**PHYSICS 621** **Autumn 2007** **Exam 4 notes**

$\Delta U = Q + W \qquad W = -P\ dV$

$U_{\text{thermal}} = \frac{1}{2}NfkT \qquad PV = NkT \qquad PV^{\gamma} = \text{constant} \quad (\gamma = 1 + 2/f)$

$S = k\ \ln(\Omega) \qquad \frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_{N,V}$

two state system: $\Omega = \frac{N!}{n_1! n_2!}$, where $N = n_1 + n_2$

Einstein solid: $\Omega = \frac{(q+N-1)!}{q!(N-1)!}$

ideal gas: $\Omega = f(N) V^N U^{3N/2}$

$\ln(n!) \approx n\ \ln(n) - n \qquad \ln(1+x) = x - \frac{x^2}{2} + \cdots$

$\frac{P(s_1)}{P(s_2)} = \frac{e^{-\beta E(s_1)}}{e^{-\beta E(s_2)}}$

$P(s) = \frac{e^{-\beta E(s)}}{Z} \qquad Z = \sum e^{-\beta E(s)}$

$\bar{E} = -\frac{\partial}{\partial \beta} \ln(Z)$

The test will have three questions, possibly multi-part, with at least one question similar to something from a past exam. I reserve the right to introduce a new multiplicity, or a new spectrum, asking a question similar to something from past exams, homework or examples I covered thoroughly in class. Any heat engine or refrigerator (arrows reversed in PV diagram) will involve only isothermal, adiabatic, constant P and constant V steps (see notes from exam 3).

Any two types of system can be put in contact (e.g., Einstein solid and paramagnet), with fixed numbers of particles in each that need not be equal. Partition functions may require approximation by an integral or a sum that needs to be matched to a known Taylor series expansion.