of the definition.

$$\text{Rate} = -\frac{\Delta[H_2]}{\Delta t} = -\frac{[H_2]_{t_2} - [H_2]_{t_1}}{t_2 - t_1}$$



Reaction Rates:

1. Can measure disappearance of reactants
2. Can measure appearance of products
3. Are proportional stoichiometrically



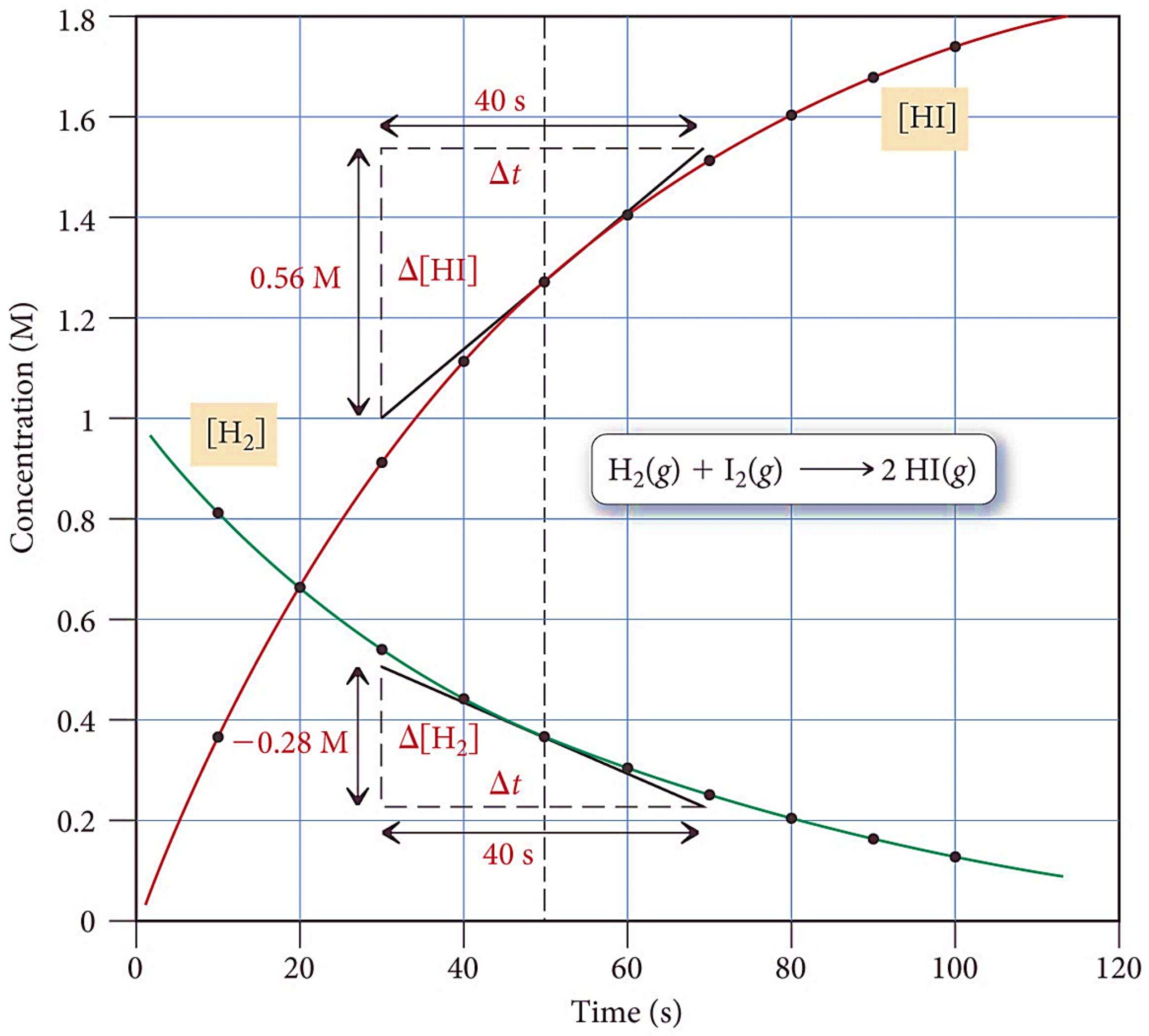
Reaction Rates:

4. Are equal to the slope tangent to that point

5. Change as the reaction proceeds, if the rate is dependent upon concentration

$$\frac{\Delta[NO_2]}{\Delta t} \neq \text{constant}$$

Reactant and Product [ ]s as a Function of Time



Reaction Rate and Stoichiometry

In most reactions, the coefficients of the balanced equation are not all the same.

$$H_{2\,(g)} + I_{2\,(g)} \rightarrow 2\,HI_{(g)}$$

Reaction Rate and Stoichiometry

$$H_{2\,(g)} + I_{2\,(g)} \rightarrow 2\,HI_{(g)}$$

For these reactions, the change in the number of molecules of one substance is a multiple of the change in the number of molecules of another.

- For every 1 mole of H_2 used,
  1 mole of I_2 will also be used and 2 moles of HI made.

Therefore, the rate of change will be different!

Reaction Rate and Stoichiometry

To be consistent, the change in the concentration of each substance is multiplied by $\frac{1}{coefficient}$

$$\text{Rate} = -\frac{1}{a}\frac{\Delta[\text{A}]}{\Delta t} = -\frac{1}{b}\frac{\Delta[\text{B}]}{\Delta t} = +\frac{1}{c}\frac{\Delta[\text{C}]}{\Delta t} = +\frac{1}{d}\frac{\Delta[\text{D}]}{\Delta t}$$

Average Rate vs. Instantaneous Rate

Average Rate

The change in concentrations over any particular time period.

- Linear approximation of a curve
- The larger the time interval, the more the average rate deviates from the instantaneous rate.

Average Rate vs. Instantaneous Rate

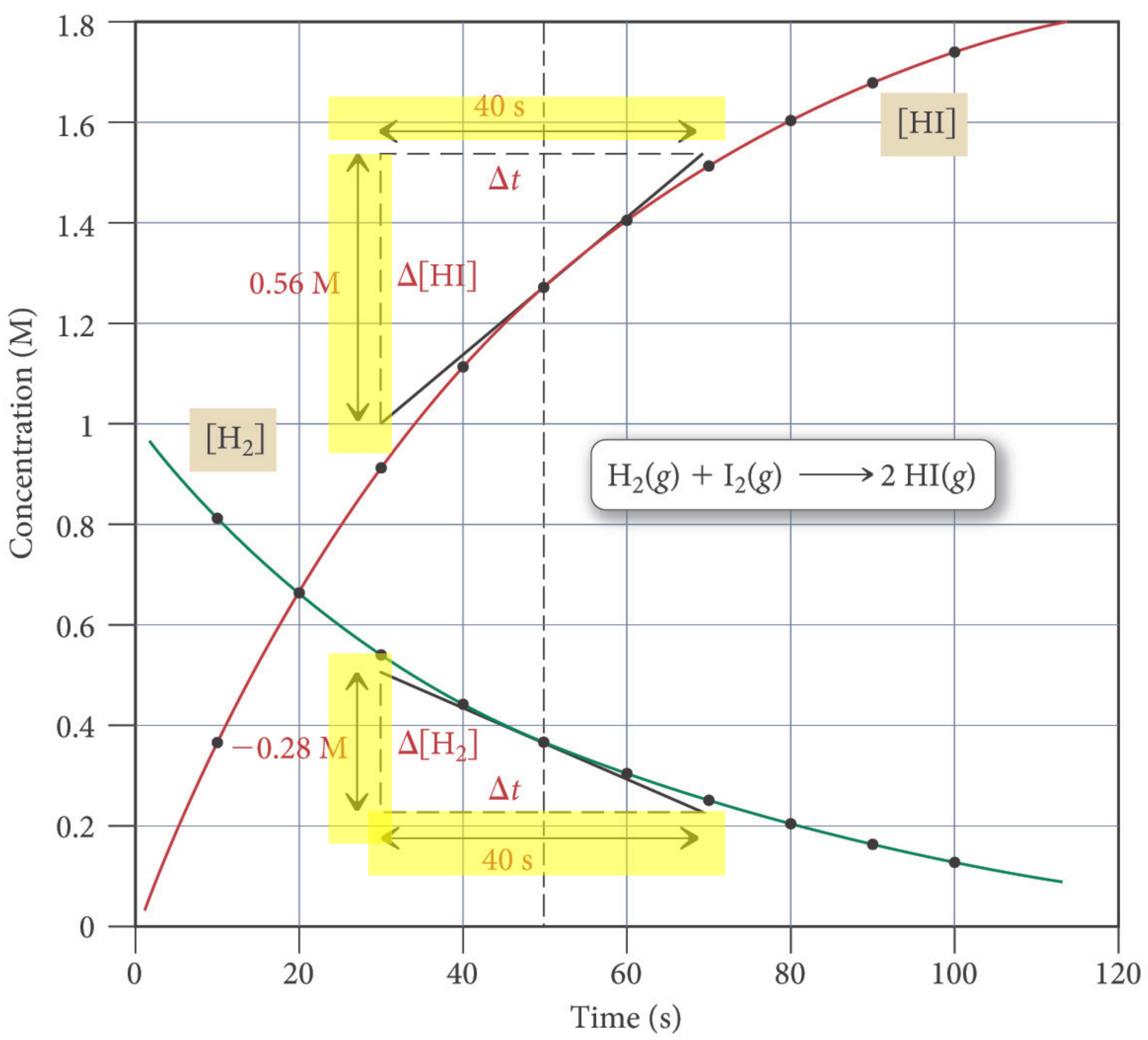
Instantaneous Rate

The change in concentration at a specific, particular time.

- Slope at one point of a curve
- Found by taking the slope of a line tangent to the curve at that particular point.
  - »First derivative of the function (for all of you calculus fans)

    (no we won't be doing calculus)

$$H_{2\,(g)} + I_{2\,(g)} \rightarrow 2\,HI_{(g)}$$



Using $[H_2]$, the instantaneous rate at 50 s is as follows:

$$Rate = -\frac{-0.28\,M}{40\,s}$$

$$Rate = 0.0070\,\frac{M}{s}$$

Using [HI], the instantaneous rate at 50 s is as follows:

$$Rate = \left(\frac{1}{2}\right)\frac{0.56\,M}{40\,s}$$

$$Rate = 0.0070\,\frac{M}{s}$$

Factors Affecting Reaction Rates

Nature of the Reactants

What kind of reactant molecules and
what physical condition they are in.

- Small molecules tend to react faster than large molecules.
- Gases tend to react faster than liquids, which react faster than solids.

Factors Affecting Reaction Rates

Nature of the Reactants

- Powdered solids are more reactive than “blocks.”
  - More surface area for contact with other reactants
- Certain types of chemicals are more reactive than others.
  - For example, K is more reactive than Na
- Ions react faster than molecules.
  - No bonds need to be broken.

Factors Affecting Reaction Rates

Temperature - Increasing temp increases the reaction rate.

Chemist's rule - for each 10 °C rise in temperature, the speed of the reaction doubles.

- Just an approximation, doesn't always work.

There is a mathematical relationship between the absolute temperature and the speed of a reaction discovered by Svante Arrhenius, which will be examined later.

Factors Affecting Reaction Rates

Catalysts

Substances that affect the speed of a reaction without being consumed. They are still there after the reaction is over.

Positive Catalysts – Most common kind, used to speed up a reaction

Negative Catalysts - Used to slow a reaction, also called **inhibitors**.

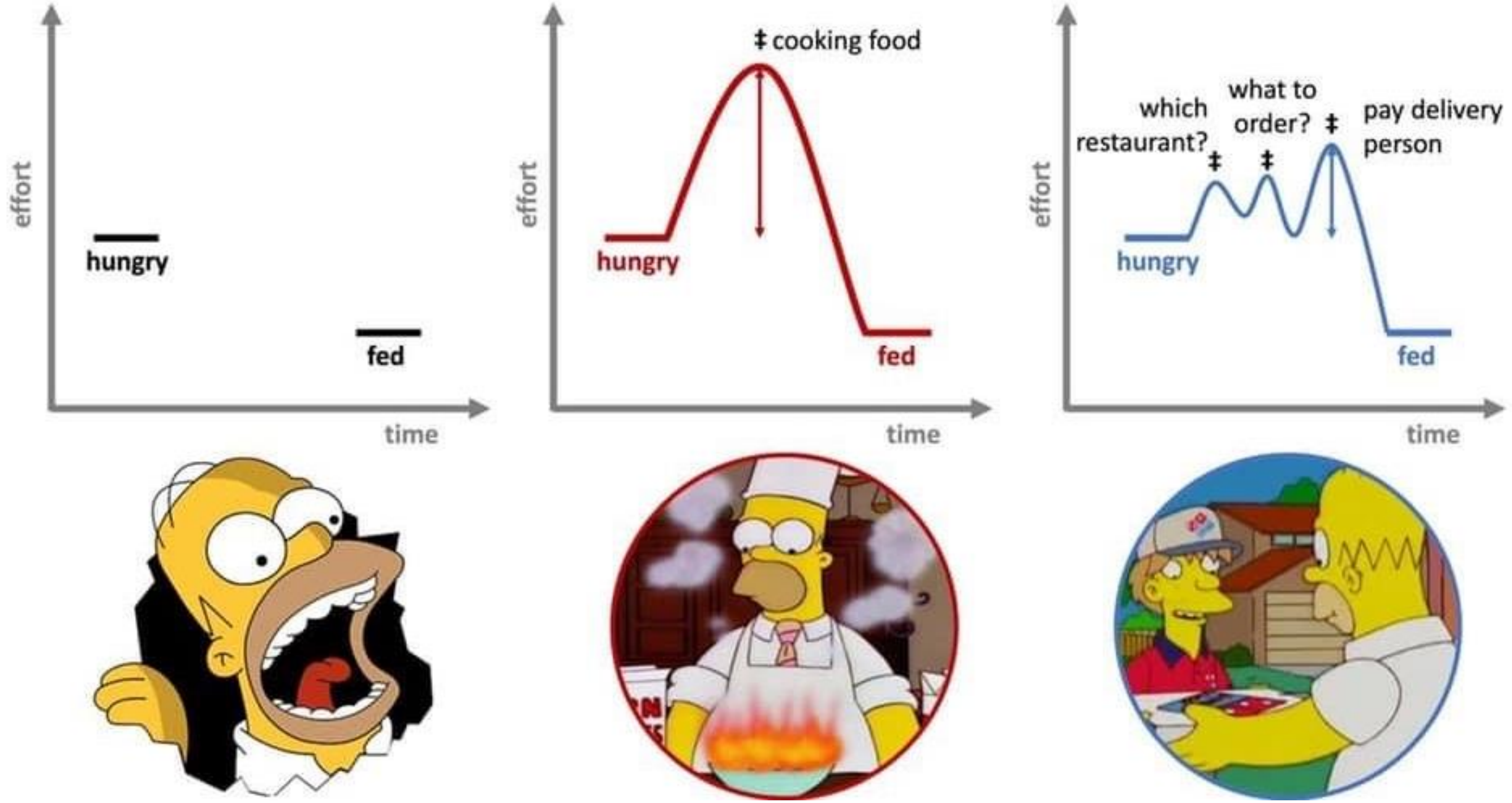
Homogeneous - present in same phase

Heterogeneous - present in different phase

Factors Affecting Reaction Rates

Catalysts

Provide an alternative pathway that has a lower activation energy.



Factors Affecting Reaction Rates

Reactant Concentration

- Generally, the larger the concentration of reactant molecules, the faster the reaction.
  - This increases the frequency of reactant molecules colliding with each other.
- Concentration of gases depends on the partial pressure of the gases.
  - Higher pressure = higher concentration
- Concentrations of solutions depend on the solute-to-solution ratio (molarity).

Remember Collision Theory???

YouTube Link to Presentation

https://youtu.be/c3JlH98mA0U