


Entropy

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Entropy of a perfect Gas

From first law

$$\begin{aligned}dQ &= dU + dW \\ &= C_v dT + P dV \quad - (1)\end{aligned}$$

$$dQ = T ds \quad - (2)$$

$$\Rightarrow T ds = C_v dT + P dV$$

$$ds = C_v \frac{dT}{T} + \frac{P dV}{T} \quad - (3)$$

(a) Entropy in terms of volume and temperature

$$S_2 - S_1 = \int_1^2 ds = \int_{T_1}^{T_2} C_v \frac{dT}{T} + \int_{V_1}^{V_2} \frac{P dV}{T} \quad \text{--- (4)}$$

$$\left\{ \begin{array}{l} PV = RT \\ \Rightarrow P = \frac{RT}{V} \end{array} \right\}$$

$$S_2 - S_1 = C_v \int_{T_1}^{T_2} \frac{dT}{T} + R \int_{V_1}^{V_2} \frac{dV}{V}$$

$$= C_v \left| \log_e T \right|_{T_1}^{T_2} + R \left| \log_e V \right|_{V_1}^{V_2}$$

$$\Rightarrow S_2 - S_1 = C_v \log_e \frac{T_2}{T_1} + (C_p - C_v) \log_e \frac{V_2}{V_1} \quad \text{--- (5)}$$

$$S_2 - S_1 = \frac{1}{M} \left[C_v \log_e \frac{T_2}{T_1} + (C_p - C_v) \log_e \frac{V_2}{V_1} \right]$$

(b) Entropy in terms of pressure and temperature

$$PV = RT \quad \longrightarrow \quad V = \frac{RT}{P}$$

$$P dV + V dP = R dT$$

$$\Rightarrow P dV = R dT - V dP \quad - (6)$$

$$\begin{aligned} S_2 - S_1 &= \int_{T_1}^{T_2} C_v \frac{dT}{T} + \int_{T_1}^{T_2} R \frac{dT}{T} - \int_{P_1}^{P_2} R \frac{dP}{P} \\ &= C_v \int_{T_1}^{T_2} \frac{dT}{T} + (C_p - C_v) \int_{T_1}^{T_2} \frac{dT}{T} - R \int_{P_1}^{P_2} \frac{dP}{P} \end{aligned}$$

$$s_2 - s_1 = c_p \int_{T_1}^{T_2} \frac{dT}{T} - (c_p - c_v) \int_{P_1}^{P_2} \frac{dP}{P}$$
$$= c_p \left| \log_e T \right|_{T_1}^{T_2} - (c_p - c_v) \left| \log_e P \right|_{P_1}^{P_2}$$

$$s_2 - s_1 = c_p \log_e \frac{T_2}{T_1} - (c_p - c_v) \log_e \frac{P_2}{P_1} \quad \text{--- (7)}$$

$$s_2 - s_1 = \frac{1}{M} \left[c_p \log_e \frac{T_2}{T_1} - (c_p - c_v) \log_e \frac{P_2}{P_1} \right]$$

(c) Entropy in terms of pressure and volume

$$pV = RT \quad \rightarrow \quad T = \frac{pV}{R} \quad - (8)$$

$$p \, dV + v \, dp = R \, dT$$

$$\Rightarrow dT = \frac{p \, dV + v \, dp}{R} \quad - (9)$$

$$dS = c_v \frac{p \, dV + v \, dp}{R} \times \frac{R}{pV} + \frac{p \, dV}{pV} \times R$$

$$\begin{aligned} ds &= c_v \frac{p dv + v dp}{pv} + \frac{R dv}{v} \\ &= c_v \left(\frac{dv}{v} + \frac{dp}{p} \right) + (c_p - c_v) \frac{dv}{v} \\ &= c_v \frac{dp}{p} + c_p \frac{dv}{v} \end{aligned}$$

$$s_2 - s_1 = \int_1^2 ds = c_v \int_{p_1}^{p_2} \frac{dp}{p} + c_p \int_{v_1}^{v_2} \frac{dv}{v}$$

$$s_2 - s_1 = c_v \log_e \frac{p_2}{p_1} + c_p \log_e \frac{v_2}{v_1} \quad (10)$$

$$s_2 - s_1 = \frac{1}{M} \left[c_v \log_e \frac{p_2}{p_1} + c_p \log_e \frac{v_2}{v_1} \right]$$

A close-up photograph of a single, vibrant blue feather. The feather's barbs are fine and densely packed, creating a soft, textured appearance. The background is a blurred, ethereal mix of light blue, white, and hints of pink and orange, suggesting a soft-focus natural setting. The overall mood is serene and delicate.

Third Law of Thermodynamics

According to Nernst, “ **The heat capacities of all solids tend to zero as the absolute zero of temperature is approached and that the internal energies and entropies of all the substances become equal there, approaching their common value asymptotically tending to zero**”.

In terms of entropy, the theorem may be stated as:

“ **at absolute zero temperature, the entropy tend to zero and the molecules of a substance or a system are in perfect order (well arranged)**”.

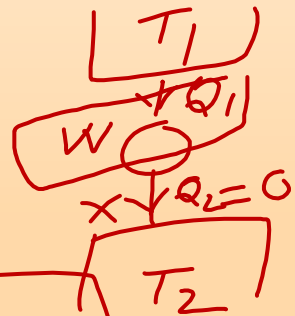
$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$$

$$\left(\frac{Q_1}{T_1} - \frac{Q_2}{T_2} \right) \rightarrow +ve \text{ quantity}$$

$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

$$T_2 = 0 \Rightarrow Q_2 = 0$$

$$T_2 = 0 \text{ K}$$



A teal-tinted photograph of a lake. The water is in the foreground, showing ripples and reflections. In the background, there is a dense forest of trees along the shore. A small dock or pier is visible on the right side of the background. A willow branch with leaves hangs over the water from the right side of the frame. The word "Thankyou" is written in white text across the middle of the image.

Thankyou