LAWS OF THERMODYNAMCIS

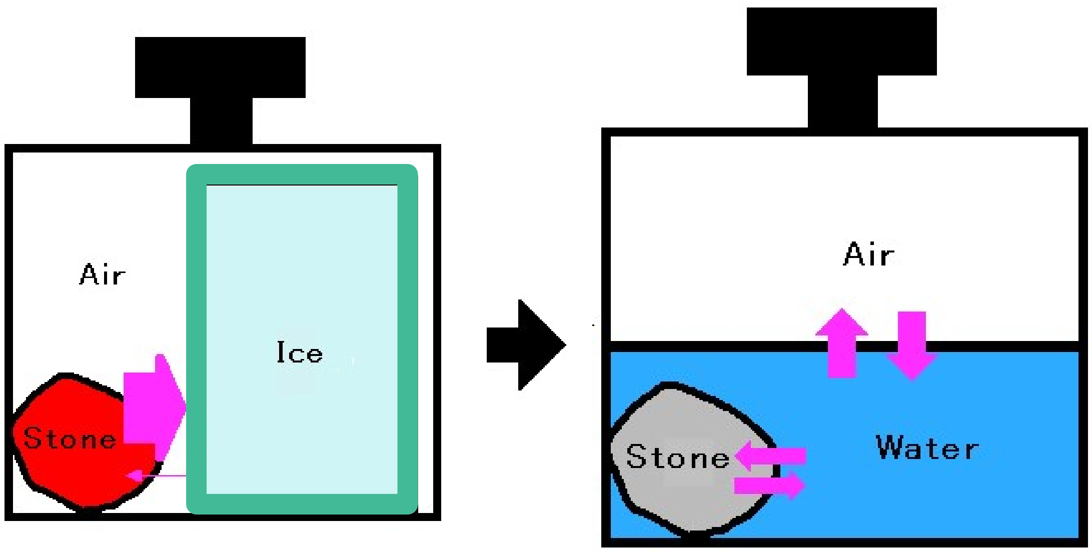
CLAUSIUS INEQUALITY

EQUILIBRIUM

Every system in this universe spontaneously move towards equilibrium.

Thermal equilibrium refers to equality of temperatures.

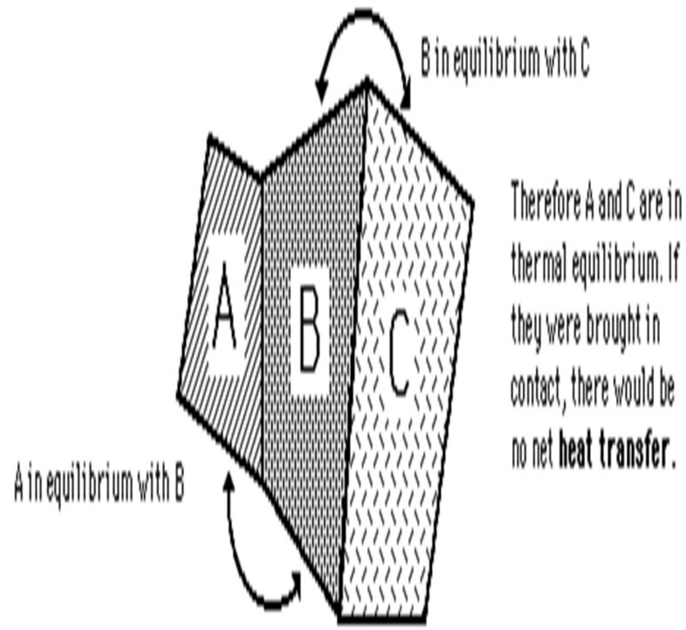
Thermal equilibrium is the subject of the Temperature measurement.



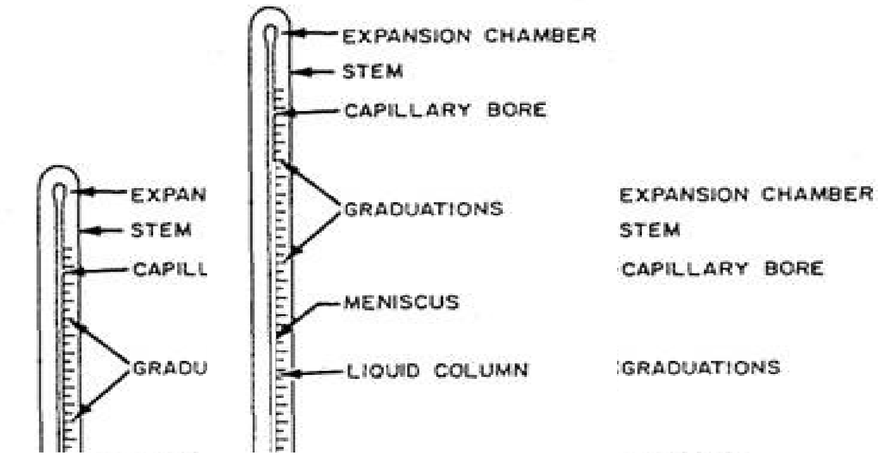
ZEROTH LAW OF THERMODYNAMICS

The "zeroth law" states that two thermodynamic systems in thermal equilibrium with the same environment are in thermal equilibrium with each other.

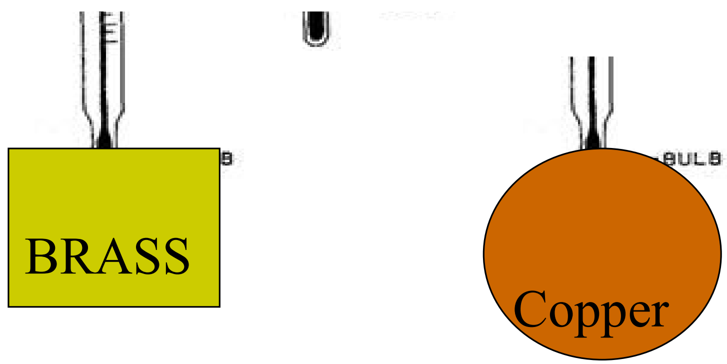
- If A and C are in thermal equilibrium with B, then A is in thermal equilibrium with C. **Maxwell** [1872]
- Practically this means that all three are at the same temperature.
- A basis for *comparison* of effect of temperatures.



DEMONSTRATION OF ZEROTH LAW



If the substance that composes the system is in thermal equilibrium, the temperature will be the same throughout the entire system, and we may speak of the temperature as a property of the system



turn have equality of temperature with each other.

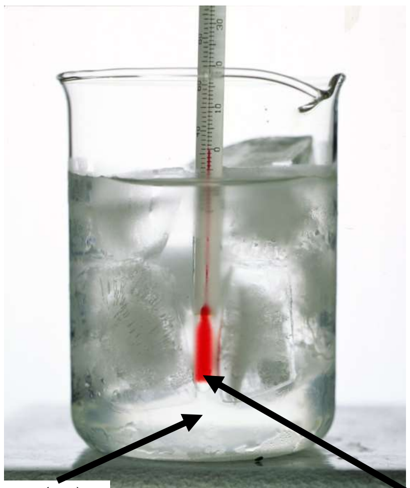
HOW LONG IT TAKES TO ACHIVE ZEROTH LAW?

Conservation of Energy during a time *dt*

Heat in = Change in energy of thermocouple

$$UA_b\left(T_s - T_{th}\right)dt = \rho V_{th} C_{th} dT_{th}$$

$$\rho V_{th} C_{th} \frac{dT_{th}}{dt} = UA_b\left(T_s - T_{th}\right)$$



$T_s(t)$

$T_{th}(t)$

$T_s(t) =$ Instantaneous Temperature of the System

$T_{th}(t) =$ Instantaneous Temperature of thermometer

SUDDEN IMMERSION OF THERMOMETER IN A KNOWN CONSTANT TEMPERATURE SYSTEM

$$\rho V_{th} C_{th} \frac{dT_{th}}{dt} + UA_b T_{th} = UA_b T_s$$

$$\frac{\rho V_{th} C_{th}}{UA_b} \frac{dT_{th}}{dt} + T_{th} = T_s$$

Define Time constant $\tau = \dfrac{\rho_{th} V_{th} C_{th}}{UA_b}$

$$\tau \frac{dT_{th}}{dt} + T_{th} = T_s$$

$$\tau s \mathrm{T}_{th}(s) + \mathrm{T}_{th}(s) = \frac{T_s}{s}$$

$$(\tau s + 1)\mathrm{T}_{th}(s) = \frac{T_s}{s}$$

$$\mathrm{T}_{th}(s) = \frac{T_s}{s(\tau s + 1)}$$