The Second Law of Thermodynamics

> Entropy in a closed system cannot decrease.
> $$\Delta S \geq 0$$

From Boltzmann's perspective, this is obvious. Why would a system not explore all the microstates accessible to it? A system can only lose entropy by heat flowing out of it (clear from Clausius' perspective) but this is not possible in a closed system.

From Clausius' Perspective, another definition of the second law is:

> Heat cannot flow spontaneously from a colder to a warmer body.

Note, from Clausius' entropy $dS = \frac{dQ}{T} \Rightarrow dQ = TdS$, we can get another definition of the first law:

$$dU = dQ + dW \Rightarrow \boxed{dU = TdS - PdV}$$

Entropy of an ideal gas

From $dU = TdS - PdV \Rightarrow \frac{dU}{T} + \frac{P}{T}dV = dS$

but $dU = C_V dT$ and $\frac{P}{T} = \frac{Nk_B}{V}$ so:

$$dS = C_V \frac{dT}{T} + Nk_B \frac{dV}{V} \quad \therefore S = C_V \ln T + Nk_B \ln V + S_0$$
$$= \underline{\underline{nC \ln T + nR \ln V + S_0}}$$

Where S_0 is the integration constant that depends on N but not on V or T.