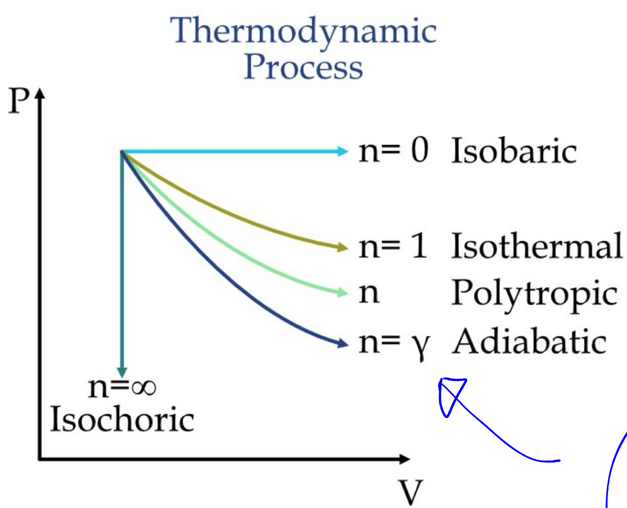
Types of thermodynamic processes

- **Adiabatic**: No heat transfer into or out of the system
- **Isobaric**: Pressure remains constant
- **Isochoric**: Volume remains constant
- **Isothermal**: Temperature remains constant
- **Isenthalpic**: Enthalpy remains constant
- **Isentropic**: A reversible adiabatic process where entropy remains constant
- **Steady state**: Internal energy remains constant

The first law:

$$\Delta U = Q - W$$



$$\boxed{PV^n = \text{Constant}}$$

($\gamma = \frac{C_p}{C_V}$ is the heat capicity ratio.)

— Heat transfer during various processes (for an ideal gas),

① Isobaric: $\Delta P = 0$, $Q = nC_p(T_f - T_i) = nC_p(\Delta T)$

heat capacity at constant pressure

② Isothermal: $\Delta T = 0$, $\Delta U = 0$,

$\boxed{\Delta U = Q - W} \Rightarrow Q = W$

(For idea gas: $PV = nRT$)

heat capacity at constant volume

③ Isochoric: $\Delta V = 0$, $\Rightarrow \Delta W = 0 \Rightarrow Q = \Delta U = nC_v(\Delta T)$

④ Adiabatic: $Q = 0 \Rightarrow PV^{\gamma} = \text{Constant}$, with $\gamma = \frac{C_p}{C_V}$

Heat transfer during various processes (for an ideal gas)

① Isobaric: $\Delta P = 0$, $Q = n C_p (T_f - T_i) = n C_p (\Delta T)$

heat capacity at constant pressure

$PV = nRT$

$W = \int p\,dV = p(V_f - V_i) \Rightarrow \Delta U = Q - W$

Using ($PV = nRT$)

change of Entropy: $\Delta S = \int \frac{dQ}{T} = \int_{T_i}^{T_f} n C_p \frac{dT}{T} = n C_p \ln\left(\frac{T_f}{T_i}\right)$

$= n C_p \ln\left(\frac{V_f}{V_i}\right)$

② Isothermal: $\Delta T = 0$, $\Delta U = 0$,

$\boxed{\Delta U = Q - W} \Rightarrow Q = W$

$W = \int p\,dV = \int \frac{nRT}{V} dV = nRT \ln\left(\frac{V_f}{V_i}\right)$

$\Delta S = \frac{Q}{T} = nR \ln\left(\frac{V_f}{V_i}\right)$

③ Isochoric: $\Delta V = 0$, $\Rightarrow W = 0$

heat capacity at constant volume

$\Rightarrow Q = \Delta U = n C_v (\Delta T)$

$\Delta S = \int \frac{dQ}{T} = \int_{T_i}^{T_f} n C_v \frac{dT}{T} = n C_v \ln\left(\frac{T_f}{T_i}\right)$

④ Adiabatic: $Q = 0 \Rightarrow PV^\gamma = C$ (a constant), with $\gamma = \frac{C_p}{C_v}$

$W = \int p\,dV = \int \frac{C}{V^\gamma} dV = \frac{P_f V_f - P_i V_i}{1 - \gamma}$,

($C_p = C_v + R$) for ideal gas,

$\Rightarrow \Delta U = Q - W = -W$

$\Delta S = \int \frac{dQ}{T} = 0$

$C_v = \frac{f}{2} R$, where

$f = 3$ for monatomic gas

$f = 5$ for diatomic gas