

Thermodynamics 1: Entropy & Enthalpy

Entropy & Enthalpy:

The Clausius theorem states that a system exchanging heat with external reservoirs and undergoing a cyclic process, is one that ultimately returns a system to its original state:

$$\oint \left(\frac{SQ}{T} \right)_b \leq 0$$

The Kelvin-Planck statement states it is impossible to devise a cyclically operating heat engine, the effect of which is to absorb energy in the form of heat from a single thermal reservoir and to deliver an equivalent amount of work. This implies that it is impossible to build a heat engine that has 100% thermal efficiency.

- Entropy balance:

$$\Delta S = S_2 - S_1 = \int_1^2 \left(\frac{SQ}{T} \right)_b + \sigma$$

Change in entropy = Entropy transfer + Entropy production

If $\sigma = 0$, it is a reversible process since no entropy is generated (can be returned to original state). If $\sigma > 0$, it is irreversible. σ can never be < 0 , as this would imply its destruction.

- Entropy rate of change:

$$\frac{ds}{dt} = \sum ms + \int_1^2 \left(\frac{SQ}{T} \right)_b + \sigma$$

- Ideal Gas

- Variable Specific Heat: $\Delta S = S^\circ_1 - S^\circ_2 - R \cdot \ln \left(\frac{P_2}{P_1} \right)$
- Constant Specific Heats: $\Delta S = C_v \ln \left(\frac{T_2}{T_1} \right) + R \cdot \ln \left(\frac{v_2}{v_1} \right) = C_p \ln \left(\frac{T_2}{T_1} \right) - R \cdot \ln \left(\frac{P_2}{P_1} \right)$

- Isentropic

$$\frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}} \text{ and } \frac{v_2}{v_1} = \frac{v_{r2}}{v_{r1}}$$

- Constant Specific Heats:

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = \left(\frac{v_1}{v_2}\right)^{k-1} \text{ and } \frac{P_2}{P_1} = \left(\frac{v_1}{v_2}\right)^k$$

$$k = \frac{c_p}{c_v}$$

Where k is the ratio of specific heats,

For more information on entropy and enthalpy, make an appointment with a [content tutor](#).
 Appointments are available in person at the [Student Success Center](#) or online.