TOPIC 2.1

HEAT AND TEMPERATURE

What's the difference between heat and temperature?

"Hot" and "cold" are commonplace terms. What they mean chemically, though, has to do with **energy**, and in chemistry, energy is all about **particle motion**.

TEMPERATURE IS A MEASUREMENT.

Thermometers are tools that indicate, on a relative scale, how fast particles are moving, on average. In science, *movement* is associated with *kinetic* energy.

Temperature = AVERAGE KINETIC ENERGY

We have a variety of scales to measure average kinetic energy. Most useful in chemistry are the Celsius and Kelvin scales. Celsius, like Fahrenheit, is a relative scale—numbers can go below zero. Kelvin, though, is an absolute scale, meaning that the lowest you can go is 0 K = zero particle motion (you may have heard of absolute zero before).

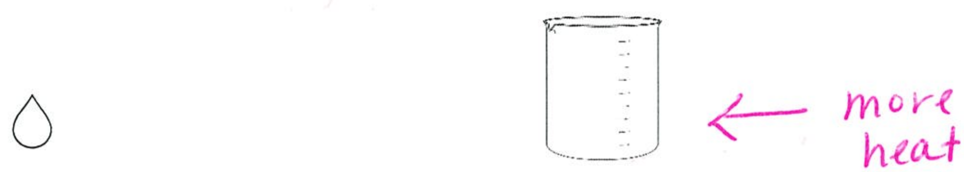
HEAT IS A THING.

Well, sort of. Heat is a **form of energy (thermal)** that can be **transferred** to particles.

What happens to particles when heat is added to a chemical system?

TWO IMPORTANT THINGS TO KNOW ABOUT HEAT:

☆ amount of material DOES matter

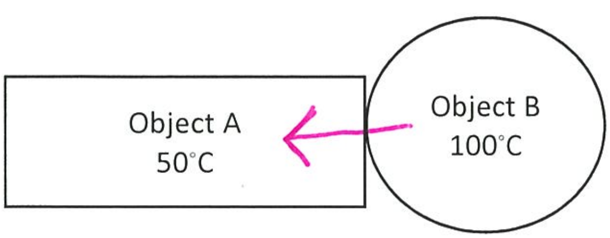


drop of H_2O 100°C

beaker w/ 1000 mL H_2O 100°C

same temp.

☆ heat flows from HIGH to LOW temperature

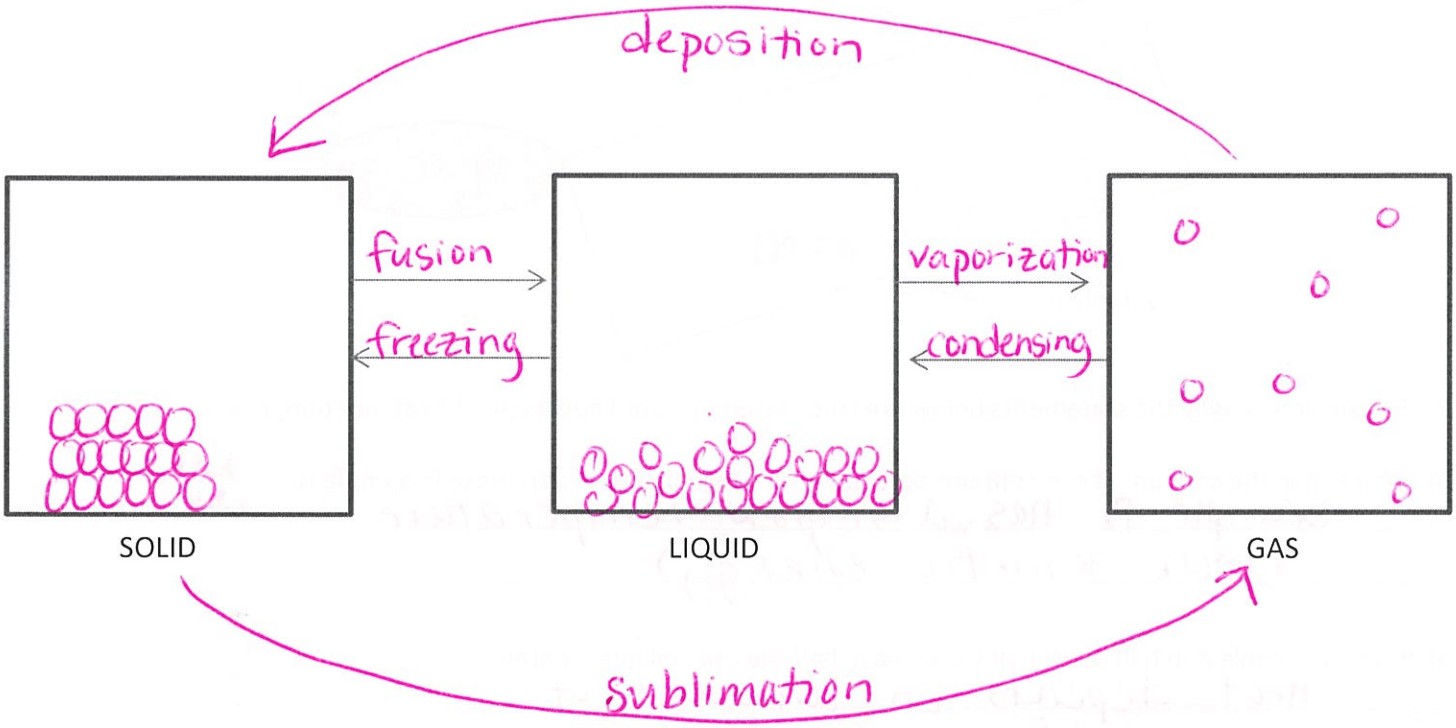


TOPIC 2.2

PHASE CHANGES

How does adding or removing energy from a substance change its physical properties?

Heat (energy) is added!



Heat (energy) is removed!

When heat <u>en</u>ters a system, the resulting change is classified as ENdothermic.

List the 3 endothermic phase changes: fusion, vaporization, sublimation

When heat <u>ex</u>its a system, the resulting change is classified as EXothermic.

List the 3 exothermic phase changes: freezing, condensing, deposition

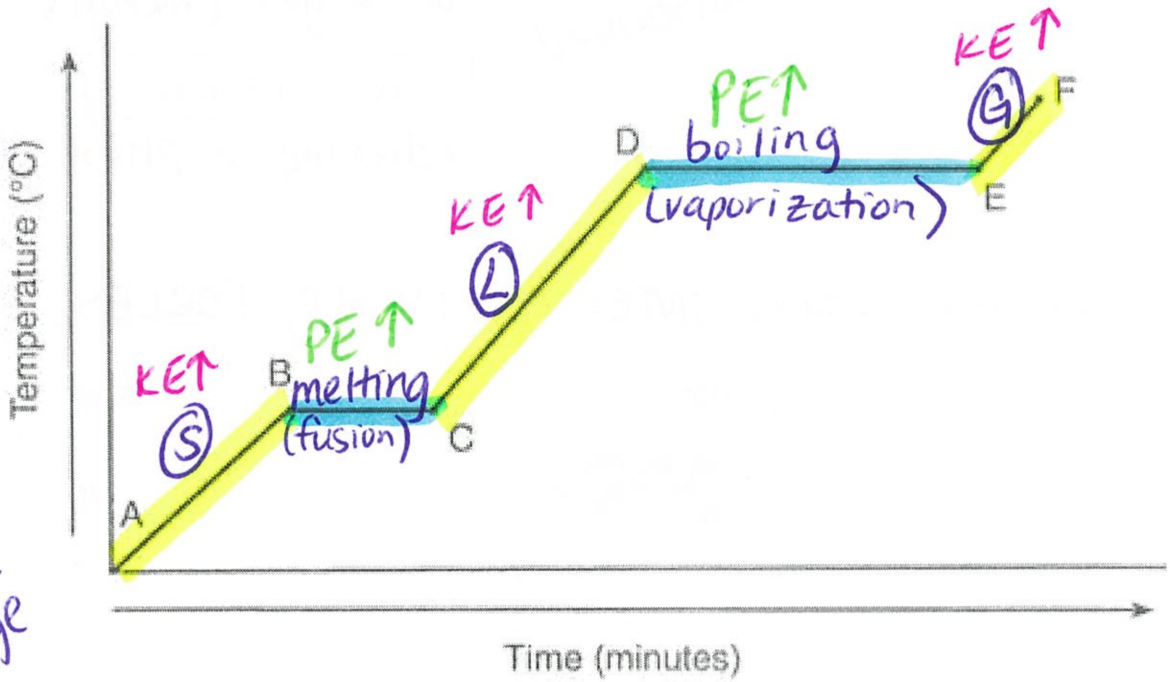
TOPIC 2.3

HEATING & COOLING CURVES

How can a graph show the relationship between particle motion and heat?

We can trace how adding (or removing) heat from a substance affects its total energy. We do so using a...

Heating Curve



"S"lants ↓ "S"ingle phase

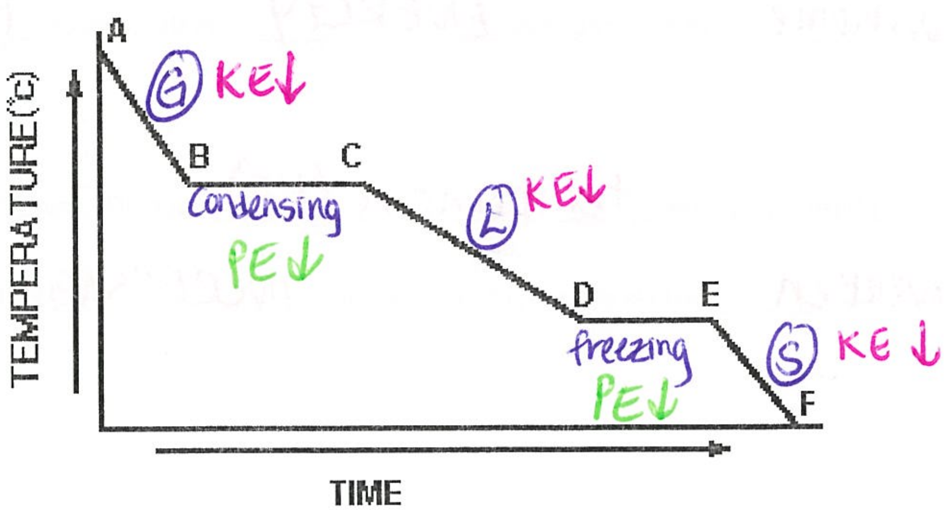
"F"lat ↓ "F"ase change

TOTAL ENERGY = KINETIC ENERGY + POTENTIAL ENERGY

To simplify these pictures, we accept that only **one type of energy will change at a time**.

- When temperature is changing, KINETIC energy changes.
- When phase of matter is changing, POTENTIAL energy changes.

Flip it around...the Cooling Curve



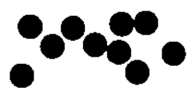
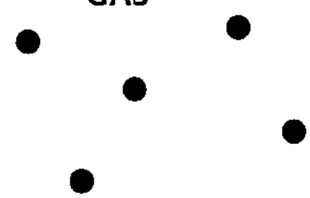
Heat (Thermal) Energy → *transformed* → **Kinetic Energy**

- *when the temperature of a solid, liquid, or a gas changes*

Heat (Thermal) Energy → *transformed* → **Potential Energy**

- *during a phase change*

PARTICLE ATTRACTIONS (*INTERMOLECULAR FORCES*)

SOLID	LIQUID	GAS
		
☆not much potential	*☆Some potential*	*☆A LOT of potential*

- So, in order to go from *S → L → G*, particle attractions (or IMFs) need to be *weakened* or *overcome*. This job requires *ENERGY*, in the form of *HEAT*.

- During a phase change, the *temperature (KE)* does NOT change because the heat is being used to *weaken* particle attractions, and therefore *INCREASING* POTENTIAL ENERGY.

TOPIC 2.4

HEAT EQUATIONS

How can we quantify heat required for a temperature change?

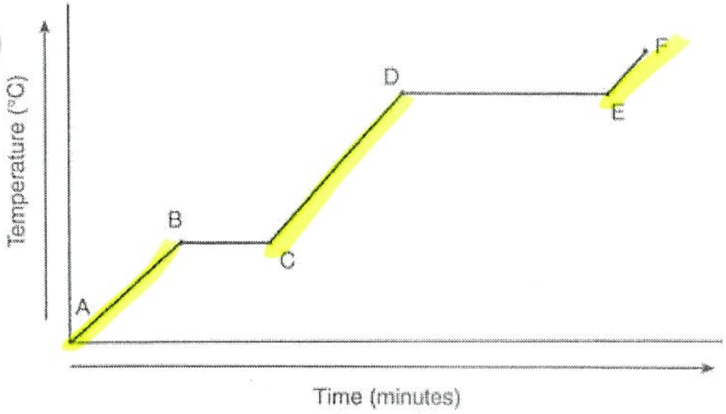


Table B
Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of $H_2O(\ell)$	4.18 J/g•K

Darken the areas of the heating curve where the **temperature** is changing. In these areas, the amount of heat you need to add is dependent on 3 things:

1. how much stuff we have
2. how much you want to change the T
3. how tolerant the substance is to changes in T

Specific heat: Tells us the amount of ENERGY (Joules) needed to raise 1 gram of a substance 1 Kelvin (or 1 °C)

- A large/high specific heat means it takes A LOT of energy for the temperature to change
- A small/low specific heat means it only takes a A LITTLE amount of energy for the temperature to change

THE EQUATION YOU NEED: q = mCΔT

Use the selection from the reference table to figure out the symbols:

1. What does q stand for? heat
2. What does m stand for? mass
3. What does C stand for? specific heat capacity
4. What does ΔT stand for? Change in temperature

Example Problem: How much heat (q) is needed to **raise the temperature** of **2 grams** (m) of liquid **water from 10 °C to 20 °C** (ΔT)? As can be seen in Table B, the specific heat capacity of water is 4.18 J/g•K (C).

$q = mC\Delta T$

$q = (2)(4.18)(10)$

$q = 83.6\ J$

$\Delta T = T_f - T_i$
$= 20 - 10$
$= 10$

TOPIC 2.5

HEAT OF FUSION & VAPORIZATION

How can we quantify heat required for a phase change?

We've seen and represented the change in particle spacing and motion when heat is added to a sample of matter. What we haven't done is calculated just *how much* heat is needed to bring about those changes.

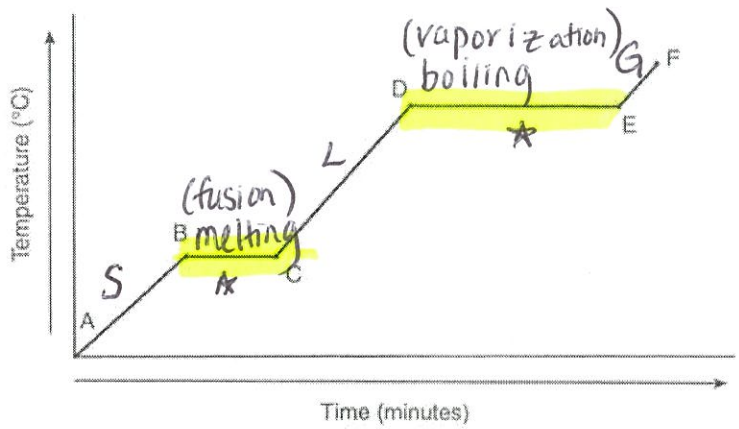


Table B
Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of $H_2O(\ell)$	4.18 J/g•K

Darken the areas of the heating curve where the **phase of matter** is changing.

Does it take more energy for melting (fusion) or boiling (vaporization) to occur?

WHY?

to go from a $\ell \rightarrow g$, you have to completely overcome particle attractions

In these areas, the amount of heat you need to add is dependent on only 2 things:

1. The mass of the substance (how much stuff do you have?)
2. How hard it is for the substance to change phase
   - **Heat of fusion**: amount of energy (J) involved in melting OR freezing a certain amount of stuff (g)
   - **Heat of vaporization**: amount of energy (J) involved in boiling OR condensing a certain amt of stuff (g)

THE EQUATION YOU NEED: $q = mH_f$ OR $q = mH_v$

Use the selection from the reference table to figure out the symbols:

1. What does q stand for? heat
2. What does H_f stand for? heat of fusion
   - You will use H_f for **melting/freezing** problems.
3. What does H_v stand for? heat of vaporization
   - You will use H_v for **evaporation/condensation** problems.