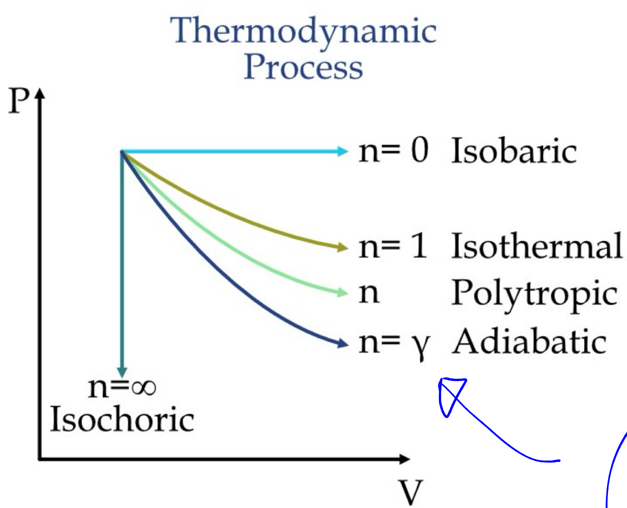
Types of thermodynamic processes

- **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:

$$\Delta U = Q - W$$



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

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

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

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

(C_p: heat capacity at constant pressure)

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

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

(For idea gas: $PV = nRT$)

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

(C_v: heat capacity at constant volume)

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

↑ 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: $\Delta S = \int \frac{dQ}{T} = \int_{T_i}^{T_f} nC_p \frac{dT}{T} = nC_p \ln\left(\frac{T_f}{T_i}\right) = nC_p \ln\left(\frac{V_f}{V_i}\right)$

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

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

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

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

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

$\Rightarrow Q = \Delta U = nC_v(\Delta T)$

↑ heat capacity at constant volume

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

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

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

$C_v = \frac{f}{2}R$, where
$f = 3$ for monatomic gas
$f = 5$ for diatomic gas)

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

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

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