Thermochemistry

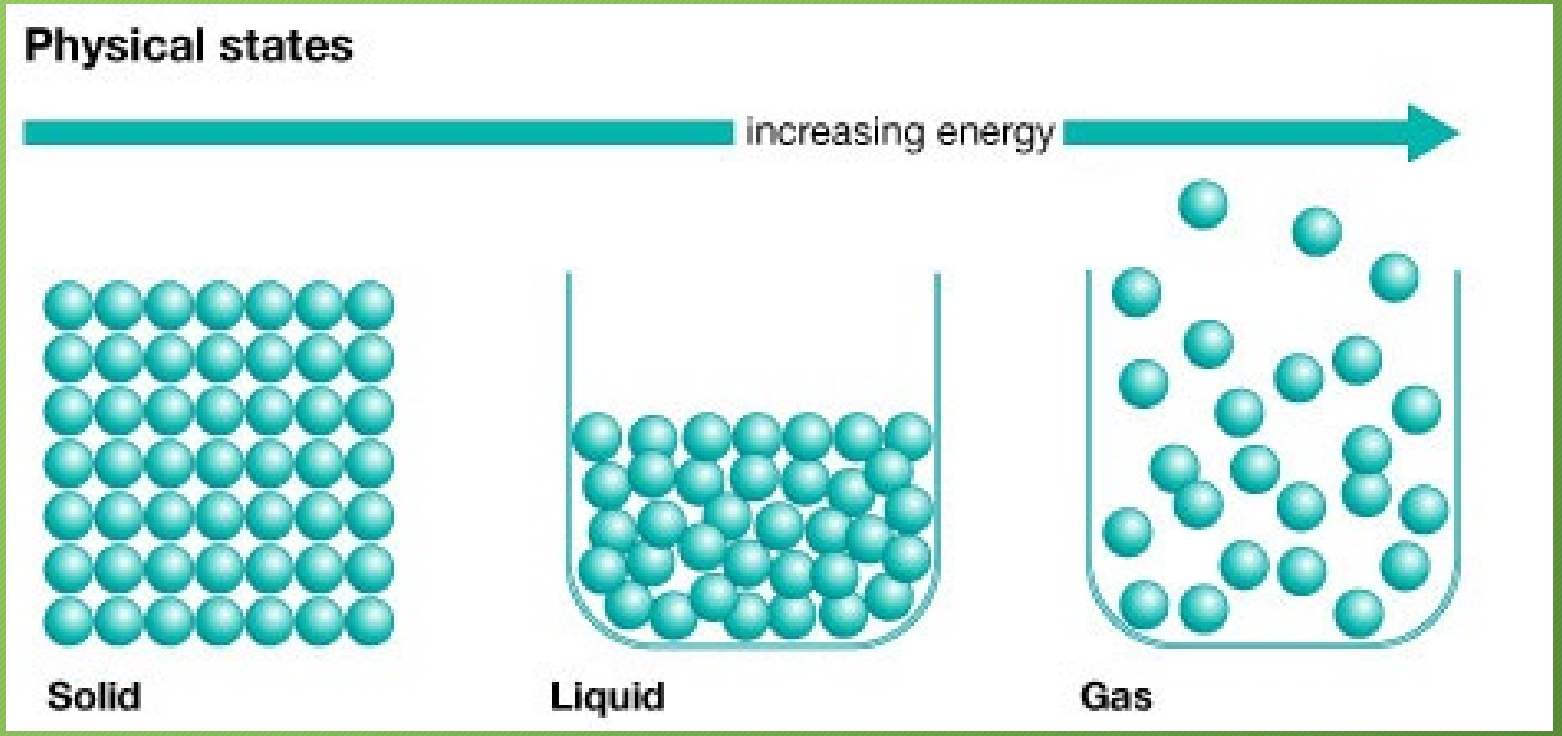
Chapter 12

What is thermochemistry?

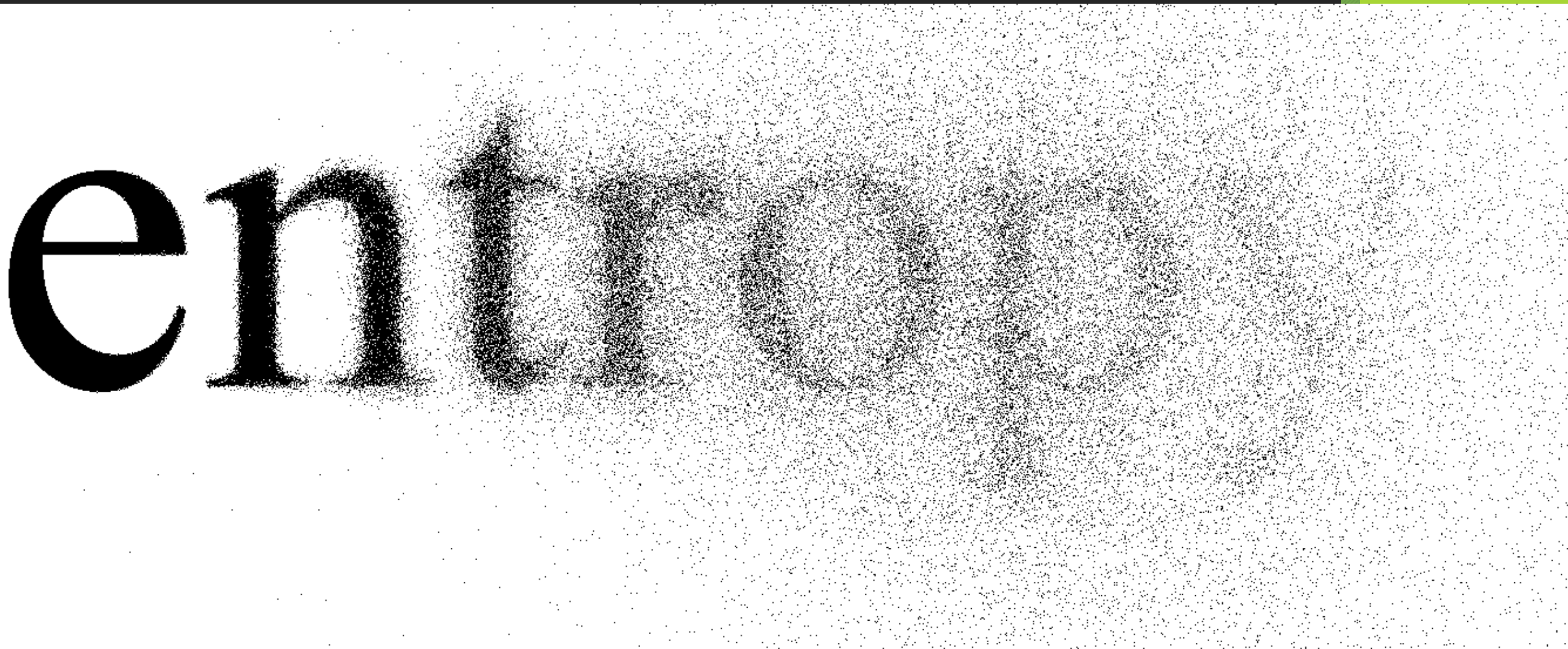
- Study of energy changes in chemical reactions

Phases of Matter

- Basic illustration of differences in energy

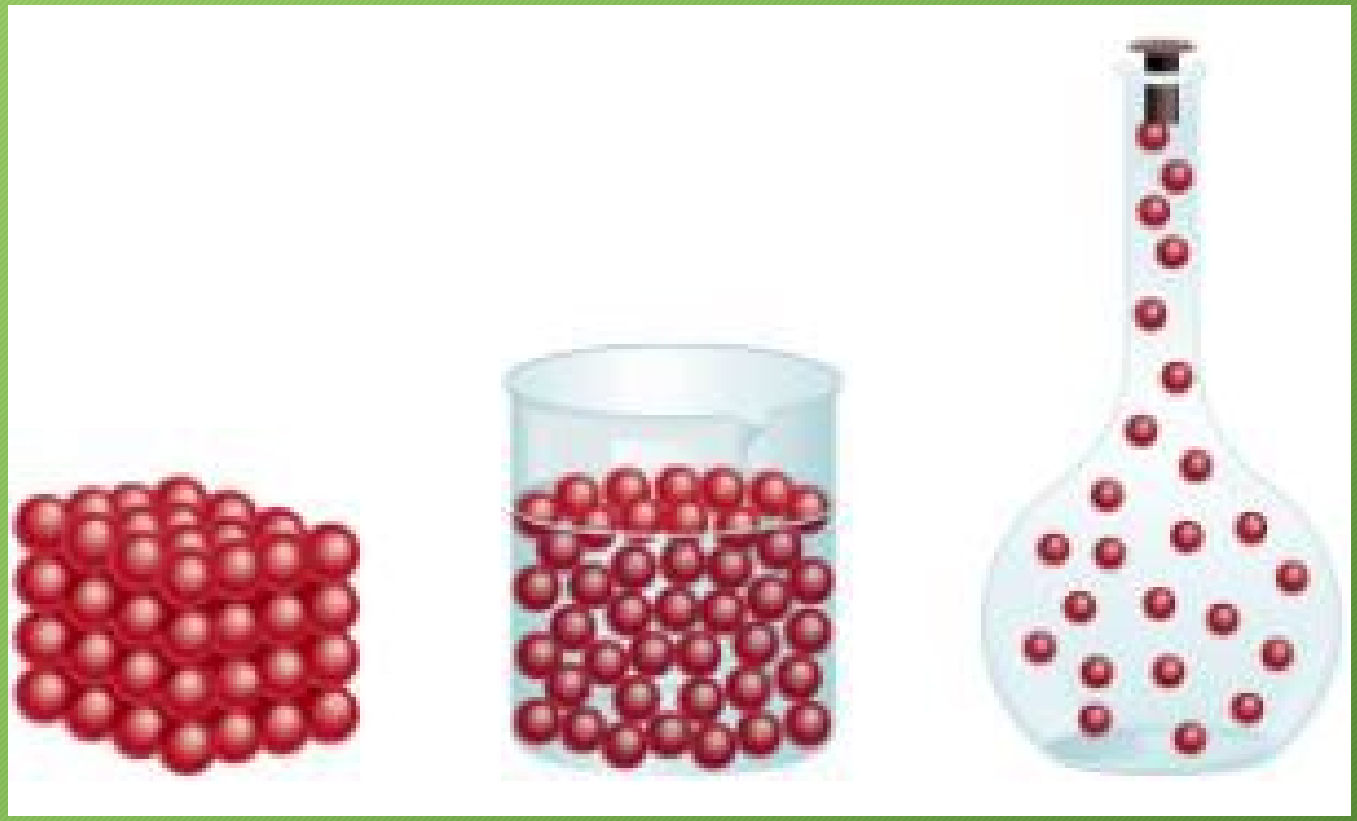


Entropy



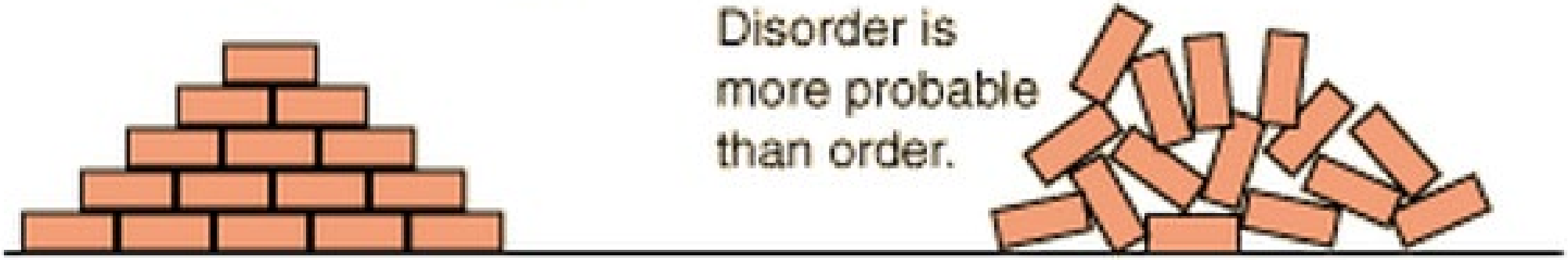
Entropy

- “disorder”



Entropy

If you tossed bricks off a truck, which kind of pile of bricks would you more likely produce?

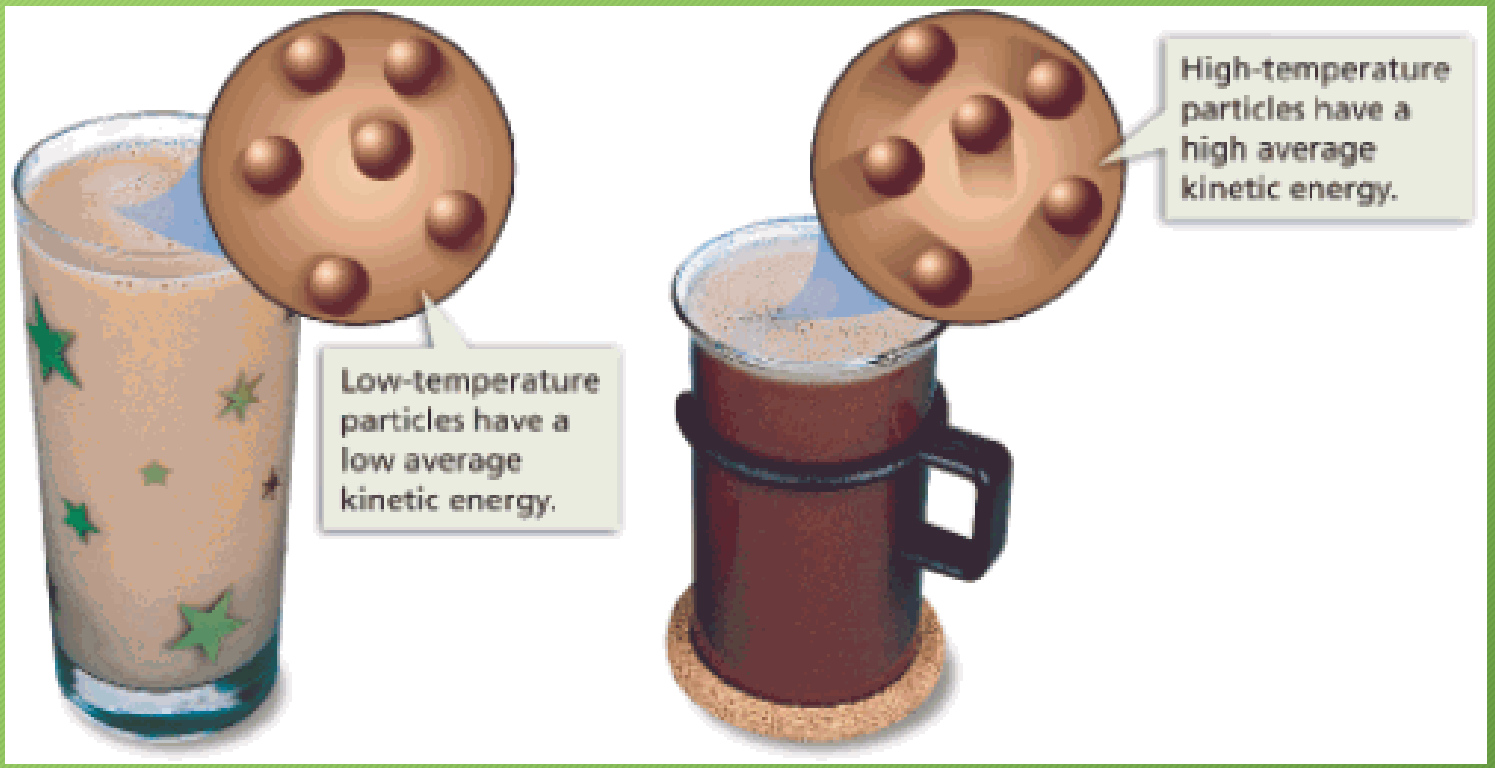


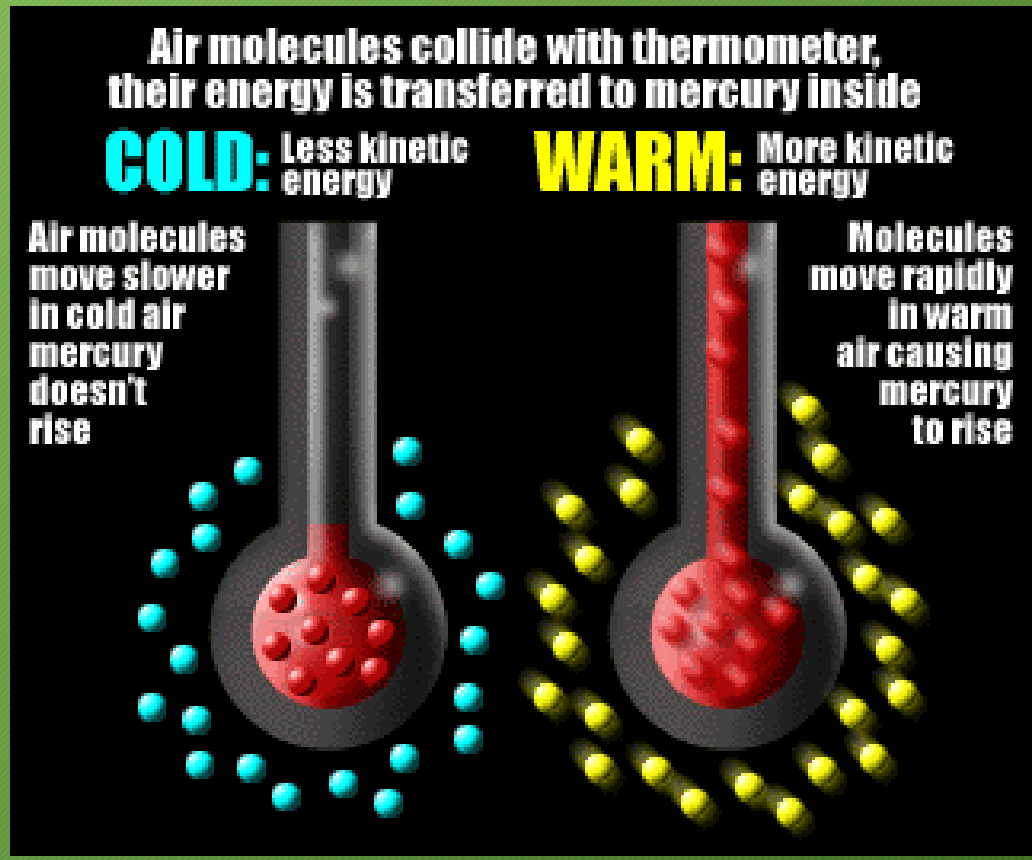
Entropy

- Examples of increasing entropy:
  - A stack of books falling over
- Examples of decreasing entropy:
  - Picking up a stack of books into a neat pile

Kinetic Molecular Theory

1) Increases in temperature cause an increase in the kinetic energy of molecules

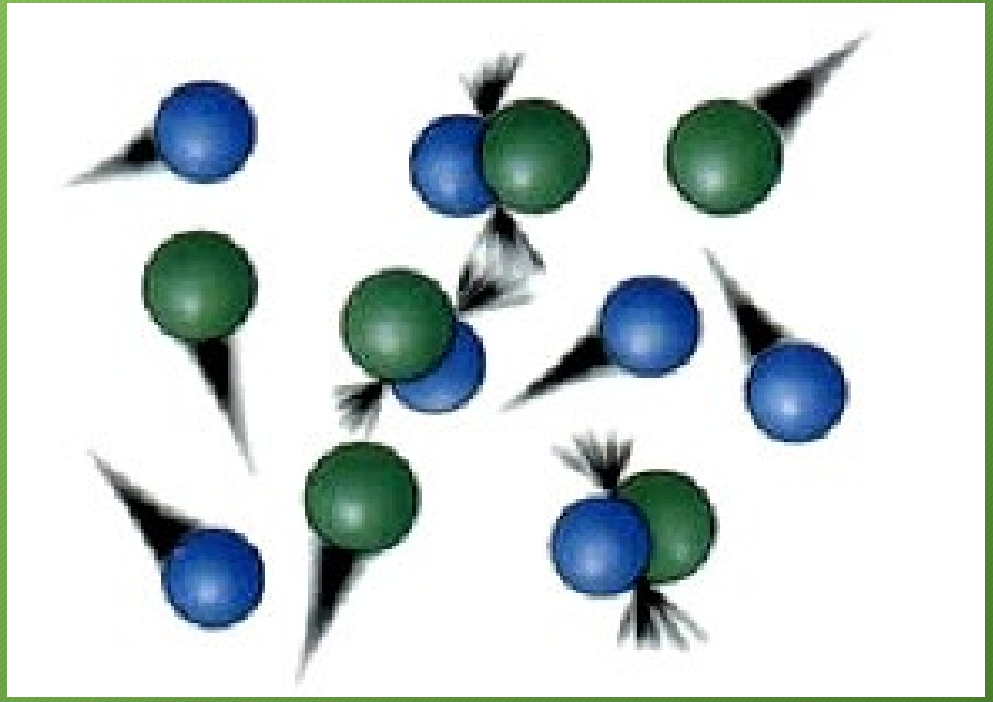




Kinetic Molecular Theory

2) …Leads to an increase in the number of collisions

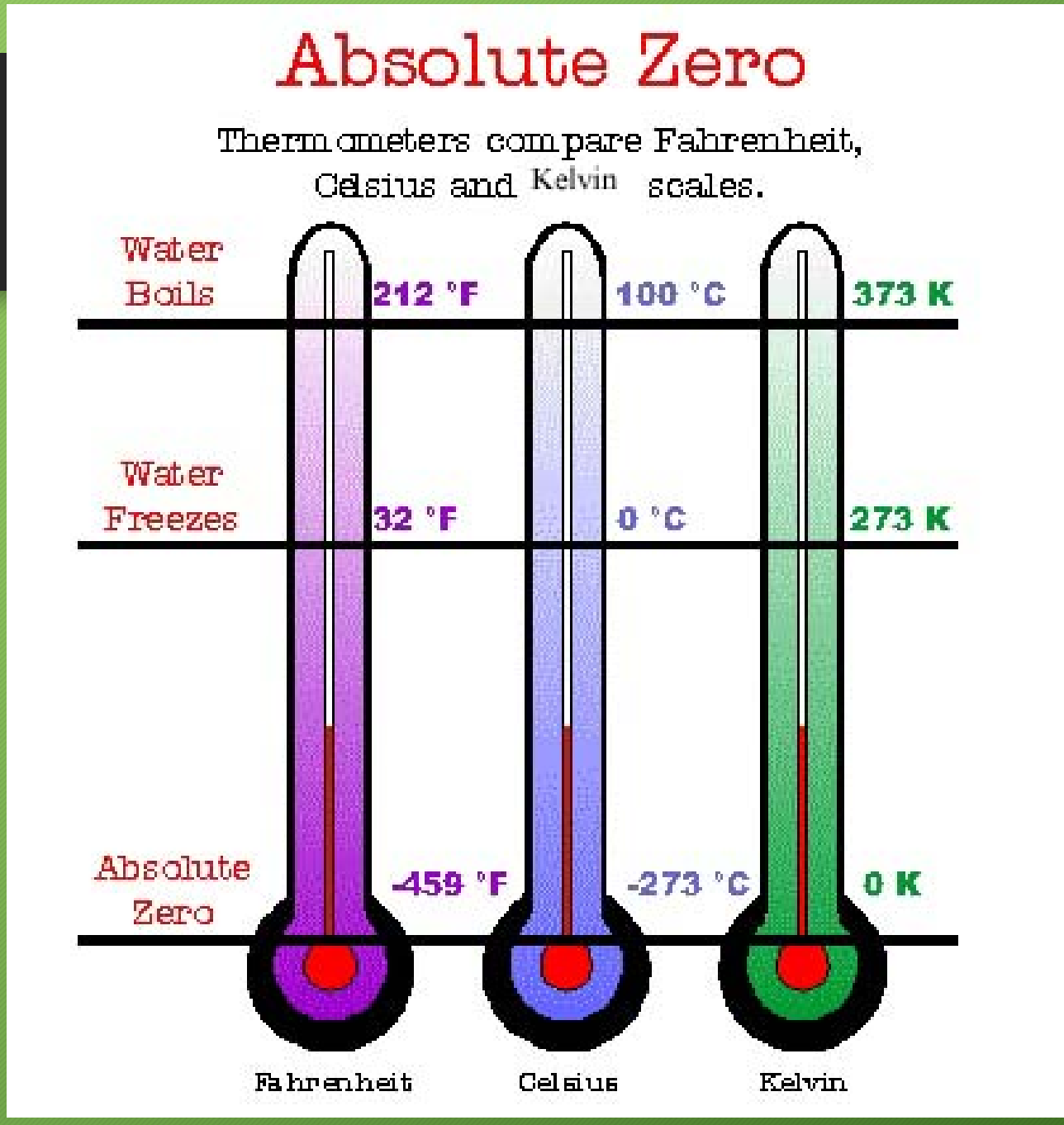
3) …Increases reaction rate



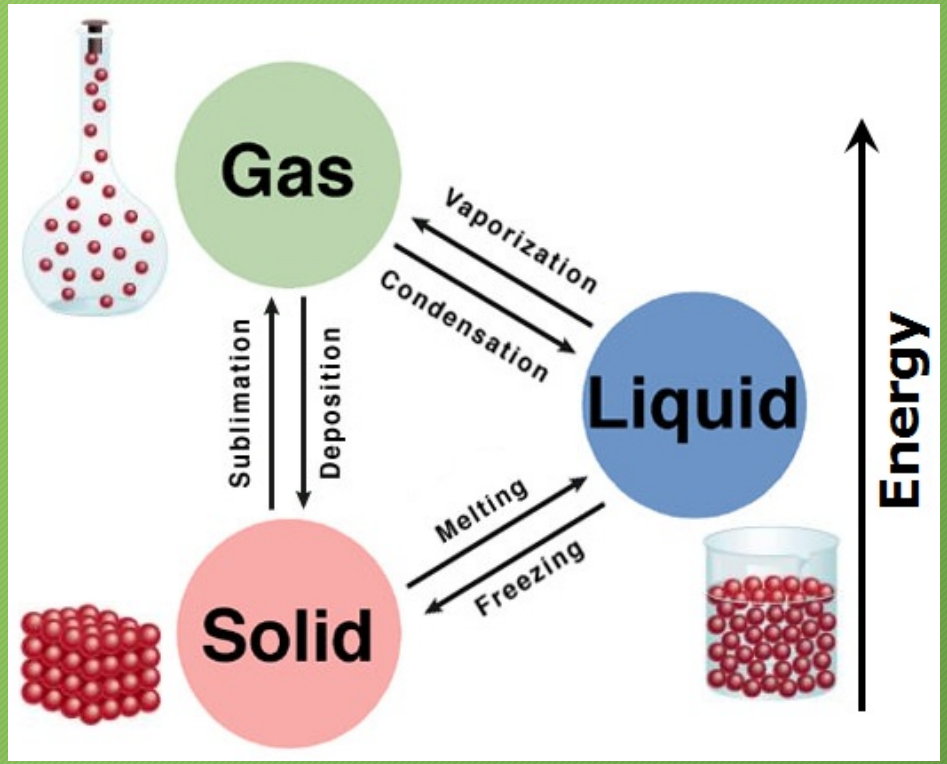
Molecules must collide in order to react.

Absolute Zero

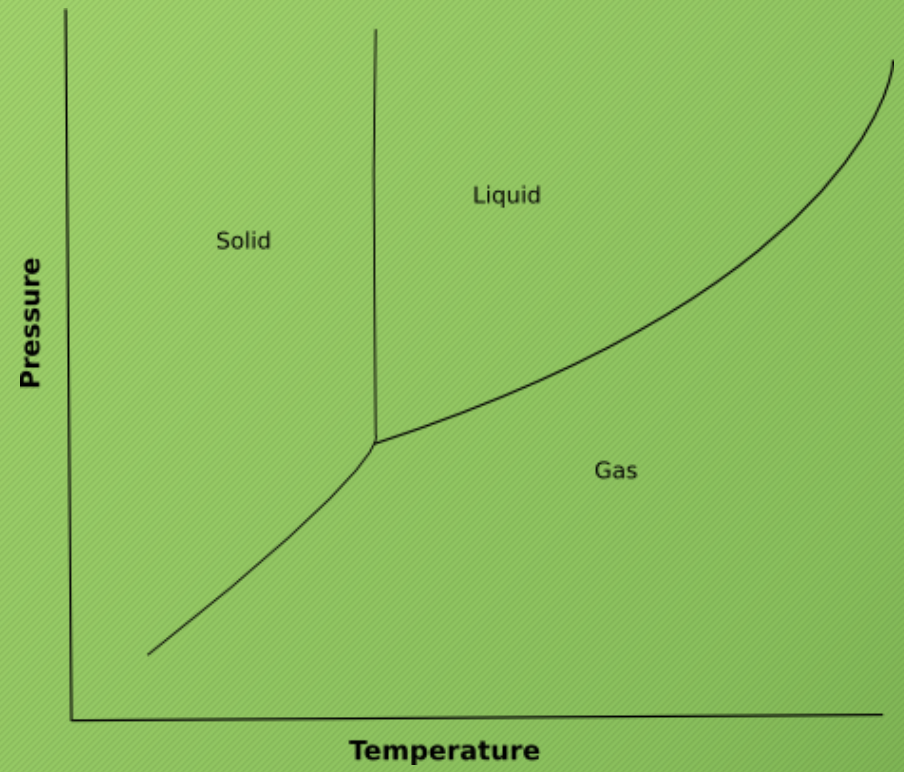
- 0 Kelvin
- All molecular motion stops
  - Can never be achieved
  - Why?
- K = °C + 273



Phase Changes



Phase Diagram

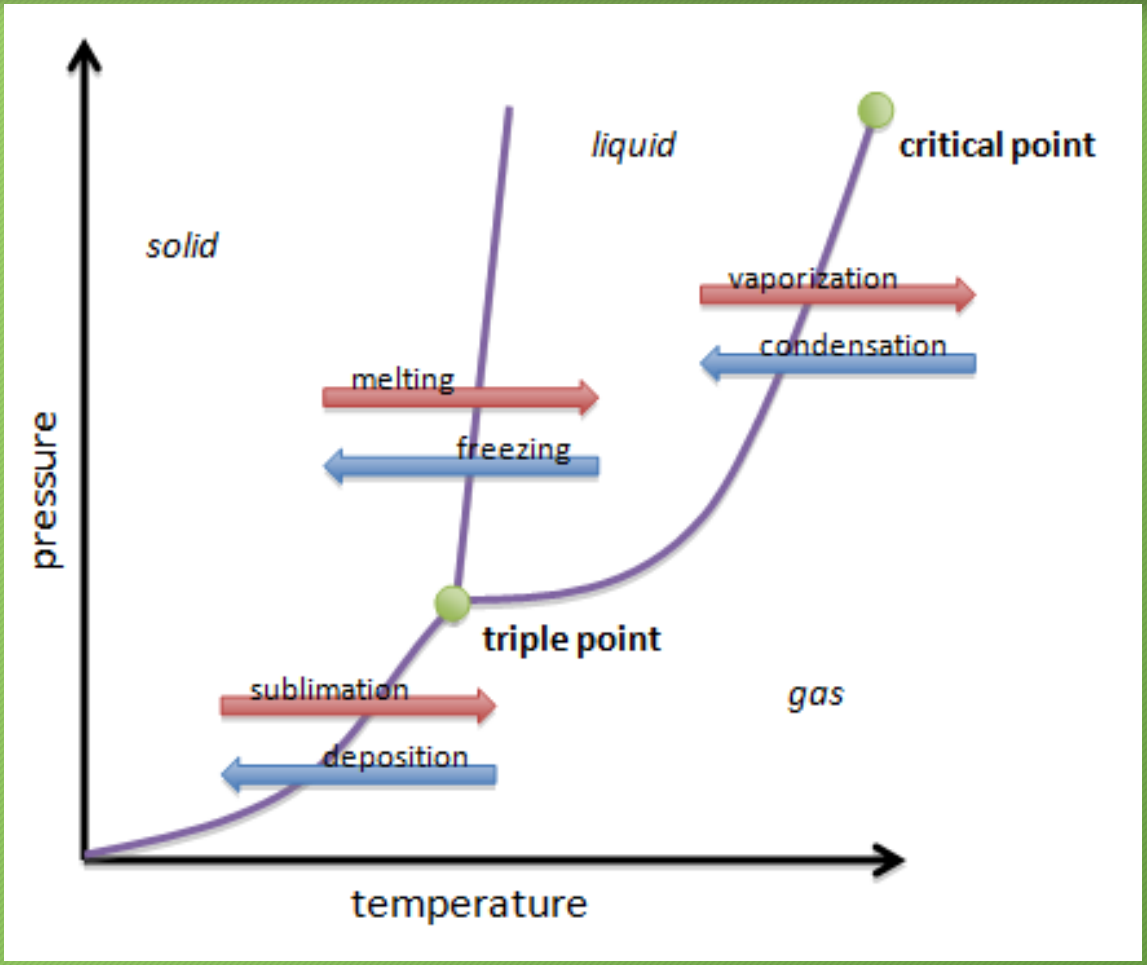


- Shows how pressure and temperature can cause changes in phase of matter

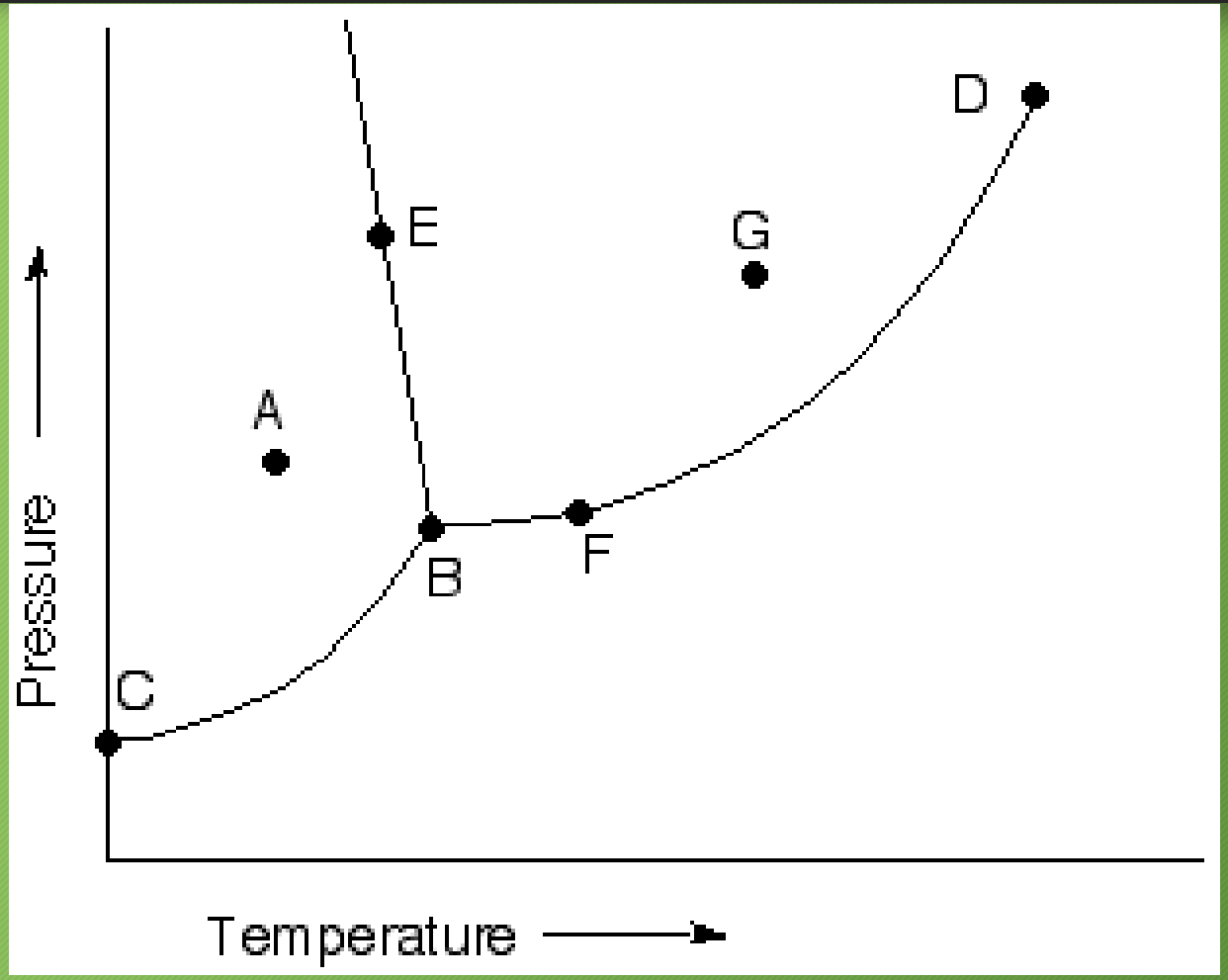
Triple Point

- Solid, liquid, and gas coexist in equilibrium at a certain pressure and temperature
  - AKA: all phase changes are taking place simultaneously

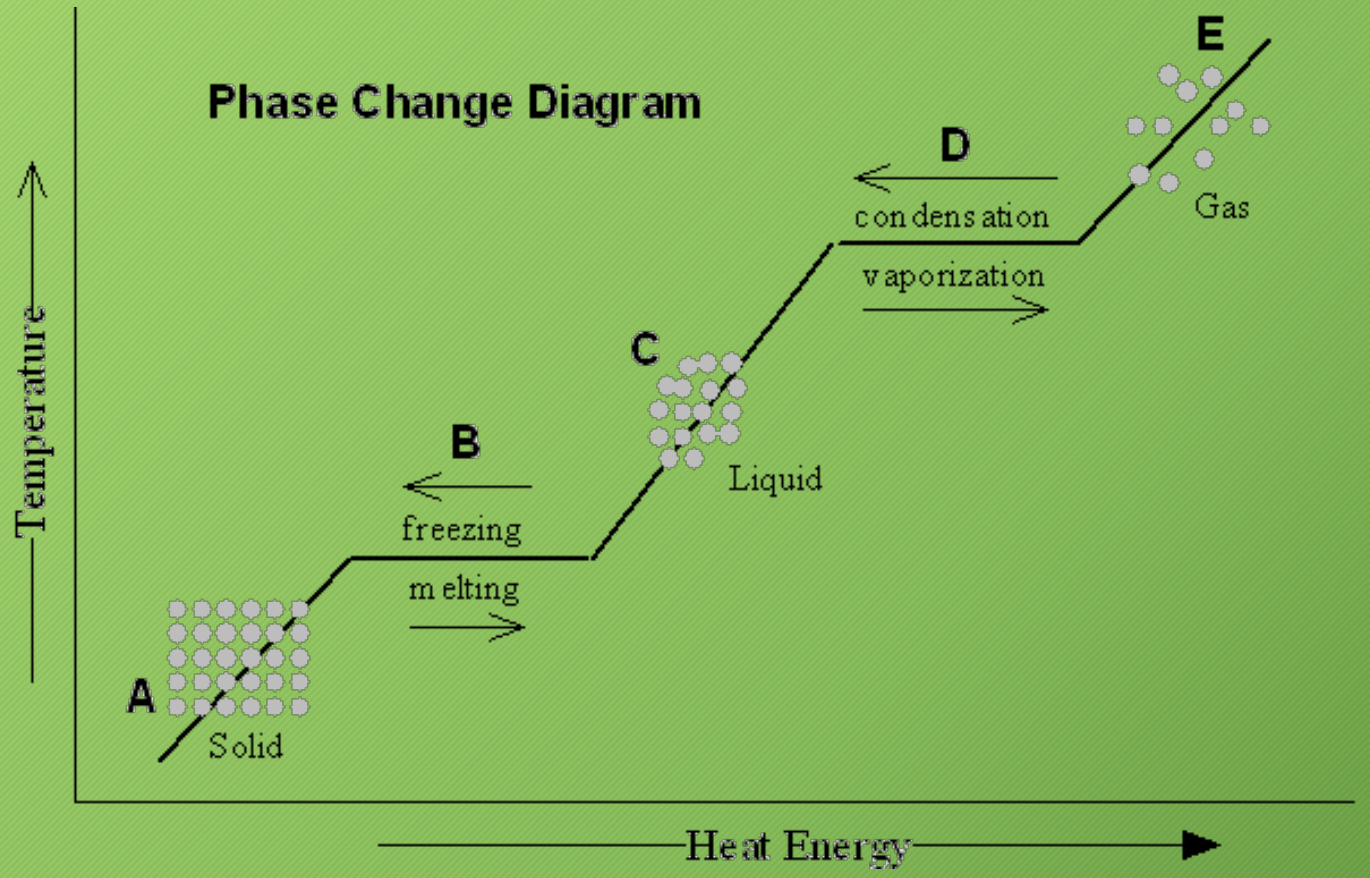
Phase Diagram



Phase Diagram



Heating Curve of Water



Temperature does NOT change during a phase change.

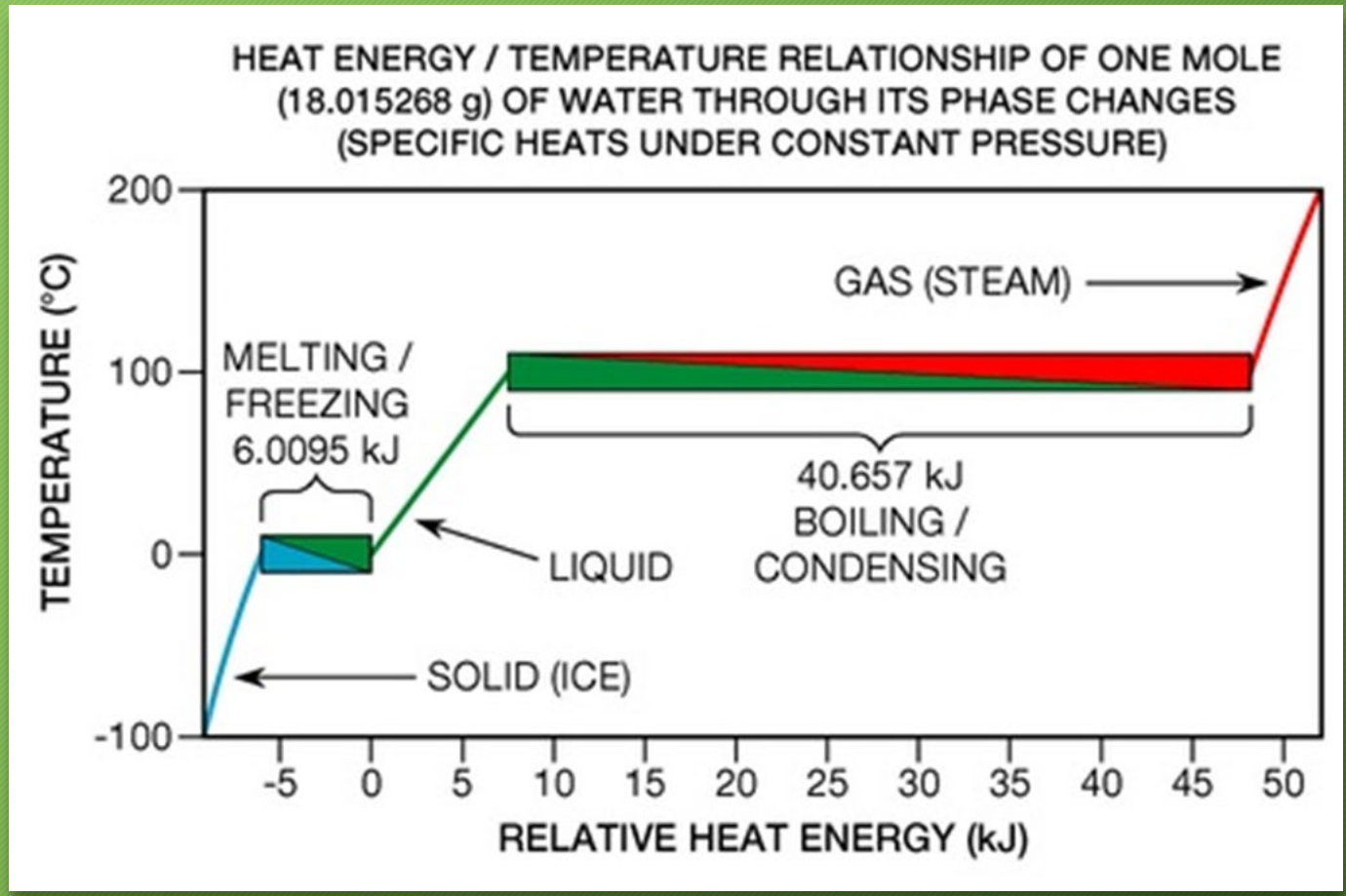
Why?

Heating Curve of Water

How much energy is required to change phase??

Heat of vaporization: energy needed to change liquid to gas

Heat of fusion: energy needed to change solid to liquid



Enthalpy

Heat content (H)

How does heat energy change in a chemical reaction?

$$\Delta H = H_{products} - H_{reactants}$$

Δ = delta = “change in”

Baggies Demo

In an exothermic reaction, energy is released into the surroundings as heat. As a result, the temperature of the surroundings increases.

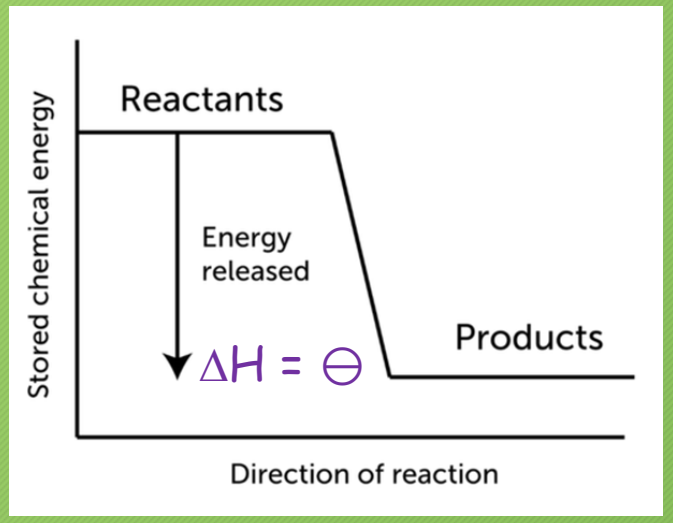
In an endothermic reaction, energy is absorbed from the surroundings. As a result, the temperature of the surroundings drops.

Remember: $\Delta H = H_{products} - H_{reactants}$

Enthalpy in Reactions: Two Types of Reactions

Exothermic

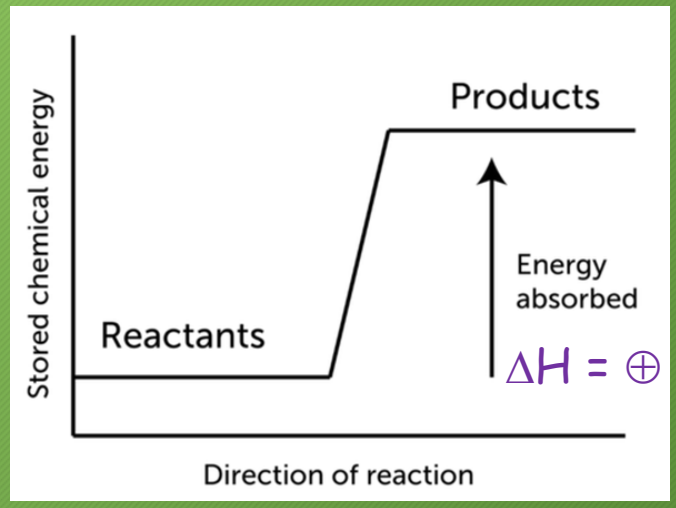
- Energy is released into the surroundings



Reactants → Products + heat

Endothermic

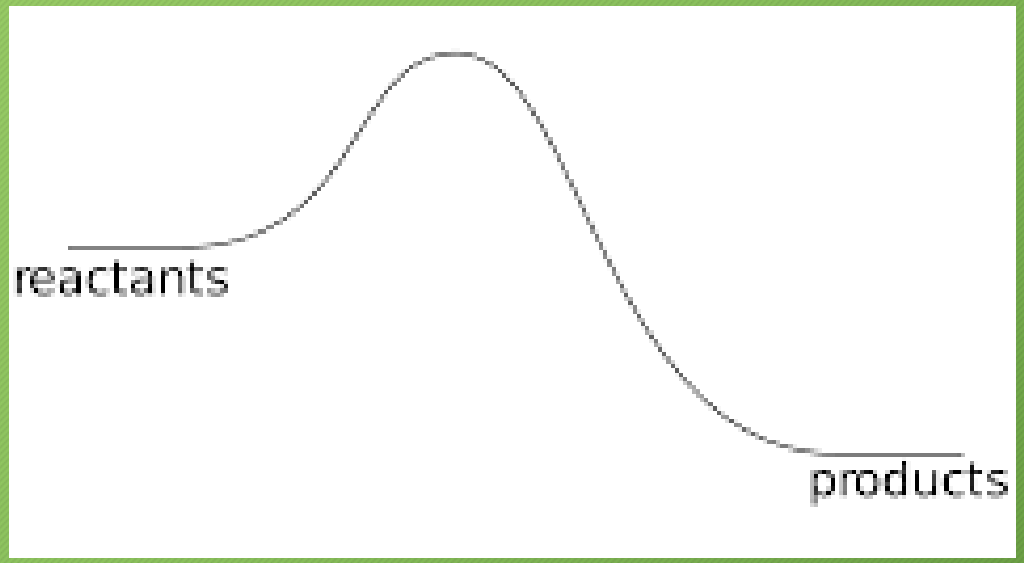
- Energy is absorbed from the surroundings



heat + Reactants → Products

Enthalpy in Reactions

Enthalpy in Reactions: Activation Energy

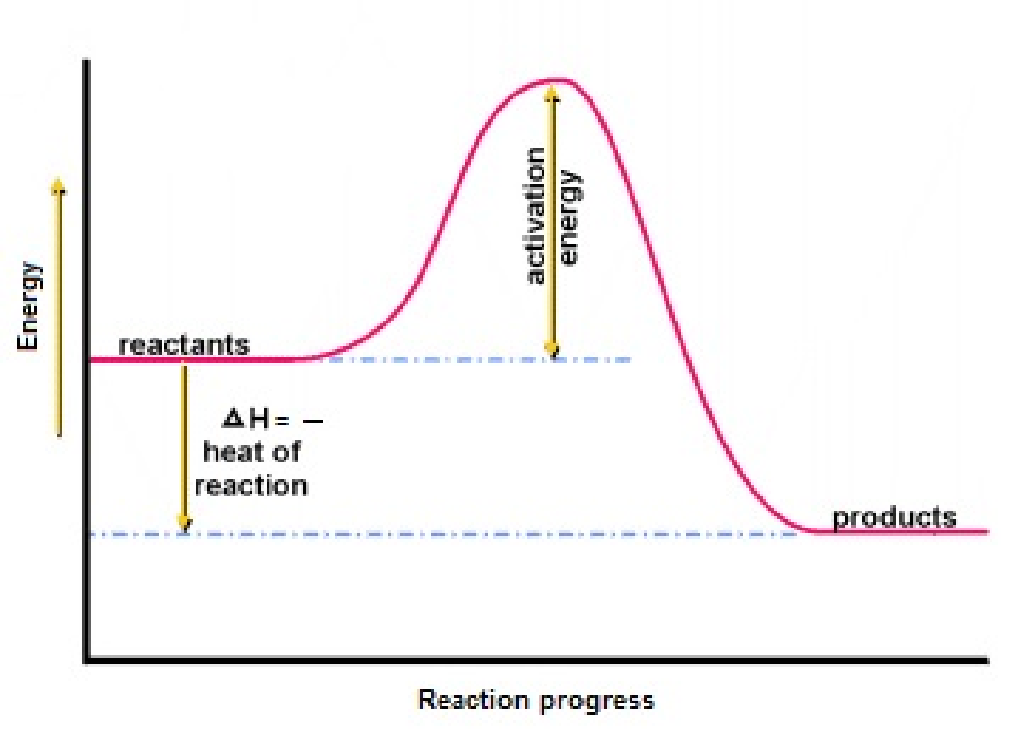


- Energy required to start a reaction
  - Present in ALL reactions

Two Types of Reactions

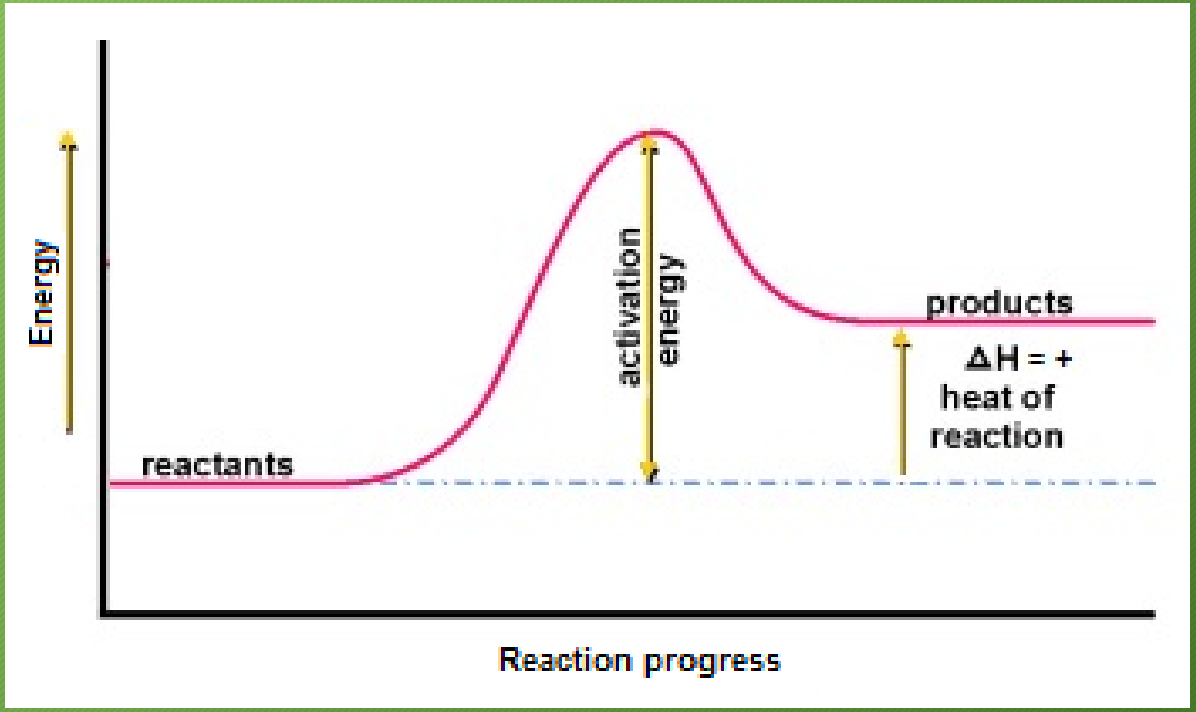
Exothermic

- Energy is released into the surroundings



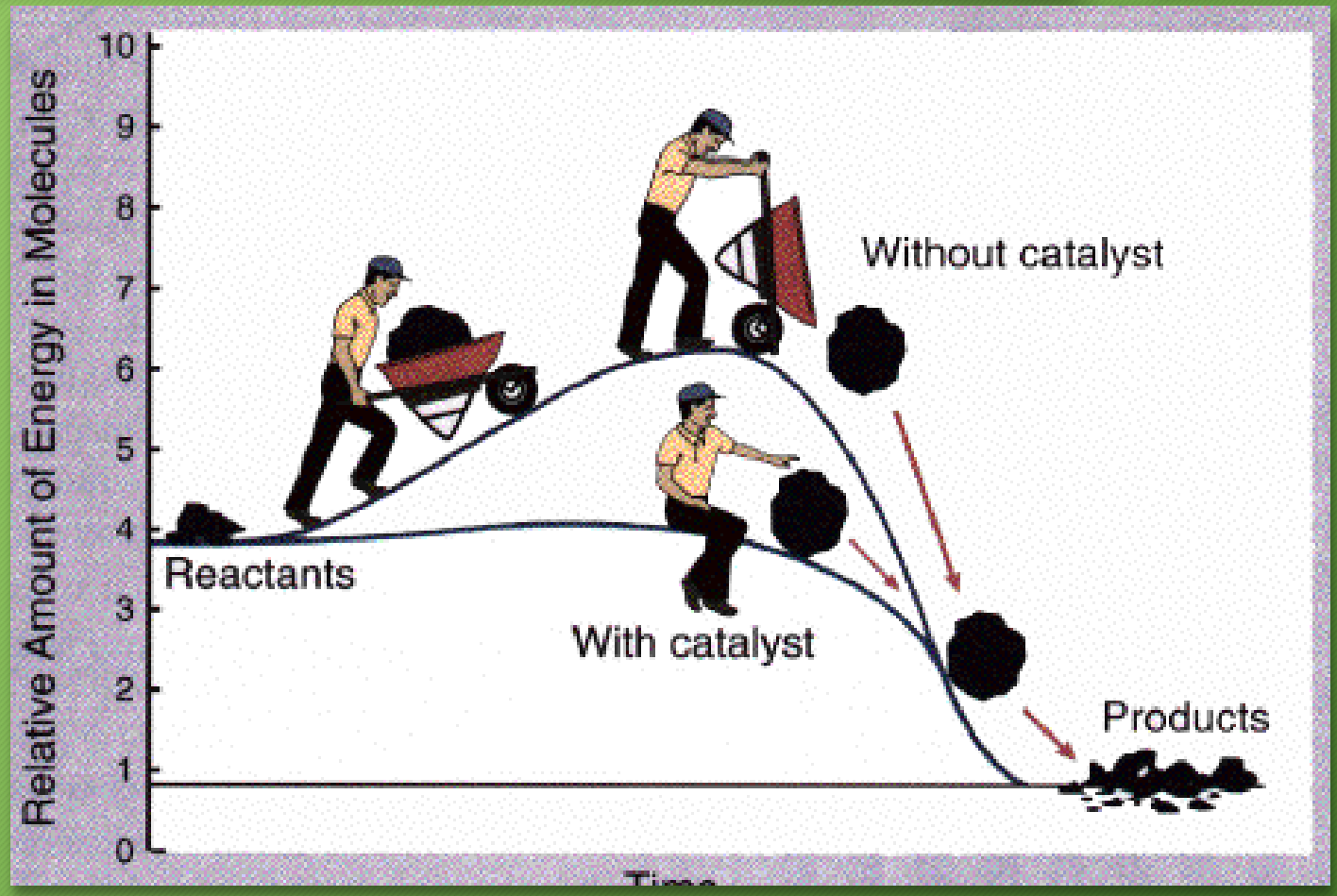
Endothermic

- Energy is absorbed from the surroundings



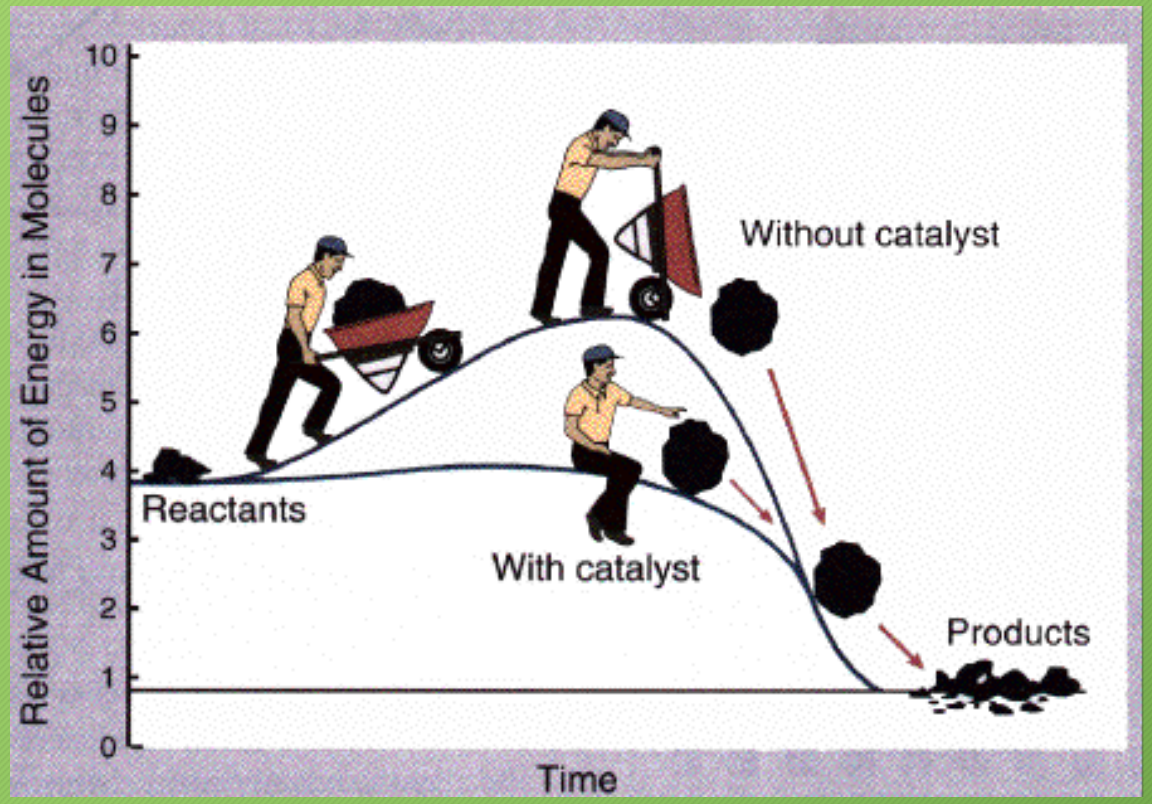
Catalyst

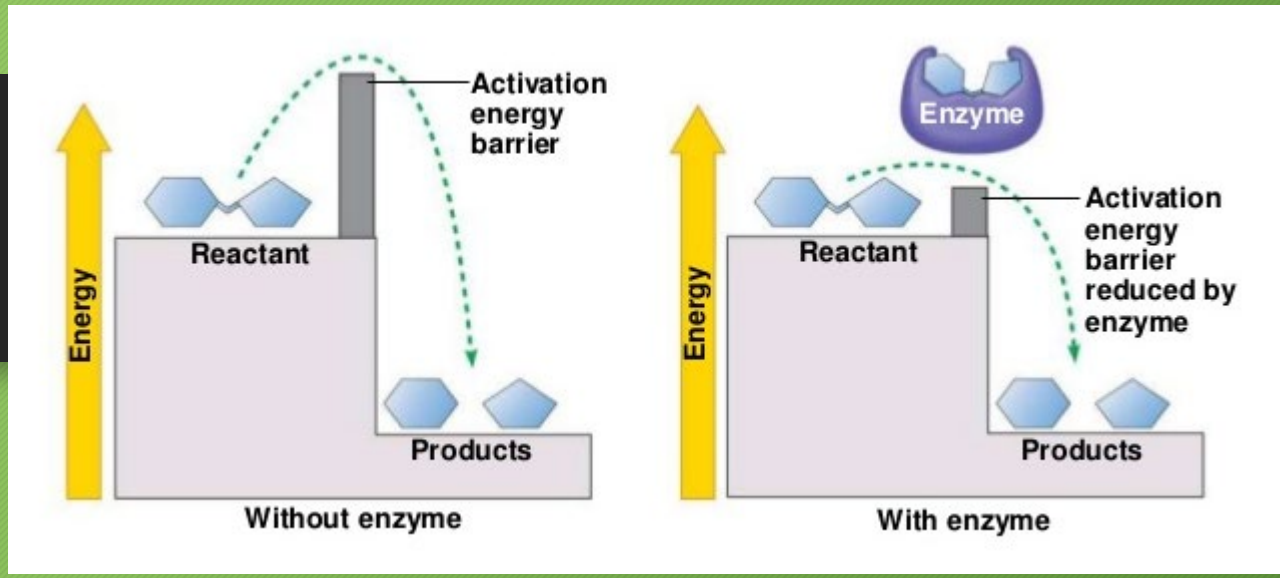
1)Speeds up a reaction
2)Lowers activation energy
3)Is not used up

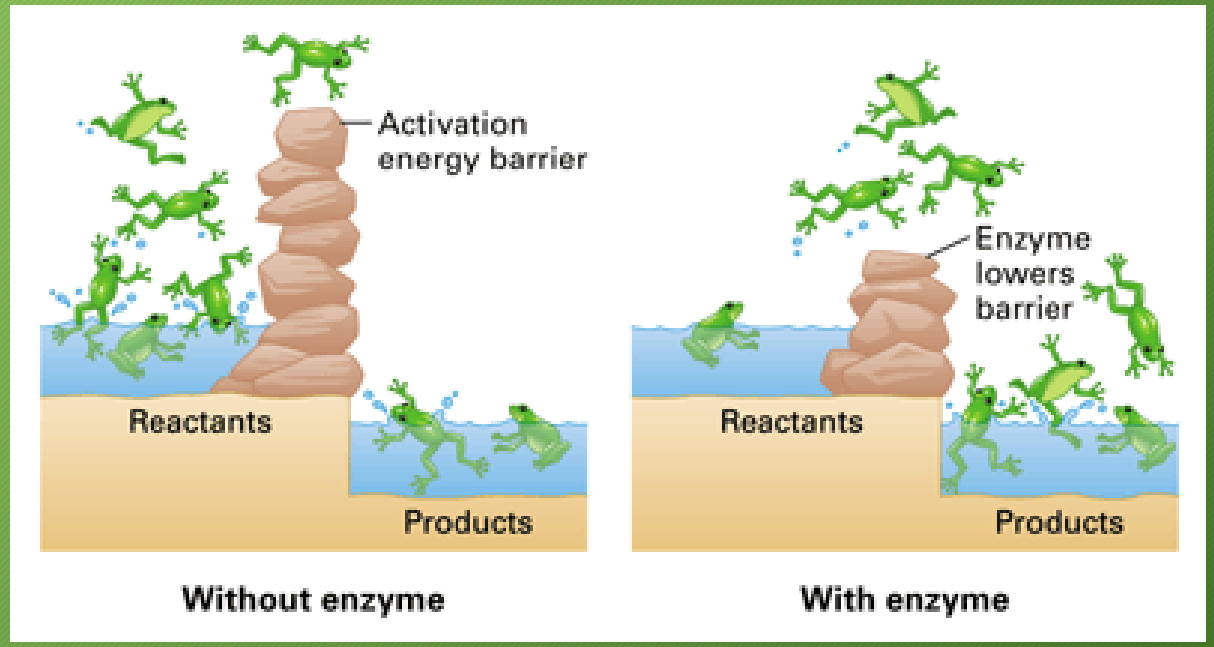


Catalyst: Examples

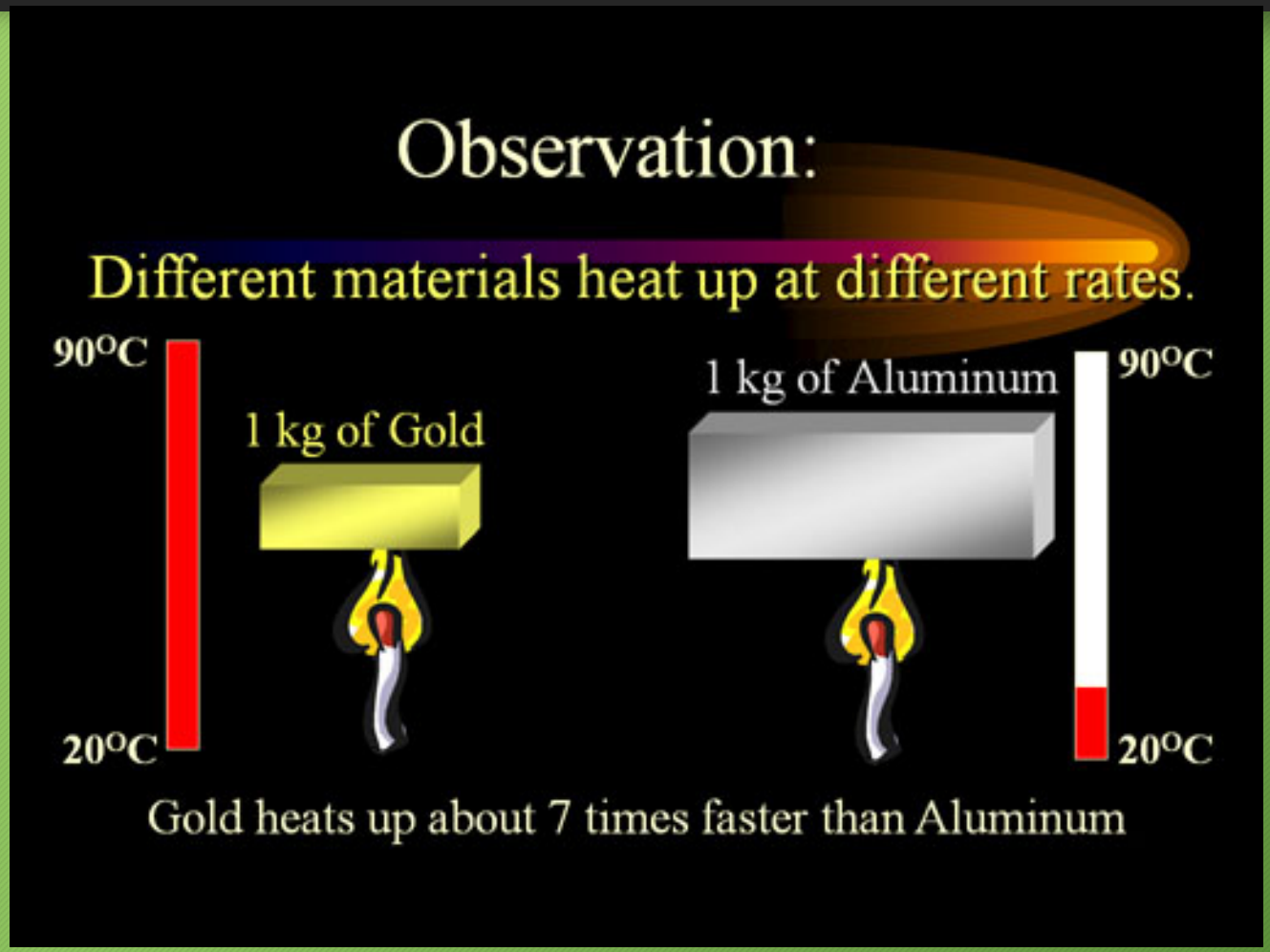
- Impacts activation energy



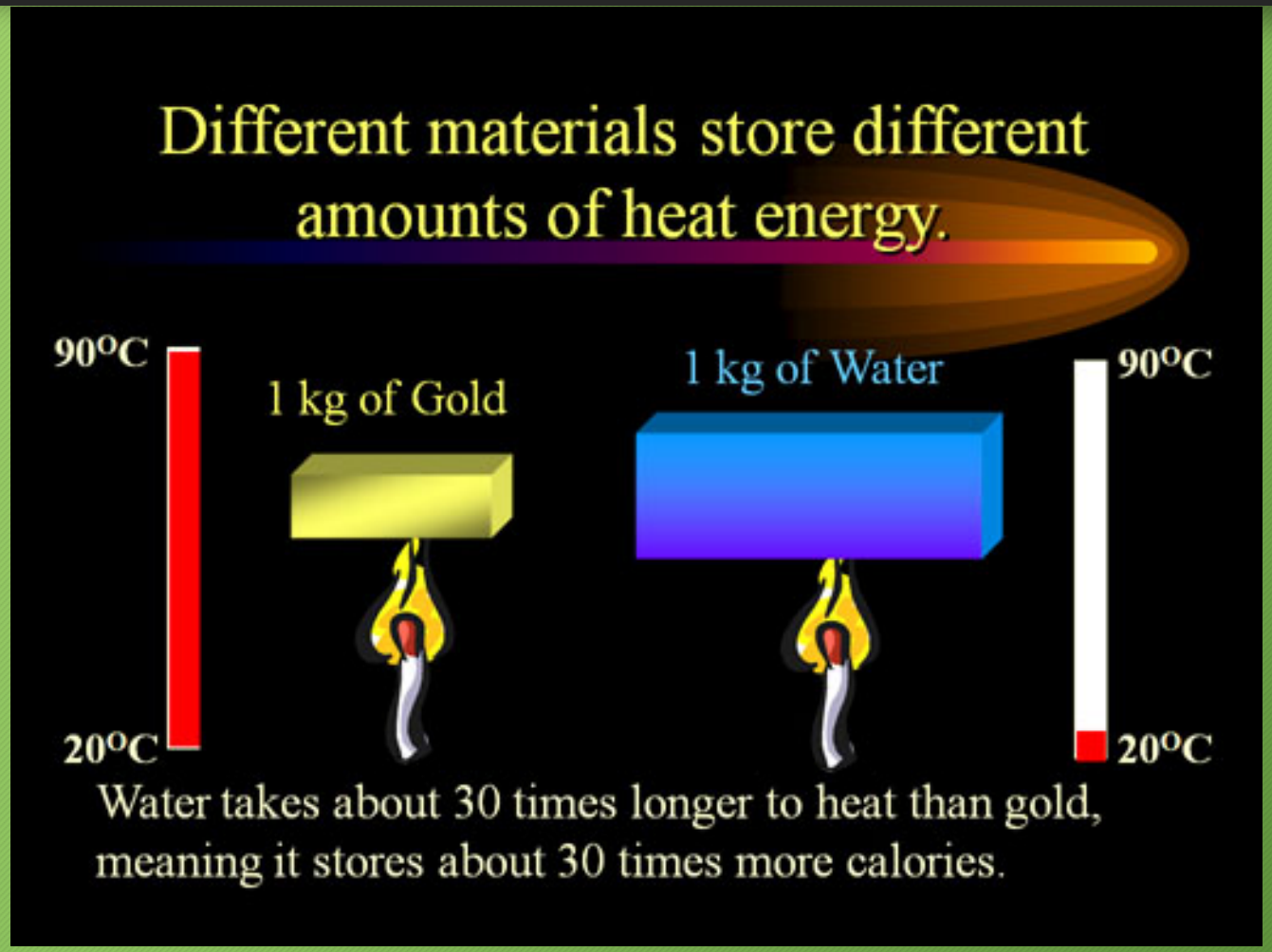




Specific Heat



Specific Heat



Specific Heat

- The amount of energy it takes to raise the temperature of 1 gram of a substance by 1°C
- Example:
  - Water $4.184\frac{J}{g\cdot°C}$
    - For every 1 gram of water, it takes 4.184 J to raise its temperature by 1°C
  - Aluminum $0.900\frac{J}{g\cdot°C}$
    - For every 1 gram of aluminum, it takes 0.900 J to raise its temperature by 1°C

- A 12 gram sample of water was initially 20^{o}C. What is the final temperature of the water when 983.2 calories of energy was released into it?

Specific Heat: Review

1) Solid magnesium has a specific heat of 1.01 $\frac{J}{g \cdot ^\circ C}$. How much heat is given off by a 30g sample of magnesium when it cools from 45°C to 30°C?

2) What is the mass of a sample of water that absorbs 4500 calories of energy when its temperature changes from 30°C to 60°C?

Determine the Number of Calories in a Marshmallow

- Find the mass of the marshmallow
- Fill aluminum can with 50 mL of water
- Spear marshmallow on ring stand
- Take temperature of water
- Light marshmallow (hold match *under*)
- Measure highest temperature of water
  - Calculate change in temperature
- Determine if marshmallow burned completely
- Clean up