

PHYS 301
Thermodynamics and Statistical Mechanics

Worksheet #2
Tuesday February 3 2026

Question 1.

Consider the multiplicity of a monoatomic ideal gas

$$\Omega(N, V, E) = \frac{V^N}{N!} \left(\frac{2\pi m E}{h^2} \right)^{3N/2} \frac{1}{\left(\frac{3N}{2}\right)!} \quad (1)$$

- (a) Using Stirling's approximation ($\ln N! \approx N \ln N - N$ for $N \gg 1$) and the properties of logs, derive the Sackur-Tetrode formula for the entropy of an ideal gas

$$S = k_B \ln \Omega(N, V, E) = N k_B \left[\ln \left(\frac{V}{N} \left(\frac{4\pi m E}{3N h^2} \right)^{3/2} \right) + \frac{5}{2} \right]. \quad (2)$$

- (b) Use the formal definition of pressure

$$P = T \frac{\partial S}{\partial V}, \quad (3)$$

check that we retrieve the ideal gas law $PV = Nk_B T$.

