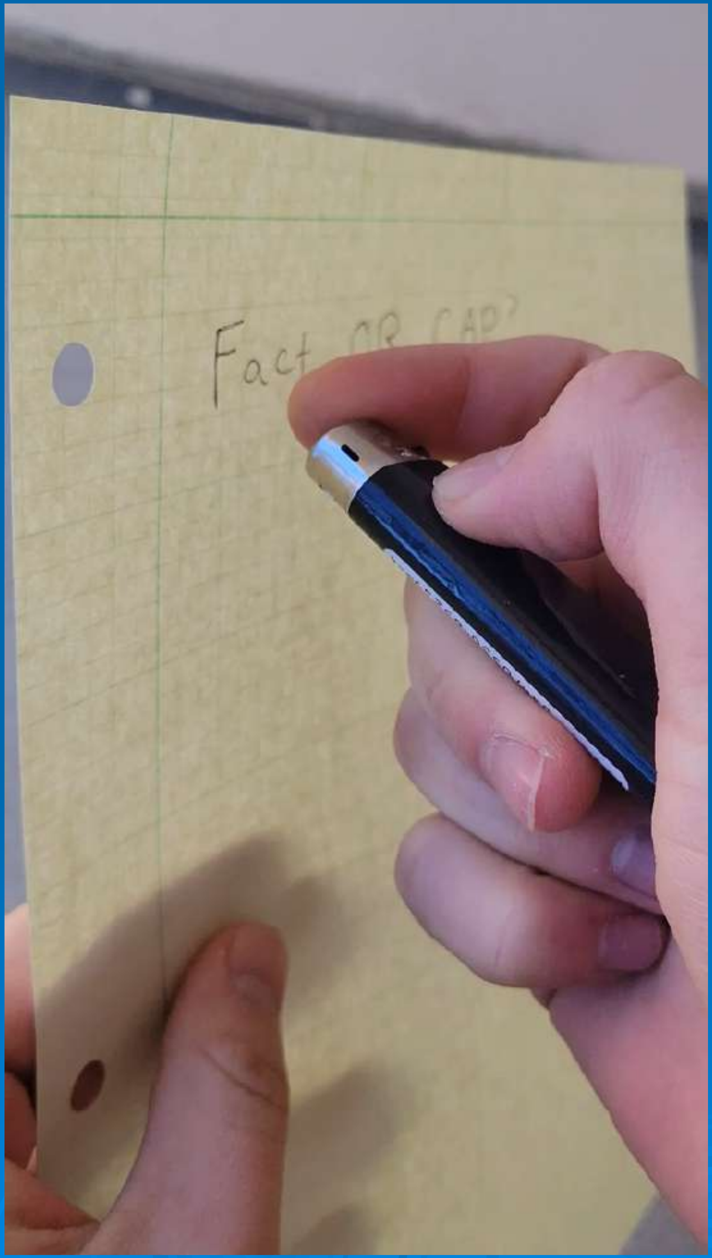
Chapter 9

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 – called **Entropy**

Thermochromatic Ink

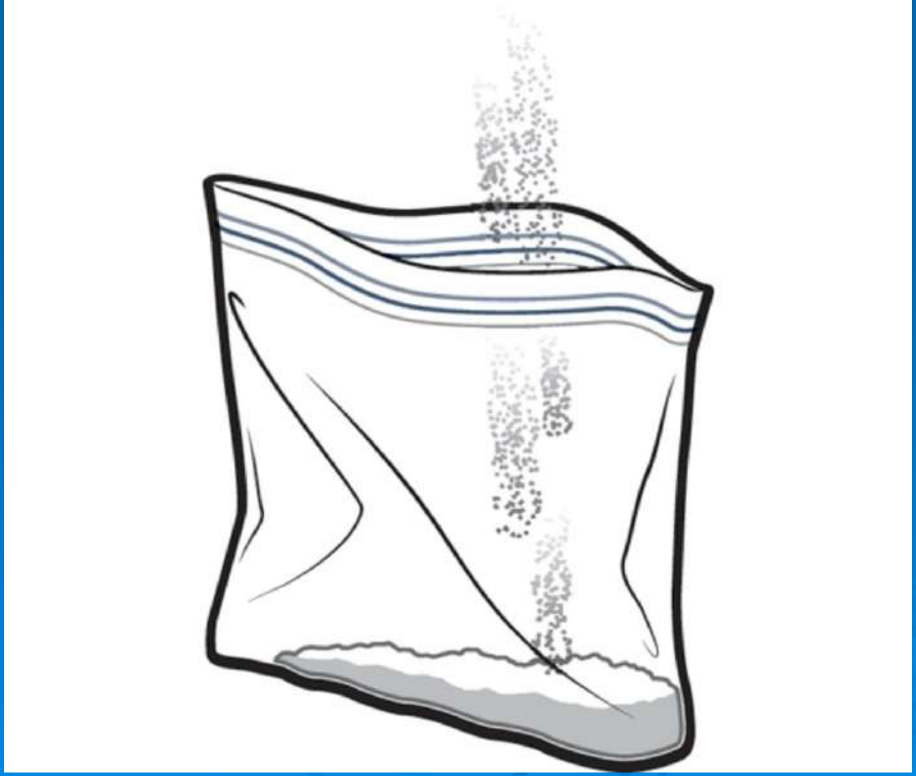


Melting Metal

Metal	Melting Point
Lead	321°C (621°F)
Aluminum	660°C (1220°F)
Copper	1084°C (1983°F)
Stainless Steel	1530°C (2785°F)
Titanium	1670°C (3038°F)

Exothermic vs Endothermic

- Exo – releases heat – feels hot (hot hands)
- Endo – absorbs heat so feels cold (ice pack)

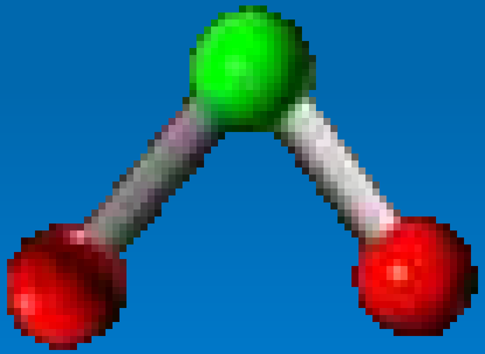


Thermal Imaging Camera

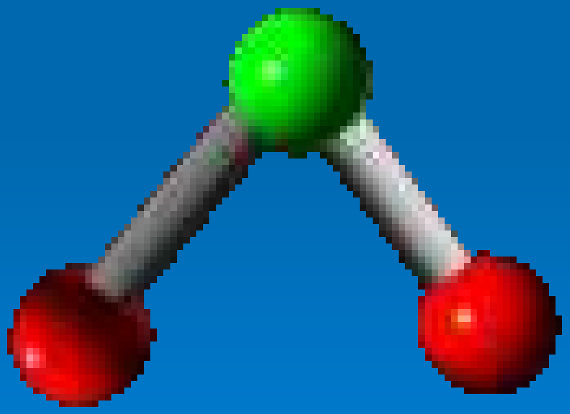
All molecules have 3 types of motion:

<u>Translational</u> movement – forward or backward movement

- **Rotational** movement – spinning motion

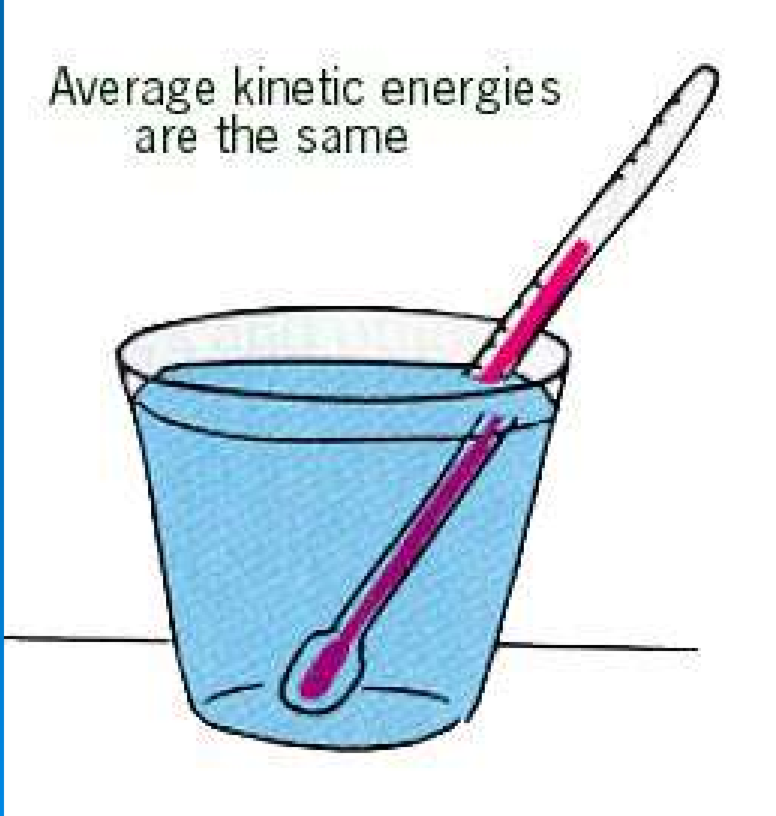


- **Vibration** – small, fast movements back and forth

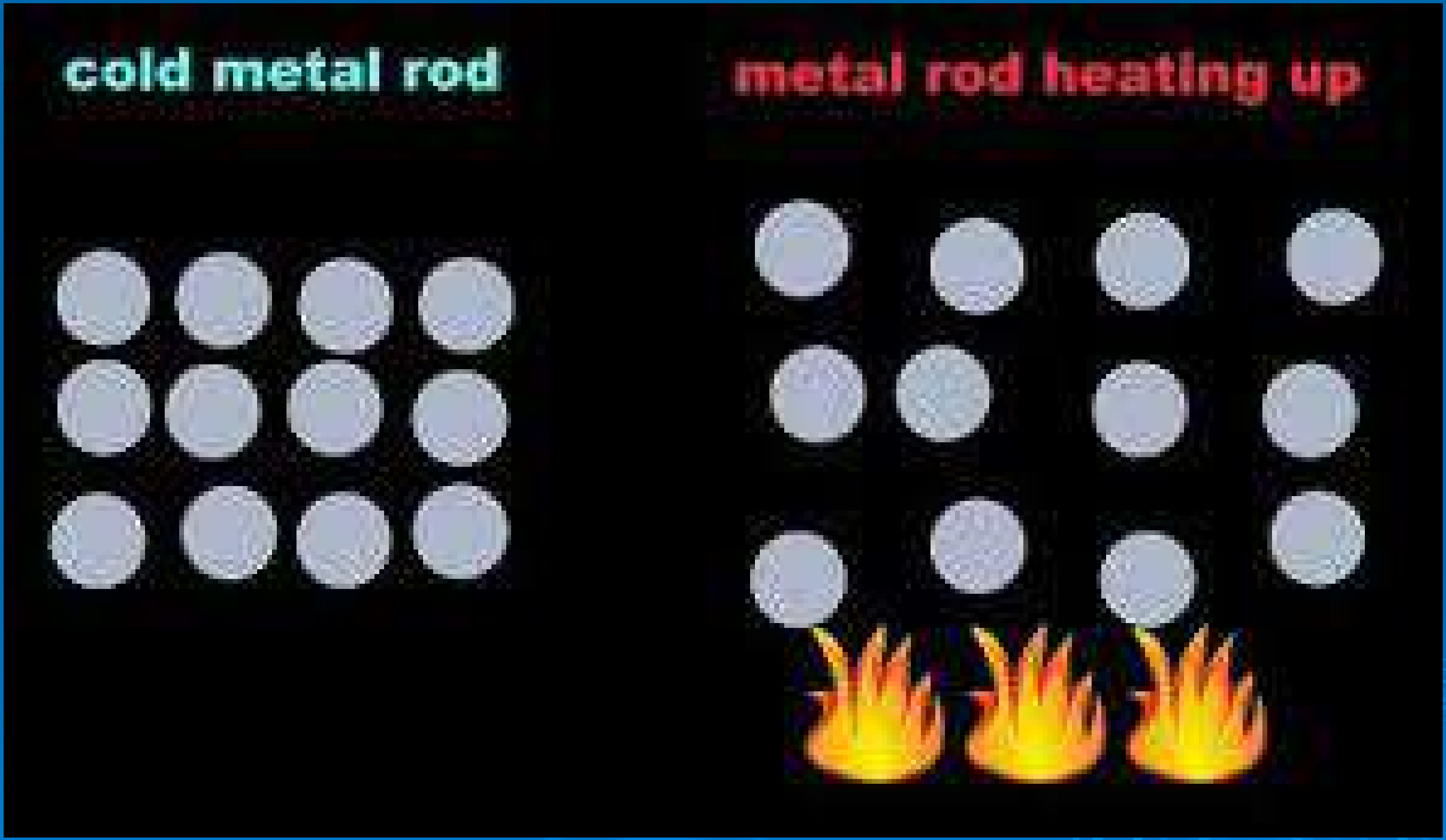


- Temperature is decided by how much a molecule or atom bounces around a container and hit another molecule and atom. Which type of movement is this?
- <u>**Translational**</u>

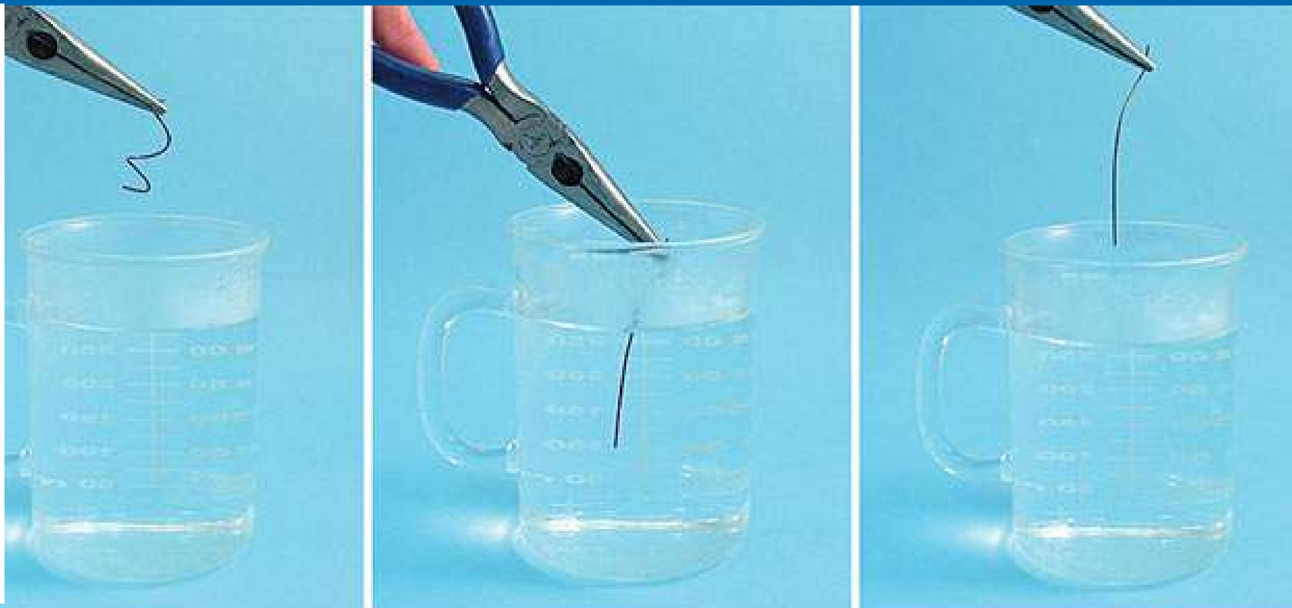
- Thermal equilibrium is the state in which two bodies in physical contact with each other have identical temperatures.



- Matter **expands** as its temperature increases.


cold metal rod
metal rod heating up

Nitinol Wire, Marbles, Ring & Ball

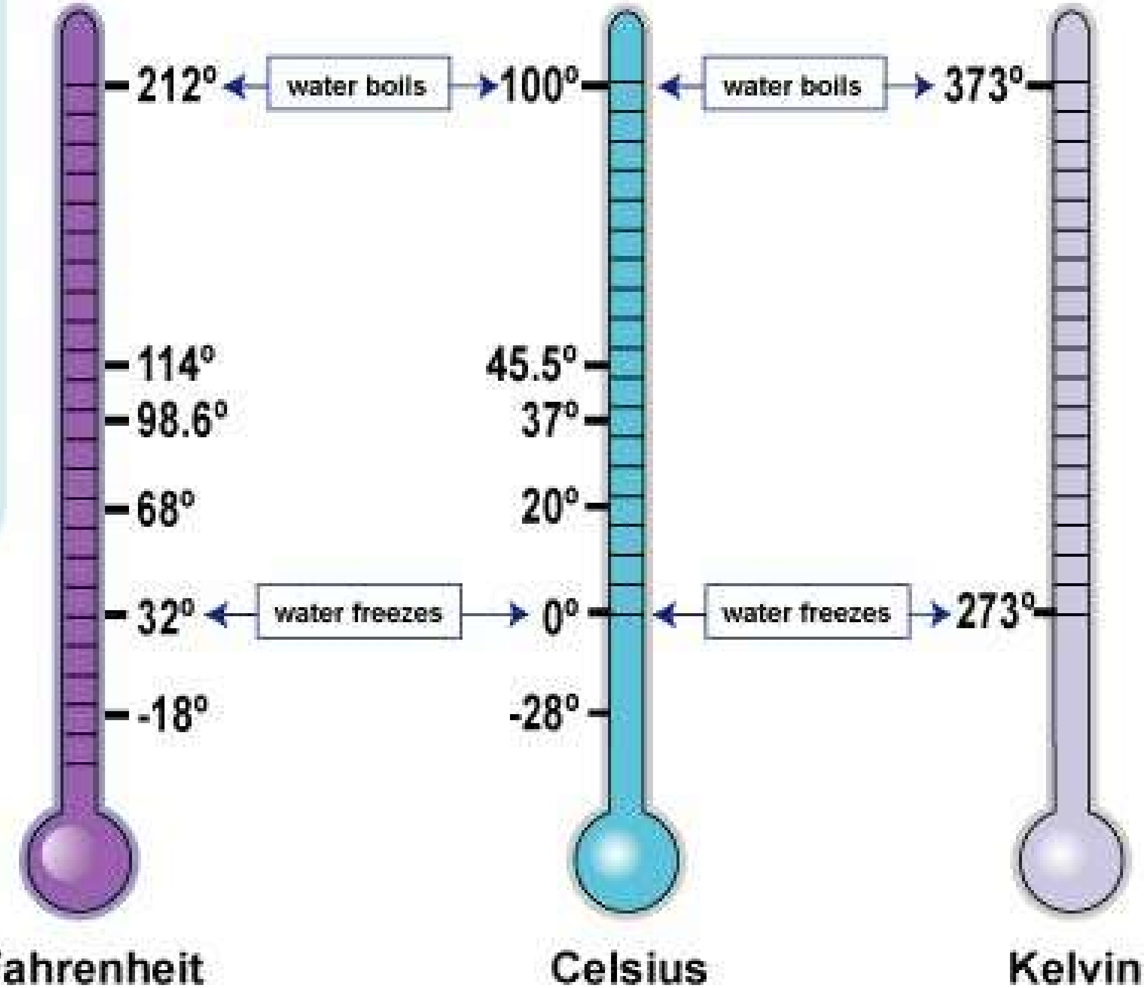


Temperature Conversion

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

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

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



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

Does Heat rise or sink?

- Demos



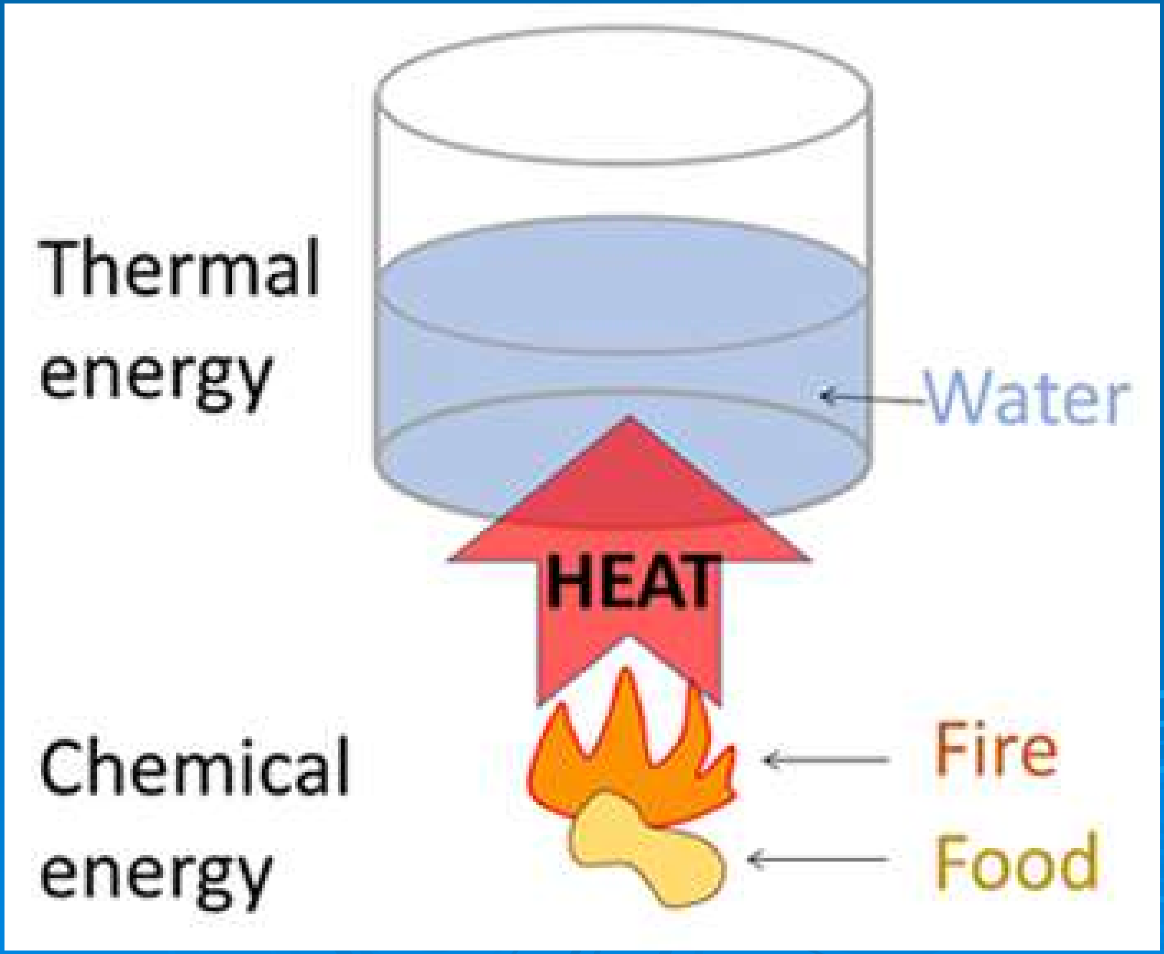
Heat Rises

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

Notes – Day 2
Chapter 10
Thermodynamics

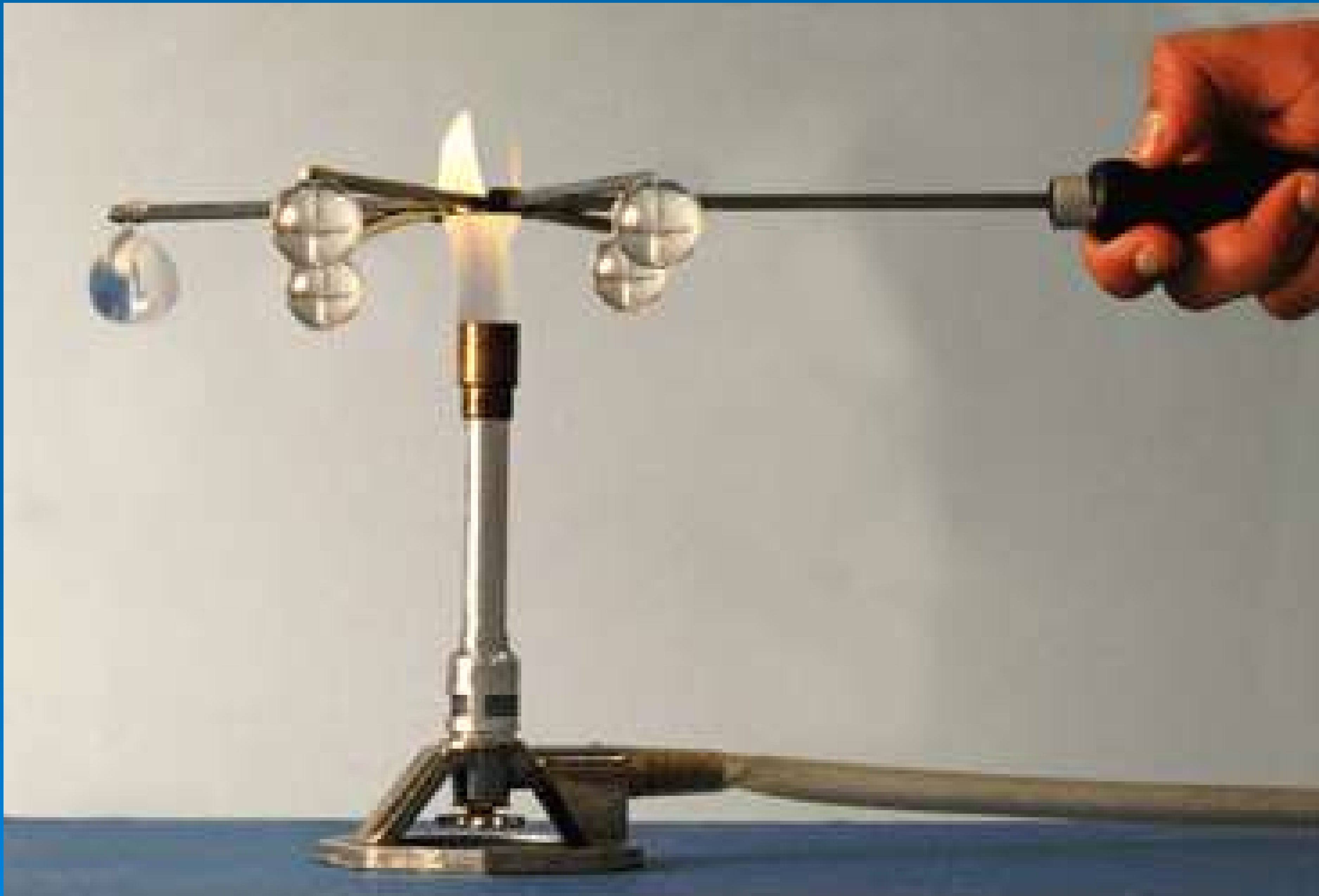
Marshmallow vs Peanut

- Which has more energy?



Specific Heat Capacity

- Each substance has amount of energy it can absorb.
- Units are J/Kg^0C



Black Squares and Ice

Heat = mass*specific heat* (Tf-Ti)

A container of water with a mass of 200 grams is heated from 20°C to 70°C. The specific heat of water is 1 cal/gC°. Find the amount of heat added to the water.

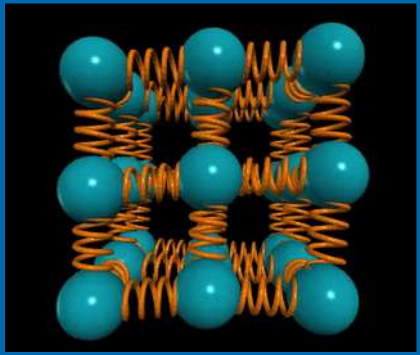
- ○ 14,000 cal
- ○ 4,000 cal
- ○ 18,000 cal
- ○ 10,000 cal

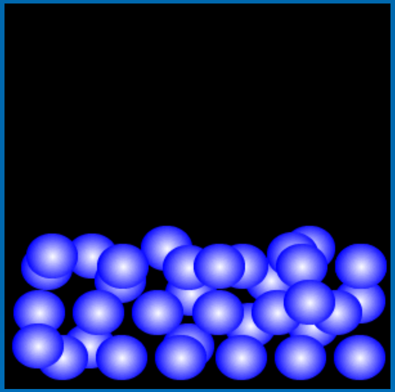
Balloon with Water

Water bottle with water

States of Matter

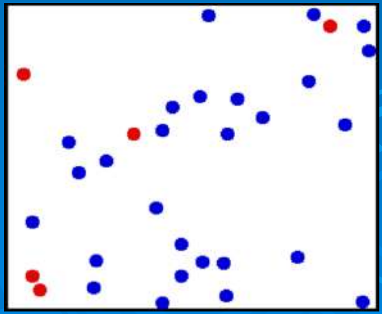
<u>Solid</u>: Particles are bound by bonds, though particles do wiggle and vibrate in place.





***<u>Liquid</u>*: The binding forces are weaker. The particles can slide around each other, but they can't expand in volume**

***<u>Gas</u>*: In a gas, the binding forces are even weaker. The particles expand away from each other to fill whatever container is available.**



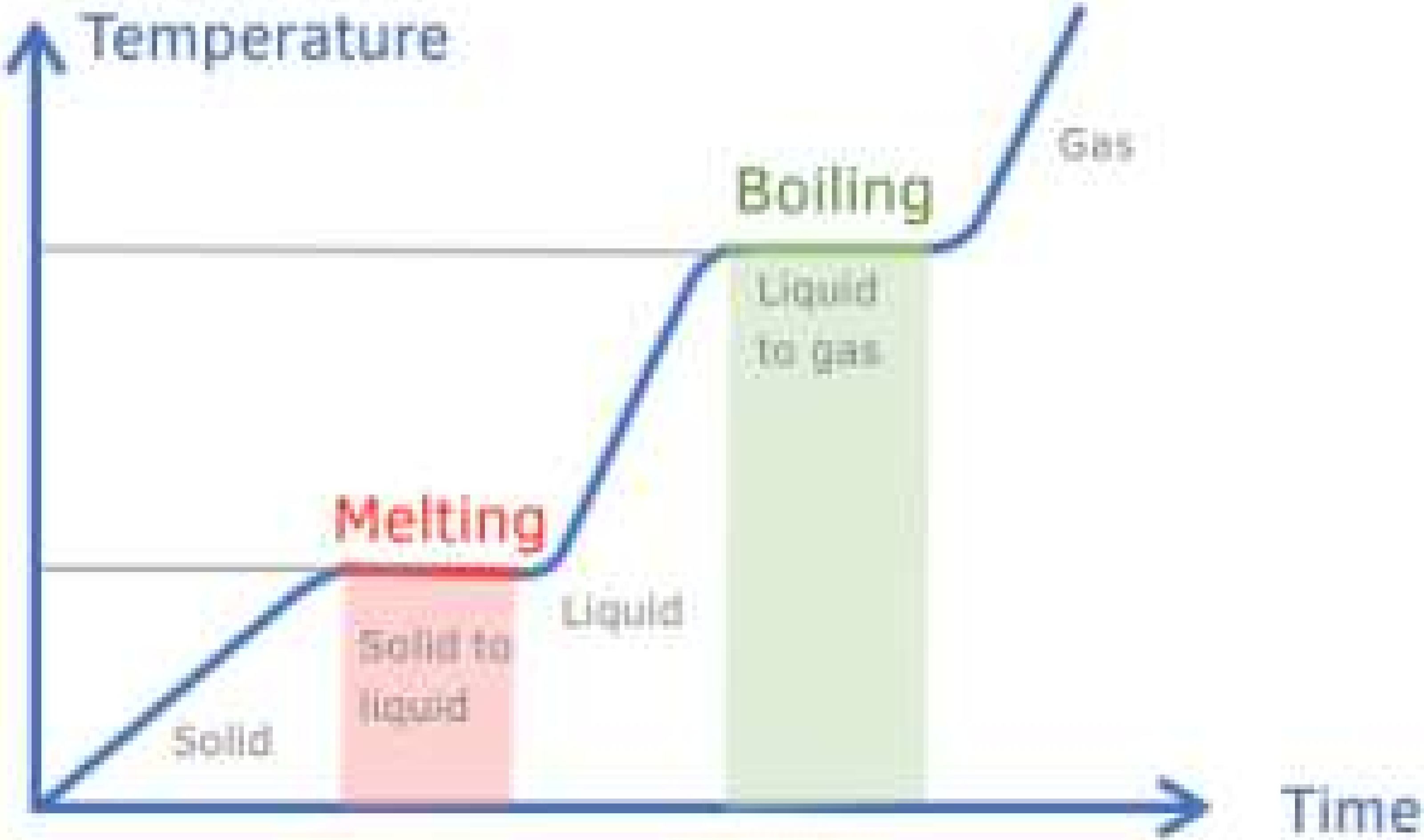
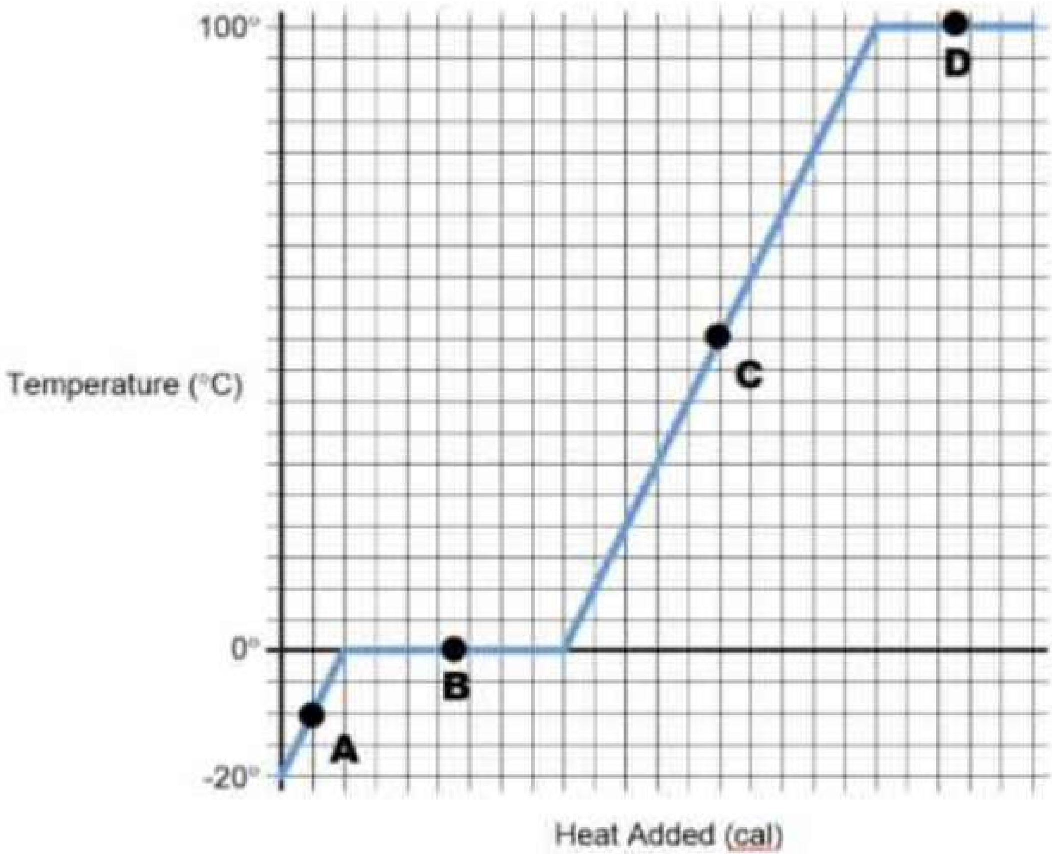


Fig 2. Heating Graph.

Ice is heated in a pot until it turns into steam. Identify ALL the points on the graph that represent a change of state (phase change).



- [ ] A
- [ ] D

Phase Change

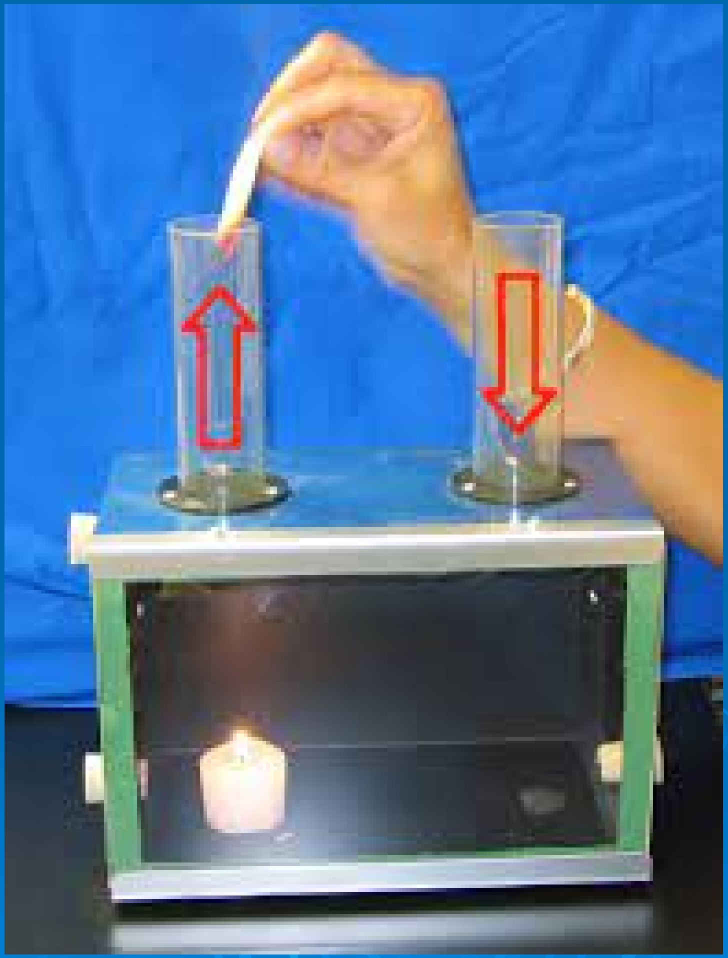
- Freezing– liquid to solid
- Boiling / Evaporation – liquid to gas
- Melting – solid to liquid
- Condensation – gas to liquid
- Sublimation – solid to gas (**Dry Ice**)

Conduction

- Thermal conduction is the process by which energy is transferred by heat through contact.
- As an object is heated, the atoms nearest the heat vibrate with greater energy.

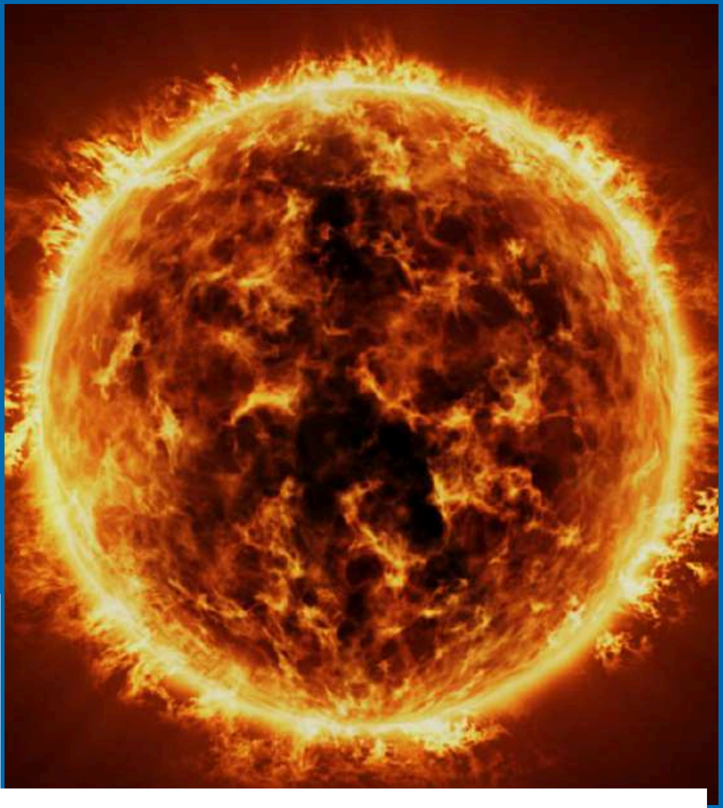
Convection

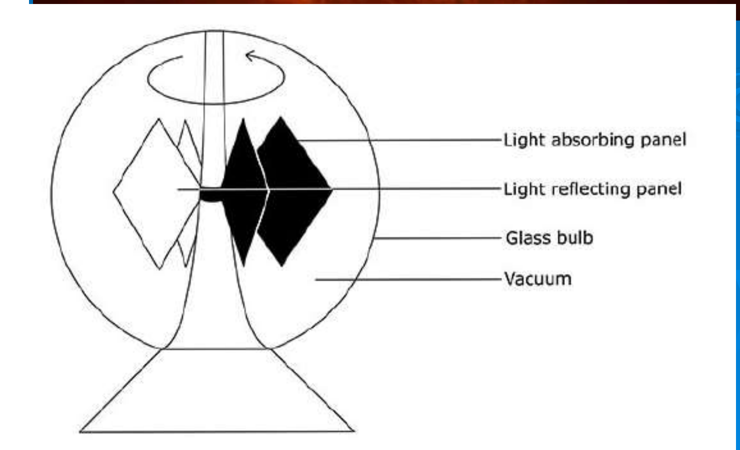
- Convection is the movement of heat through a fluid.
- Like through the **heater** in this room. The air is heated and we feel the heated air.



Electromagnetic Radiation

- Electromagnetic radiation transfers energy through the **sun**.





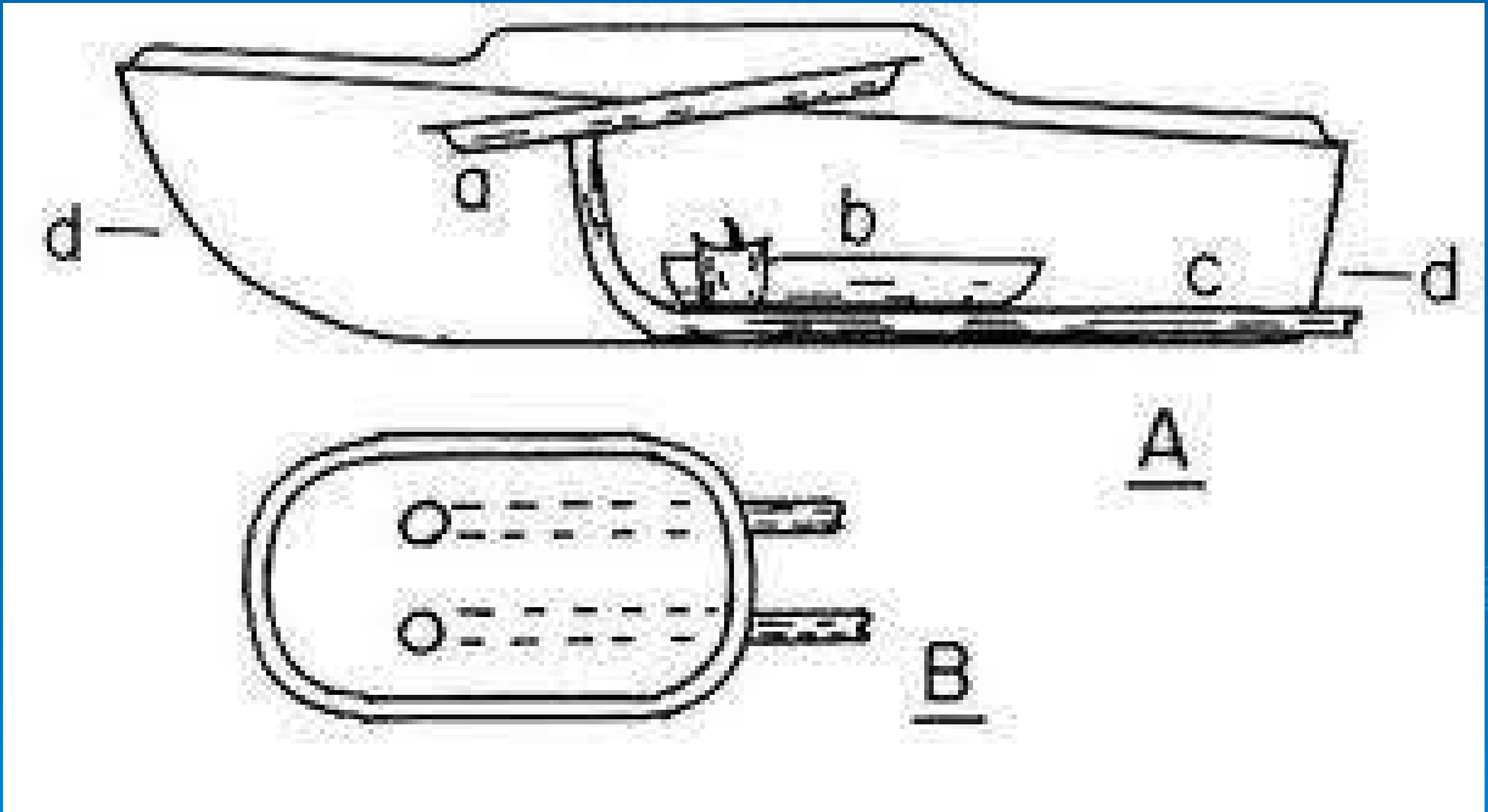
Heat and Work

- Heat can be used to do work.
- Energy transferred to heat turns water into steam which then exerts a force on a turbine and does work.

Heat Engine


Est.1885
12 FL OZ

Steam "Pop Pop" Boat



Work Equation

- Work = Pressure x volume change
- $W = P \times \Delta V$
- Volume = Area x distance (cylinder)

$W = V \times (P_f - P_i)$

- A gas has a volume of 20 and starts with a pressure of 1900. If it does 20 J of work, what is the final pressure?

Isovolumetric Process

- No work is done if the volume is not changed (to have work you must have movement)

Isothermal Process

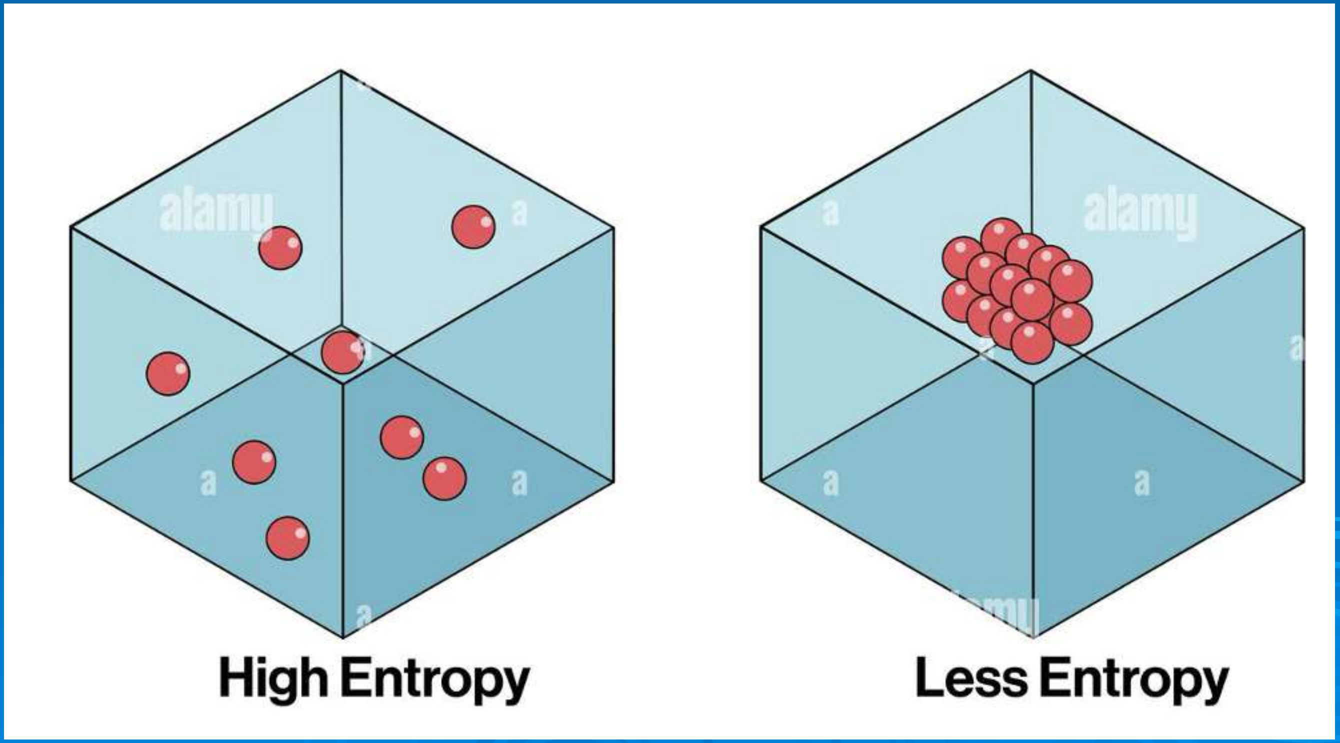
- When the system's temperature remains constant and the internal energy does not change.
- Pressure can change but not temperature.

Adiabatic Process

- A thermodynamic process during which work is done but no energy is transferred as heat.
- $Q = 0$
- No heat can be lost because there is usually not enough time in the process. (It happens to quickly for heat to escape)

Entropy

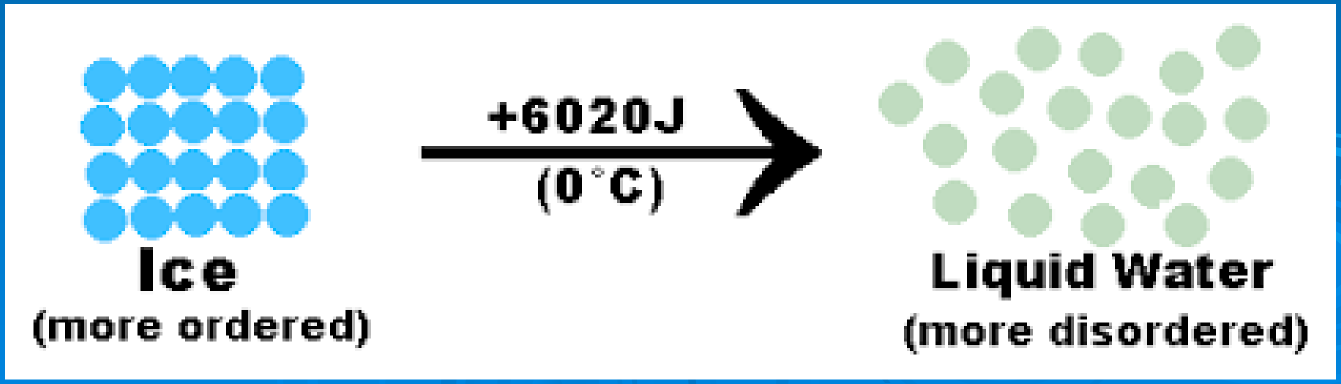
- Entropy is the measure of a system's disorder.



A tray filled with ice is removed from the freezer. After a short period of time, the ice begins to melt.

As the ice melts, the molecules start to move around more

It increases in **entropy**



1st Law of Thermodynamics

- Energy (heat) cannot be created or destroyed only changed to other forms.

Cyclic Process

- A thermodynamic process in which a system returns to the same conditions under which it started is called a cyclic process.
- For example, a refrigerator process restarts each time under the same conditions. - no loss or gain of energy

Heat Engines

- Heat engines use heat to do work.
- $W_{net} = Q_h - Q_c$
- Q_h = heat added
- Q_c = heat removed

Gas Engine - Steps

- Step 1: Spark plug fires.
- Step 2: Gas is ignited.
- Step 3: Gas creates pressure.
- Step 4: Pressure moves Piston.
- Step 5: Piston moves crankshaft.

2nd Law of Thermodynamics

- No process that converts heat entirely into work is possible.
- In other words, some energy must always be transferred as heat to the environment.
- Cannot be 100% efficient!
- Perpetual motion machine?

Efficiency Equation

- $Eff = W_{net} / Q_h$
- $Eff = (Q_h - Q_c)/Q_h$
- $Eff = 1 - (Q_c/Q_h)$

If a steam engine takes in 2200 J from a boiler and gives up 1500 J in exhaust during one cycle, how efficient is it?

Work = input/output * 100

A pulley system is used to lift an engine. The operator has an input work of 2000 Nm. The work output of the pulley is 1800 Nm. Calculate the percent efficiency of the pulley system.

- ○ 20%
- ○ 90%
- ○ 50%
- ○ 111%

THE END OF THE UNIVERSE!

- Everything in the world is moving towards thermal equilibrium and the temperature will be the same everywhere.
- Since there will be no temp difference, no heat can be transferred and thus no work can be done.
- This is called ultimate “heat death” of the universe and is predicted to happen in 100 trillion years. So make your plans now!

Mini Ice Cream