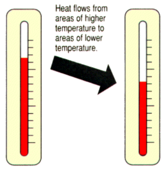
TOPIC 3 - Thermal Physics

Temperture → we can think of temperature as
- the degree of "hotness" or "coldness"
- measure with a thermometer ⇒ calibrated in °C or K (°F)
  - 0°C → melting/freezing
  - 100°C → boiling/condensation
- SI unit is the kelvin (K)

Transfer of heat (thermal energy)

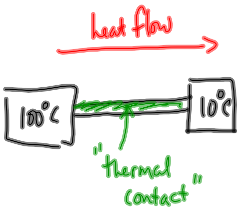


Temperature determines the direction of the thermal energy transfer between two objects

↑ Another way to define temperature.

* It is ONLY temperature that determines the direction of thermal transfer. The direction of thermal transfer is NOT determined by the amount of internal energy in a body.

* The direction of thermal transfer is determined by temperature alone ⇒ high temp to low temp. (heat flow)



Two bodies are in "thermal contact" if thermal energy can be exchanged between them

The direction of heat flow does not depend on:
- the mass of the bodies
- the internal energy of the bodies
- the size of the bodies

Heat flow only depends on temperature!!

Thermal Equilibrium

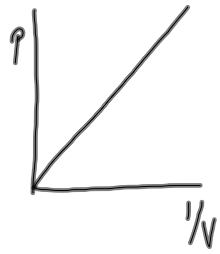
Two bodies are in thermal equilibrium if, when they are in thermal contact, there is no transfer of thermal energy between them.

Since thermal energy flows between two bodies when they are at different temperatures then the two bodies must be at the same temperature if they are in thermal equilibrium.

Kelvin & Celsius Temperature Scales

Boyle's Law – the pressure of a fixed mass of gas at a constant temperature is inversely proportional to its volume.

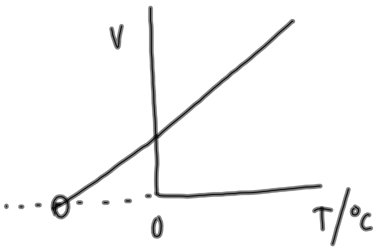
$P \propto \frac{1}{V}$



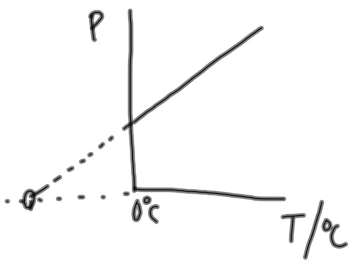
Iso thermal Process – a process which is done at constant temperature.

i.e. Boyle's law would not apply to a bicycle pump since it gets warm when compressing the air inside. (OK if done very slowly)
↓
obey Boyle's Law.

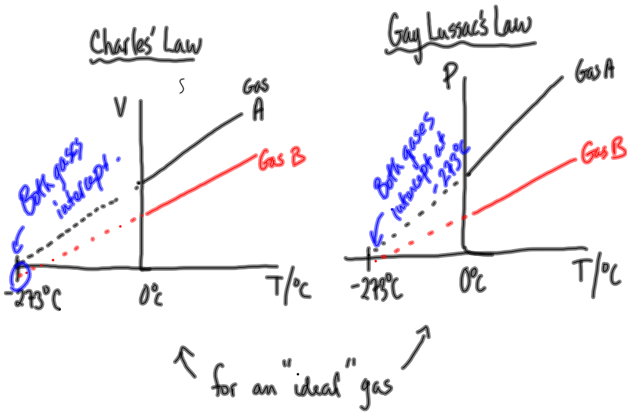
Charles's Law – the volume of a fixed mass of gas at a constant pressure depends linearly on its temperature (°C).



Gay-Lussac's Law (Pressure Law) – the pressure of a fixed mass of gas at a constant volume depends linearly on its temperature (°C).



Extrapolation of pressure + volume graphs back to zero:

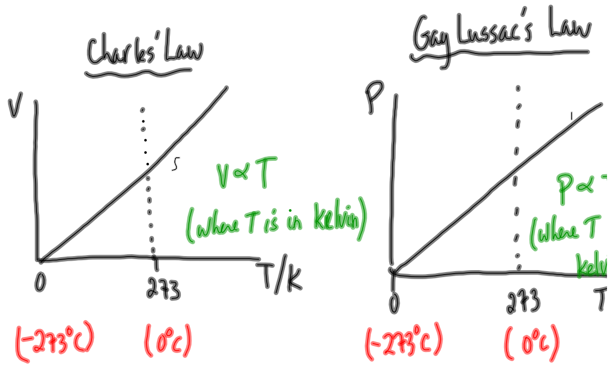


The Kelvin temperature Scale

The kelvin is the SI unit for temperature.

The zero of kelvin is taken to be at -273°C and the size of the kelvin is the same as the size of the Celsius degree

There are 273 kelvin between -273°C and 0°C.



Converting between kelvin and degrees Celsius.

$$T/K = t/°C + 273$$

Example:

350K = (350 − 273) = 77°C

100°C = (100 + 273) = 373K

Note that temperature changes are the same i.e. a temperature increase of 40°C = a temperature increase of 40

Better version of:

Absolute Zero

- The temperature at which both the volume and pressure of a gas will be zero.
- The Laws of thermodynamics show that absolute zero (-273°C or 0 K) is the coldest temperature and it can never be reached.

Near absolute zero, some strange things happen:

- superconductivity (electrical resistance is zero)
- superfluidity (viscosity of a fluid is zero)
- at about 10^{-9} K => Bose Einstein condensate. (a new state state of matter)

Formula for temperature

It can be shown using kinetic theory (more... later). that the temperature in Kelvin is related to the mean translational kinetic energy per particle.

$$E_K = \frac{3}{2}kT = \frac{1}{2}m\overline{v^2}$$

← mean kinetic energy

↑ Temperature in Kelvin

k = Boltzmann's constant $= 1.38 \times 10^{-23}$ J K^{-1}

Conversions:

1. 27°C to kelvin 300 K
2. 100 K to degrees Celsius. -173 °C
3. -100°C to kelvin 173 K
4. a change in temperature of 100°C to kelvin 100 K