9 First Law of Thermodynamics

Specific Heat Capacity

The **specific heat capacity, *c*** of a body is defined as the <u>amount of heat *Q*</u> required to produce <u>unit temperature rise</u> in a <u>unit mass</u> of the body, without the body going through a change in state, i.e. $c = \frac{C}{m} = \frac{Q}{m\Delta T}$ ($J\ kg^{-1}\ K^{-1}$)

Specific Latent Heat

The **specific latent heat of fusion/vaporisation, l_f/l_v** of a substance is defined as the amount of heat *Q* required to change a <u>unit mass</u> of the substance from solid to liquid/liquid to gas state <u>without</u> a change in temperature.

$$\ell_f = \frac{Q}{m} \qquad \ell_v = \frac{Q}{m}\ (J\ kg^{-1})$$

Internal Energy

The **internal energy *U*** of a system is the sum of the random distribution of kinetic and potential energies associated with the molecules of the system, i.e. $U = \Sigma PE + \Sigma KE$ of molecules

Internal Energy of Ideal Gas

$U = \frac{3}{2}NkT = \frac{3}{2}nRT$ (only for ideal gas)

First Law of Thermodynamics

The **first law of thermodynamics** states that the <u>increase</u> in the internal energy of a system is the sum of the work done on the system and the heat supplied to the system, i.e. $\Delta U = Q_{to} + W_{on}$

Note: Signs must be attributed properly.

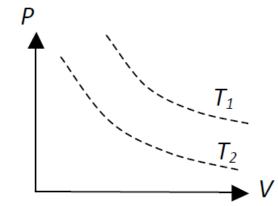
Work done on a gas

Work done on a gas $W_{on} = -\int p dV$, i.e. area under p-V graph. If pressure is constant, $W = p\Delta V$ (given)

Compression: positive WD; Expansion: negative

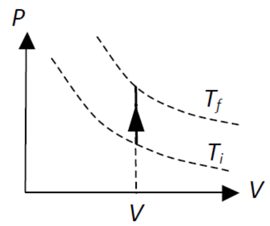
First Law of Thermodynamics

Isotherms

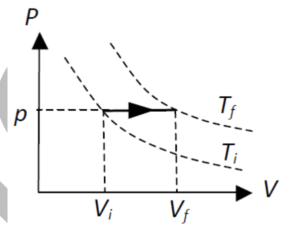


Due to the equation $pV = nRT$, $p \propto \frac{1}{V}$ when <u>temperature</u> is constant.

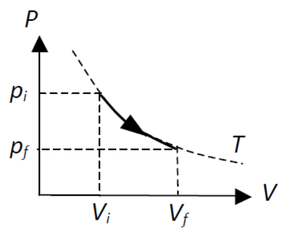
Thermodynamic Processes



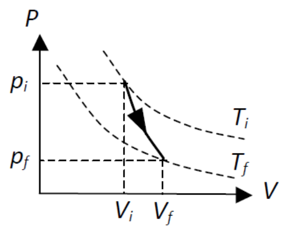
An **isochoric** process is one where <u>volume remains constant</u>, i.e. $\Delta V = 0$. Thus, $W = p\Delta V = 0$ and $\Delta U = Q$.



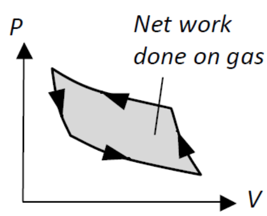
An **isobaric** process is one where <u>pressure remains constant</u>. Thus, $W = -p(V_f - V_i)$ and $\Delta U = Q - p(V_f - V_i)$.



An **isothermal** process is one where <u>temperature remains constant</u>. Since $\Delta T = 0$, $\Delta U = 0$. Thus, $Q = -W$.



An **adiabatic** process is one where no heat flows into or out of the system, i.e. $\Delta Q = 0$. Therefore, $\Delta U = W$.



A **cyclic** process is one where the system goes through a round trip. Internal energy is thus unchanged. $\Delta U = 0$ and thus $Q = -W$.