3.3 Change of entropy

Here we provide some fundamental equations regarding the entropy for the expansion of a perfect gas under different boundary conditions resulting in reversible changes between an initial state i and a final srate f. As stated above we use the first law to calculate dq_{rev} and finally apply Eq. (3.1) to calculation ΔS:

- Isothermal expansion, i.e. $U = 3/2\, n\, R\, T = const.$ or $0 = dU = \delta q + \delta w$ (cf. Eq. (2.16)):

$$\Delta S = \int_i^f \frac{dq_{rev}}{T} = \frac{1}{T}\int_i^f dq_{rev} = -\frac{1}{T}\int_i^f dw = n\, R \ln\frac{V_f}{V_i} = n\, R \ln\frac{p_i}{p_f} \tag{3.3}$$

- Isochoric expansion, i.e. $\delta w = 0$, or $C_V dT = \delta q = dU$:

$$\Delta S = \int_i^f \frac{dq_{rev}}{T} = C_V \int_i^f \frac{dT}{T} = C_V\, \ln\frac{T_f}{T_i} \tag{3.4}$$

- Adiabatic expansion:

$$\Delta S = 0 \quad \text{since} \quad \delta q = 0 \tag{3.5}$$

Fig. 3.1 visualizes the logarithmic behavior described by Eq. (3.3) and Eq. (3.4)

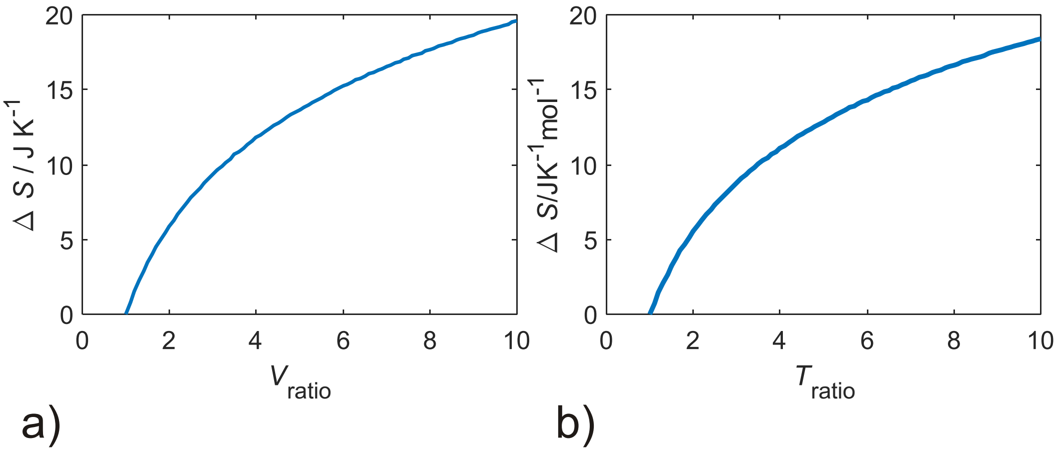

Figure 3.1: Entropy change for a) isothermal expansion; b) isochoric change.