[tex78] **Array of classical harmonic oscillators (canonical ensemble)**

Consider an array of N 3-dimensional classical harmonic oscillators, representing a system of $3N$ uncoupled degrees of freedom:

$$H = \sum_{i=1}^{3N} \left(\frac{p_i^2}{2m} + \frac{1}{2} m\omega^2 q_i^2 \right).$$

(a) Calculate the canonical partition function Z_N for this model.

(b) Derive from Z_N the Helmholtz free energy $A(T, V, N)$, the entropy $S(T, V, N)$, the pressure $p(T, V, N)$, the internal energy $U(T, V, N)$, the chemical potential $\mu(T, V)$, and the heat capacity $C \equiv (\partial U/\partial T)_{V,N}$.