Chapter 9

Heat

Temperature

- Temperature is equal to the kinetic energy of atoms.
- Internal energy is the energy of a substance due to the random motions of its particles and equal to the total energy of those particles.

Exothermic vs Endothermic

- Exo – releases heat – feels hot
- Endo – absorbs heat so feels cold

Thermal Imaging Camera

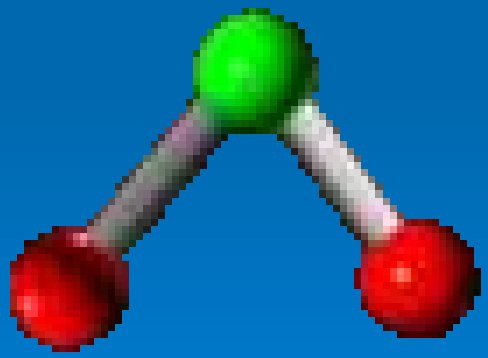
SEE “heat”


Color Changing Cup
cold/hot sensitive
HYDRA
VODKA WATER
Village Inn

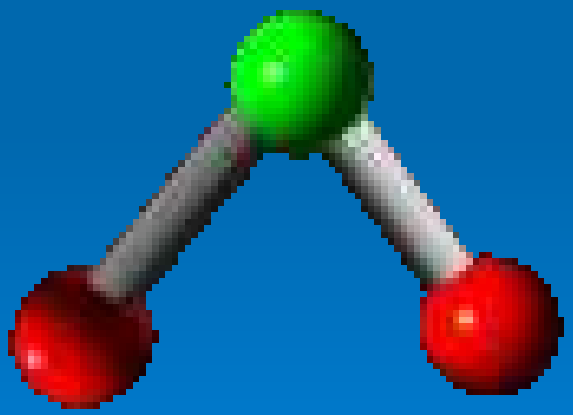
All molecules have 3 types of motion:

Translational movement – forward or backward movement

- **Rotational** movement – spinning motion

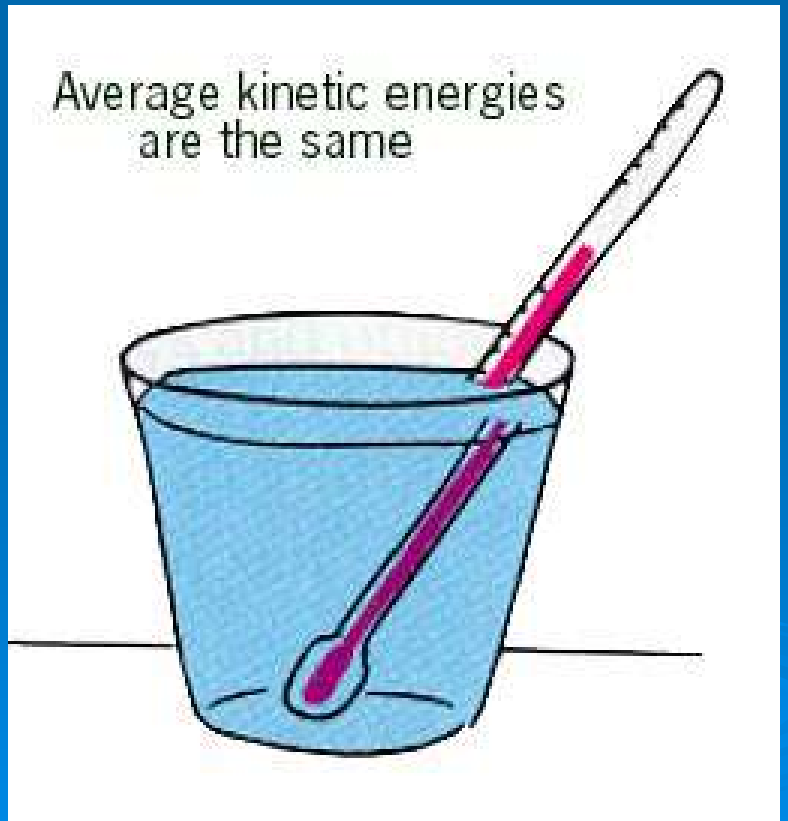


- **Vibration** – small, fast movements back and forth



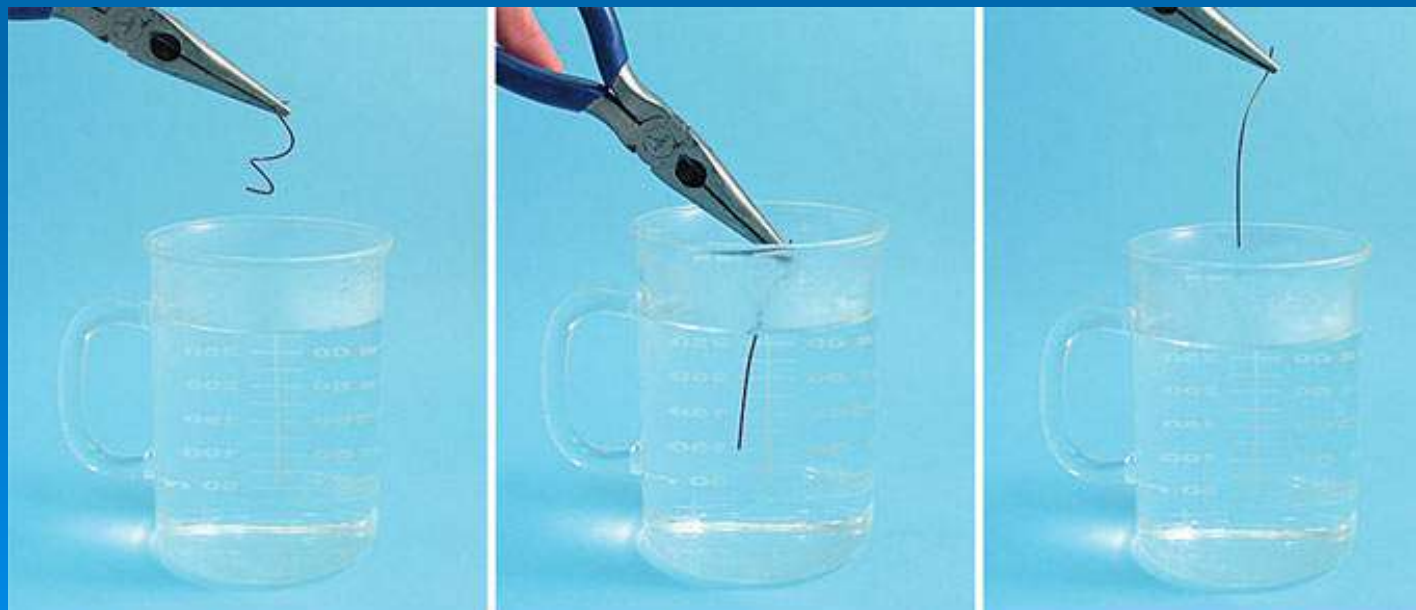
- Temperature is decided by how much a molecule or atom bounces around a container and hit another molecule and atom. Which type of movement is this?
- **Translational**

- Thermal equilibrium is the state in which two bodies in physical contact with each other have identical temperatures.



- Matter expands as its temperature increases.

Nitinol Wire, Marbles, Ring & Ball

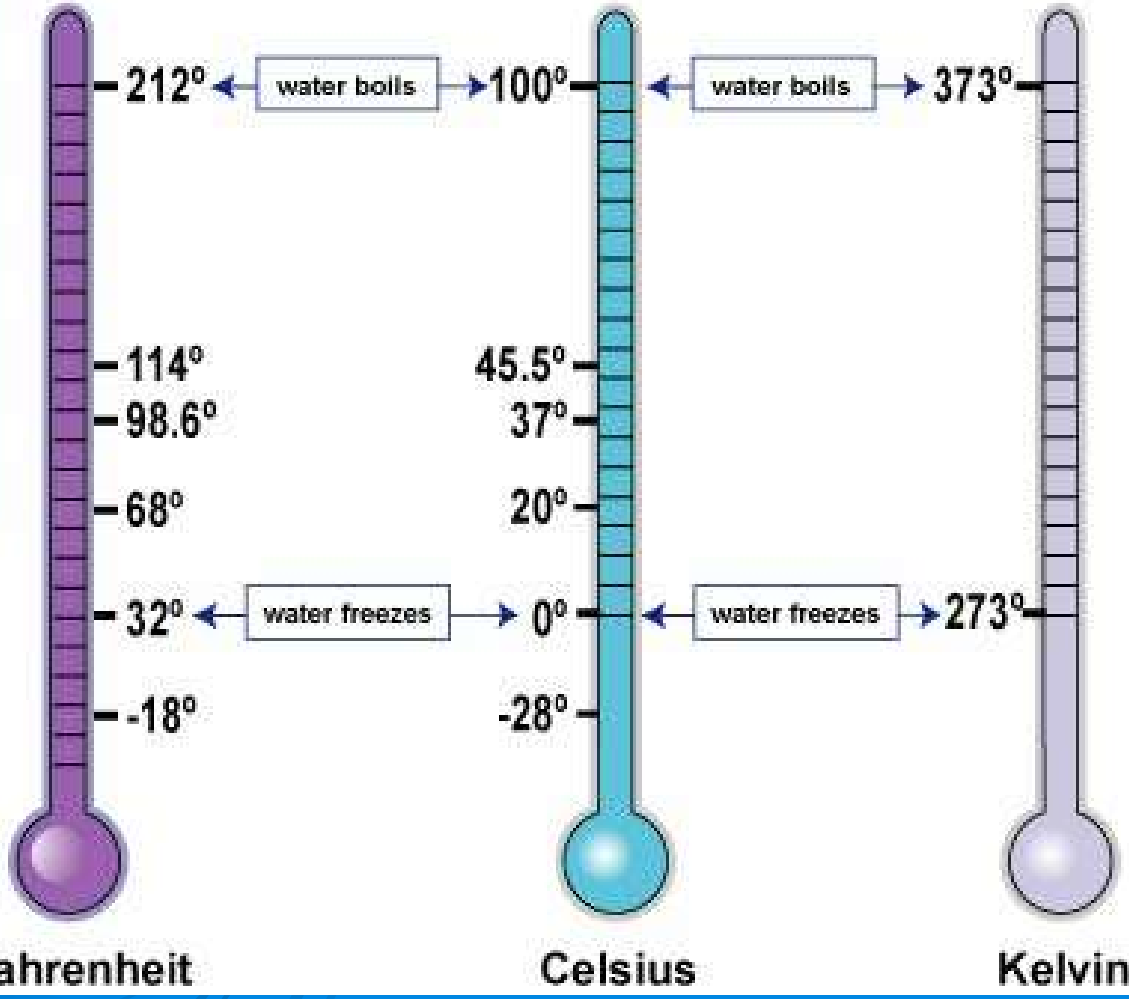


Temperature Conversion

$$T_{Fahrenheit} = \frac{9}{5} T_{Celsius} + 32$$

$$T_{Celsius} = \frac{5}{9} (T_{Fahrenheit} - 32)$$

$$T_{Kelvin} = T_{Celsius} + 273$$



Temperature Conversion

- $T_f = (9/5T_c) + 32$
- $T_c = 20$; $T_f = ?$

- $T\ kelvin = T_c + 273$
- $T_c = 20$; Kelvin =?

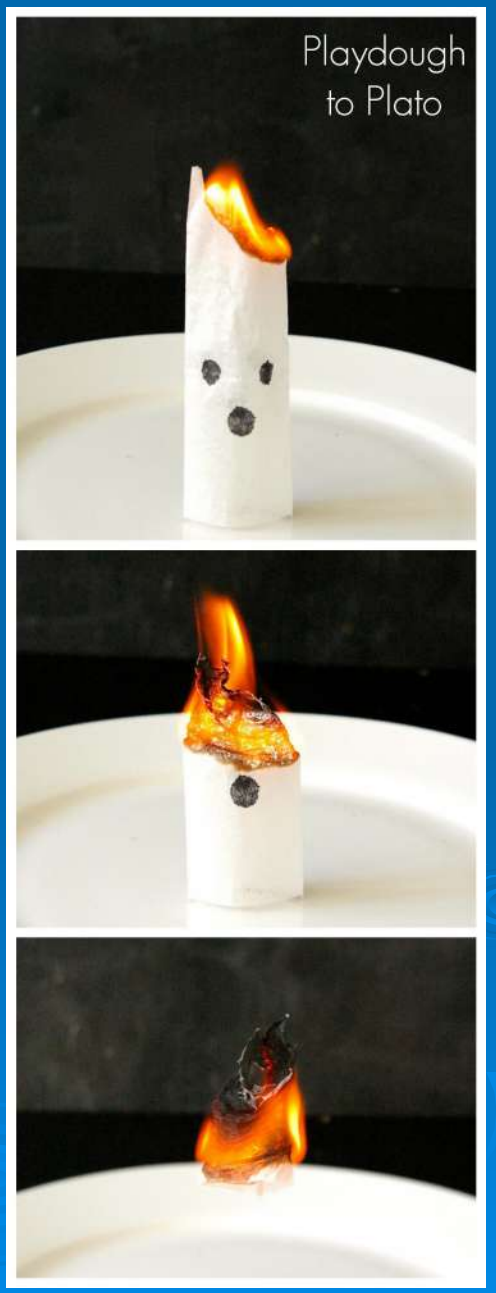
Defining Heat and Energy

- Energy that is transferred is defined as heat.
- Heat has the units of energy (Joules, J)

- Total Energy is conserved.
- $\Delta PE + \Delta KE + \Delta U = 0$
- $PE = mgh$
- $KE = \frac{1}{2} mv^2$

Heat Rises

- Particles get hot, move around more, than rise
- Hot Air Balloon



Specific Heat Capacity

- Each substance has it's own value for the amount of energy it needs to change the temperature of 1 kg of a substance by 1^0 C. This is value is known as specific heat.
- Specific Heat = c_p
- Units are J/Kg^0C

Specific Heat Equation

- c_p = Heat / (m ΔT)
- Heat = 20J, m = 10kg
- Ti = 20 F, Tf = 25 F

Black Squares

Calorimetry

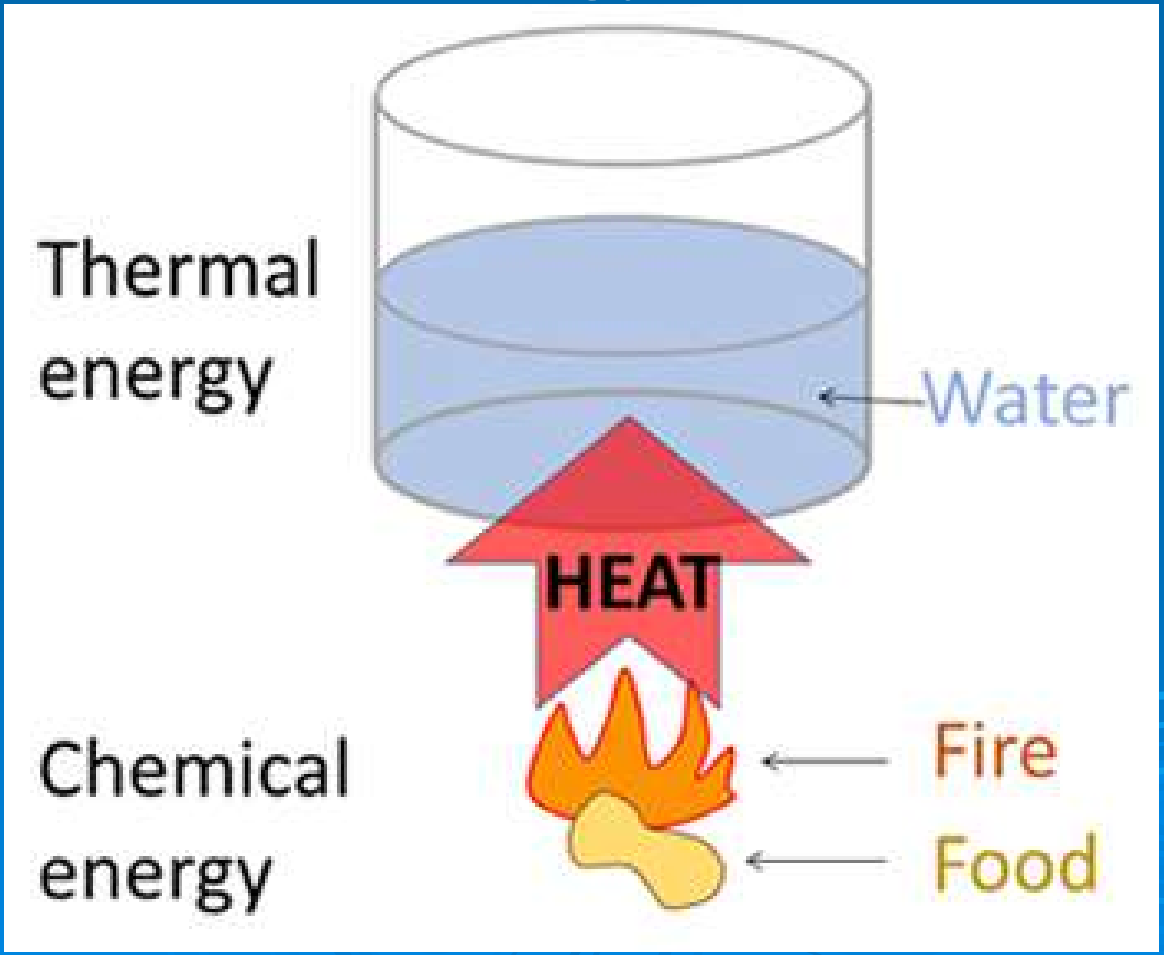
- Since the specific heat of water is known to be 4186 J/Kg^{0}C, we can use an approach called calorimetry to determine a 2nd object's specific heat.
- We place a heated unknown object in an insulated container of cool water.
- Since energy is conserved, the energy the substance gives up must equal the energy absorbed by the water.

Calorimetry Equation

- $c_{p,w} m_w (Tf - Ti_w) = c_{p,x} m_x (Tf - Ti_x)$
- Mass water = 100 kg Mass of x = 200 kg
- Initial temp of water = 20 F
- Initial temp of x = 40 F
- Final temp = 30 F

Marshmallow vs Peanut

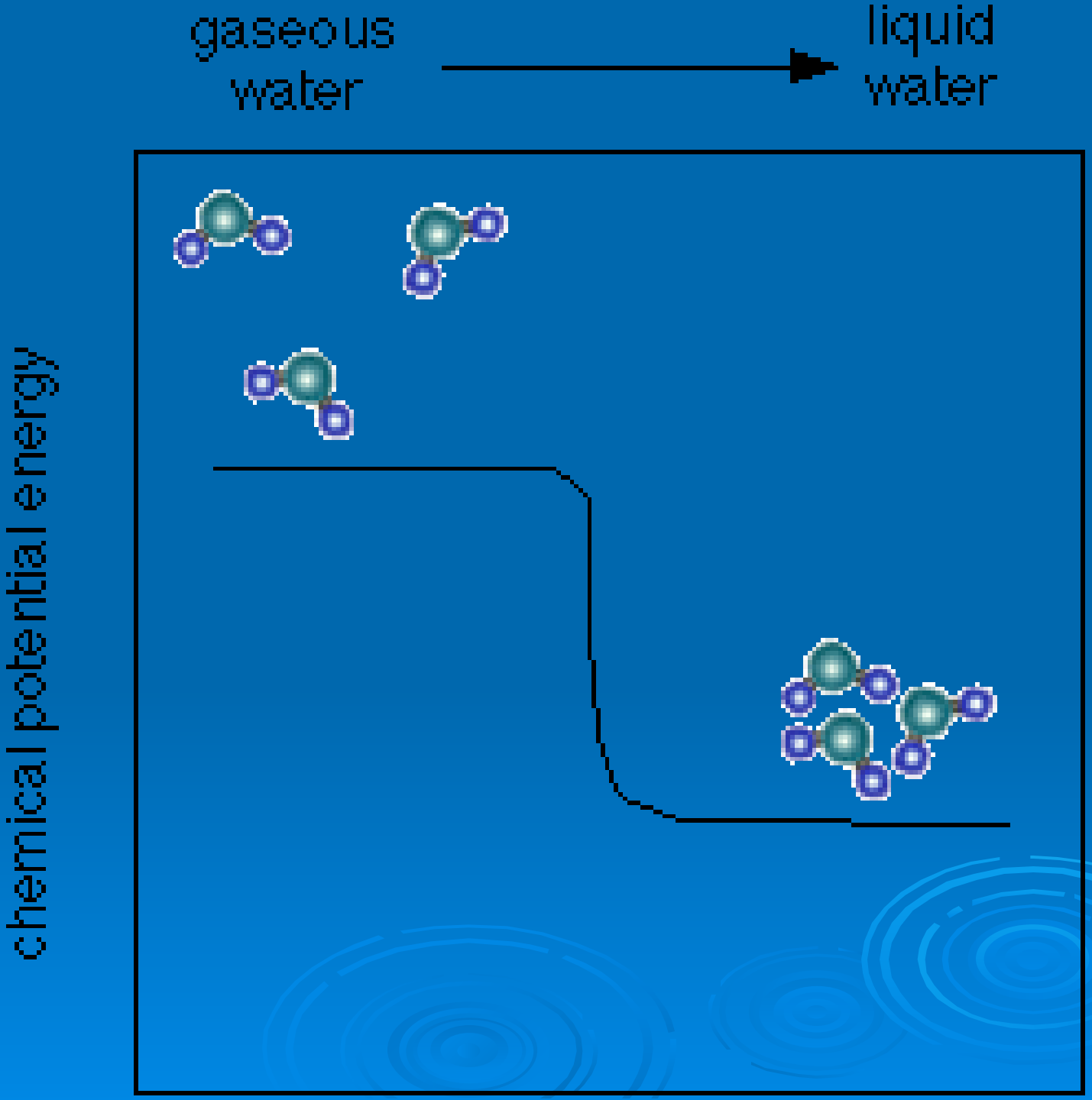
- Which has more energy?



Phase Change

- Potential energy is in particles in a solid or a liquid in the form of bonds.
- The potential energy increases with increasing atomic separation from the equilibrium position. This resembles a spring.
- If the particles are far enough apart, the bonds between them break and release kinetic energy.

- Freezing – liquid to solid
- Boiling / Evaporation – liquid to gas
- Melting – solid to liquid
- Condensation – gas to liquid
- Sublimation – solid to gas


gaseous water
liquid water
chemical potential energy

Gallium

Conduction

- Thermal conduction is the process by which energy is transferred by heat through a material between two points of different temperatures.
- As an object is heated, the atoms nearest the heat vibrate with greater energy. These vibrating atoms jostle their less energetic neighbors and transfer some of their energy. Gradually, atoms farther away from the heat are also vibrated and gain energy.

Glass Globes / Hand Boilers

Convection

- Convection involves the displacement of cold matter by hotter matter, such as when hot air over a flame rises upward.
- This method does not use heat alone but uses pressure and buoyancy.

Dehydrator, Incubator

Electromagnetic Radiation

- Electromagnetic radiation transfers energy through wavelengths.
- This form does not involve the transfer of matter like conduction and convection.

Solar Dish, Sun Tea, Radiometer, Sun paper