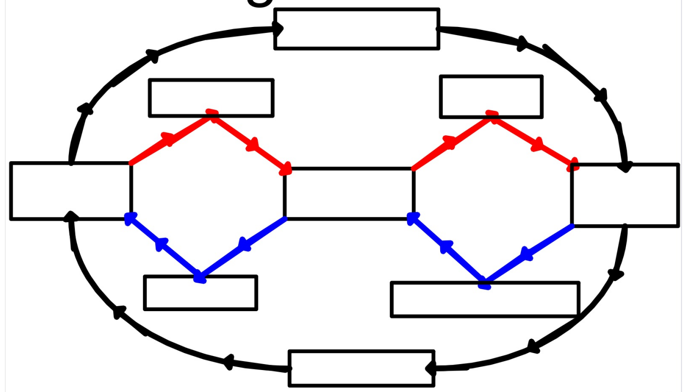
States of Matter

Solid Liquid Gas Plasma

Movement increases
Kinetic Energy Increases

Changes in States



Adding Energy

What is Energy?

Energy is the ability to do work.
"Do work Son!"

Money Isn't All You're Saving

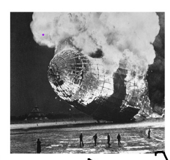
2 Types of Energy

1. Kinetic Energy - energy of motion
   a. KE = $0.5mv^2$
   b. hot gas particles have more KE -->moving faster
   c. Temperature is a measurement of Kinetic Energy

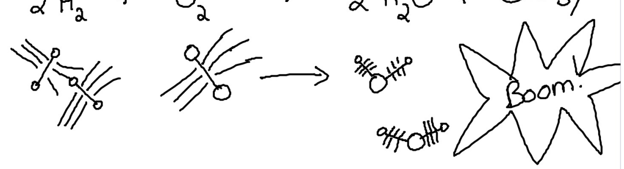
2. Potential Energy - stored energies
   a. chemical potential - energy stored in chemical bonds
   b. Examples: wood, fossil fuels, batteries , fats

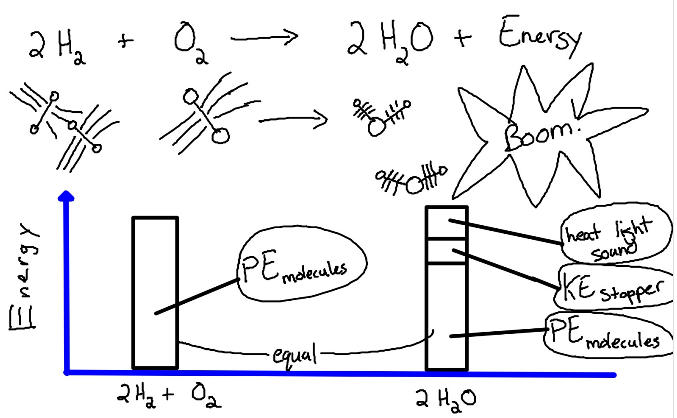
Law of Conservation of Energy

Energy cannot be created nor destroyed but transformed



$2H_2 + O_2 \longrightarrow 2H_2O + \text{Energy}$





Energy Changes - 2 Types

1. Endothermic Reaction - Energy goes into the reaction
   a. Absorbs Heat
   b. Feels Cold
   c. Examples: ice getting heat from water
      ammonium chloride in water

2. Exothermic Reaction - Energy is released from the rxn
   a. Releases Heat
   b. Feels Warm
   c. Examples: burning wood
      water giving heat to ice

Chemistry Humor

A solid in a test tube told a bunsen burner, "I melt every time I see you."

The bunsen burner responded, "This is just a phase you are going through."

Heating Curves

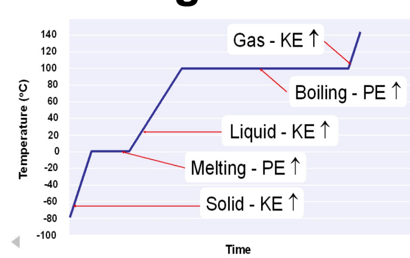


Diagram that shows the temperature changes of a substance.

- **Flat regions show phase changes**
- **Steep areas show increase in temperature**

Terminology of Heat Curves

Temperature Change
- Change in KE (molecular motion)
- Depends upon the specific heat

Specific Heat
- Energy required to raise the temperature of 1 gram of a substance 1°C.
- Different types of substances transfer energy at different rates
- Ex: Liquid Water = 4.18 J/g x K
  Solid Silver = 0.235 J/g x K

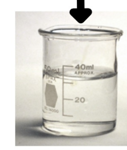
<u>Larger the number More energy it takes to heat.</u>

Relating to Law of Conservation of Energy

Hypothetical Situation time:
If we had hot silver and cold water…

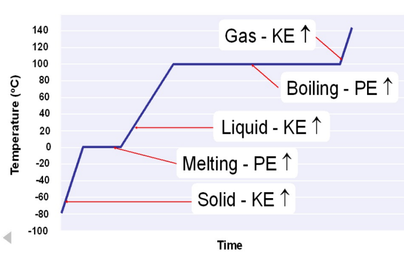
Which one will experience the more drastic temperature change?

Which one will experience the most energy change?



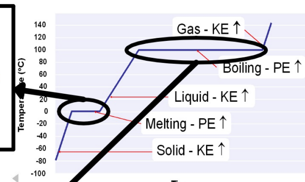
<u>This again is because temperature is a measurement of kinetic energy, not the rate of thermal energy transfer.</u>

Terminology of Heat Curves



Phase Change
- Change in PE (molecular rearrangement)
- Temperature remains constant

Terminology of Heat Curves



Heat of Fusion (ΔH_{fus})
- Energy required to melt 1 gram of a substance at its melting point

Heat of Vaporization (ΔH_{vap})
- Energy required to boil 1 gram of a substance at its boiling point
- ΔH_{vap} is much larger than ΔH_{fus}

Calculations involving Specific Heat

$$q = s \cdot m \cdot \Delta T$$

q = heat lost or gained (J)

-q = heat lost

+q = heat gained

s = specific heat (J/g · °C)

m = mass (g)

ΔT = Temperature Change = $T_f - T_i$ (°C)

Calculations at phase changes

For substances at freezing/melting point

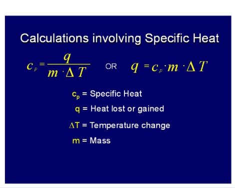
$q = \Delta H_{fus} \cdot m$

For substances at condensing/boiling point

$q = \Delta H_{vap} \cdot m$

Example:

You have 15.75g of Iron and it absorbs 1086.75 J of heat energy. The temperature raises from 25°C to 175 °C. What is the specific heat of iron?



To what temperature will a 50 g piece of glass raise to if it absorbs 5275 J of heat and its specific heat capacity is 0.5 J/g·°C?

The initial temperature of the glass was 20°C.

A: [redacted]

$q = s \cdot m \cdot \Delta T$

Calculate the heat capacity of a piece of wood if 1500 grams of the wood absorbs 6.75×10^4 J of heat, and its temperature changes from 32°C to 57°C.

Answer: 1.8 J/g˚C [redacted]

$q = s \cdot m \cdot \Delta T$

$q = s \cdot m \cdot \Delta T$

100 g of 4.0°C water is heated until its temperature is 37°C. If the specific heat of water is 4.18 J/g·°C, calculate the amount of heat energy needed to cause this temperature change.

Answer: [redacted]

$q = s \cdot m \cdot \Delta T$

25.0 g of mercury is heated from 25°C to 155°C, and absorbs 455 joules of heat in the process. Calculate the specific heat for mercury.

Answer: [redacted]

$q = s \cdot m \cdot \Delta T$

If a sample of chloroform is initially at 25°C, what is the final temperature if 150.0 g of chloroform absorbs 1.0 kilojoules of heat?

The specific heat of chloroform is 0.96 J/g·°C

Answer [redacted]

Now, how do two objects interact with each other?

When comparing two objects at different temperatures, you simply use the same equation but set them equal to one another.

$$q_{\text{object 1}} = - q_{\text{object 2}}$$

*The reason for the negative sign is the gain of energy for the first object is the release of energy of the second.

Example: 125g of water is initially at 25.6 °C. A 50g sample of iron at 115 °C is added to the water. If the specific heat of water is 4.184 J/(g °C) and iron's is 0.453 J/(g °C), what is the final temperature of both the iron and water?

Example: 125g of water is initially at 25.6 °C. A 50g sample of iron at 115 °C is added to the water. If the specific heat of water is 4.184 J/(g °C) and iron's is 0.453 J/(g °C), what is the final temperature of both the iron and water?

Water = 4.18 J/g C
Silver = 0.235 J/g C
Ethanol = 2.44 J/g C
NaCl = 0.864 J/g C
Hg = 0.14 J/g C
Iron = 0.45 J/g C
Al = 0.902 J/g C

Water Heat Properties
Ice: C_p = 2.108 J/g C
Heat of Fusion: ΔH_{fus} = 334 J/g
Liquid: C_p = 4.184 J/g C
Heat of Vap.: ΔH_{vap} = 2,270 J/g
Steam: C_p = 1.996 J/g C

Example #1 from handout:

$Cp_{water} = 4.184\ J/g \cdot °C$

$m_{water} = 200g$

$T_{i\,water} = 30°C$

$Cp_{silver} = 0.24\ J/g \cdot °C$

$m_{silver} = 20g$

$T_{i\,silver} = 350°C$

$$q_{water} = -q_{silver}$$

$$Cp \cdot m \cdot \Delta T = -(Cp \cdot m \cdot \Delta T)$$

$$4.184 \cdot 200 \cdot (T_f - 30) = -(0.24 \cdot 20 \cdot (T_f - 350))$$

$$836.8(T_f - 30) = -(4.8(T_f - 350))$$

$$836.8T_f - 25104 = -(4.8T_f - 1680)$$

$$836.8T_f - 25104 = -4.8T_f + 1680$$

$$+4.8T_f \quad +25104 \qquad +4.8T_f \quad +25104$$

$$\frac{841.6\,T_f}{841.6} = \frac{26{,}784}{841.6}$$

$$T_f = 31.8\ °C$$