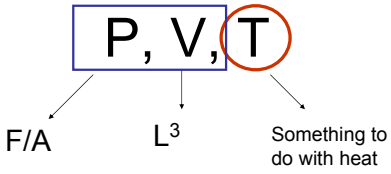
Pressure, Volume, Temperature



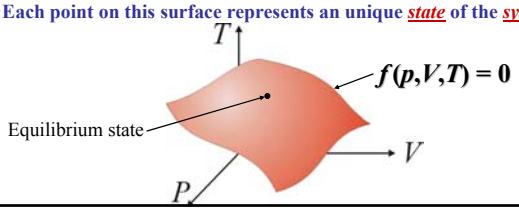
Equations of state

- An *equation of state* is a mathematical relation between *state variables*, e.g. p, V & T.
- This reduces the number of independent variables to two.

General form: $f(p,V,T) = 0$

Example: $pV - nRT = 0$ **(ideal gas law)**

- Defines a 2D surface in *p-V-T state space*.
- Each point on this surface represents an unique *state* of the *system*.



- ***Extensive property***: ∝ mass (e.g. V)
- ***Intensive property***: not a function of mass (e.g. T, p, ρ)
- ***Specific value***: $\frac{\text{Extensive property}}{\text{Mass}}$

Ideal gas equation of state

Boyle's law

$p \propto 1/V$

Robert Boyle (1627 – 1691)

Charles' law

$V \propto T$

Jacques Charles (1746 – 1823)

Gay-Lussac' law

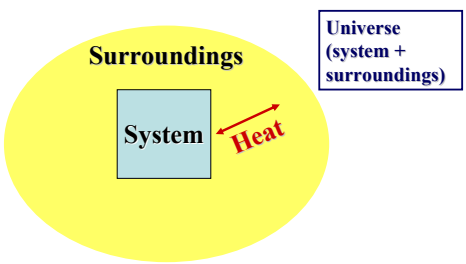
$p \propto T$

Joseph Louis Gay-Lussac (1778 - 1850)

$pV = Nk_B T$

$k_B = 1.38 \times 10^{-23}$ J/K

Heat is energy in transit



Heat capacity

$$C = \frac{đQ}{dT}$$

$$C_V = \left(\frac{\partial Q}{\partial T}\right)_V$$

$$C_P = \left(\frac{\partial Q}{\partial T}\right)_P$$

Specific heat capacity (c) is the heat capacity per unit mass.

What is temperature?

Temperature is what you measure with a thermometer

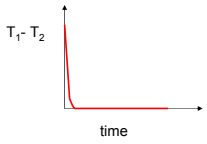
Temperature is the thing that's the same for two objects, after they've been in contact **long enough.**

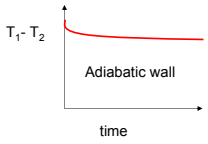
Long enough so that the two objects are in thermal equilibrium.

Time required to reach thermal equilibrium is the ***relaxation time.***

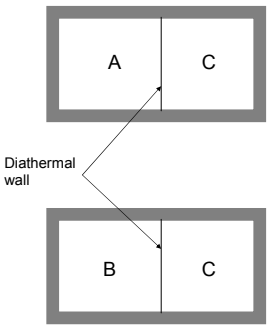
Temperature is a measure of the tendency of an object to spontaneously give up/absorb energy to/from its surroundings.

Diathermal wall is a boundary that freely allows heat to be exchanged i.e. very short relaxation time for systems separated by a diathermal wall.





Zeroth law of thermodynamics



If two systems are separately in thermal equilibrium with a third system, they are in thermal equilibrium with each other.

C can be considered the thermometer. If C is at a certain temperature then A and B are also at the same temperature.