

## Physics 410 -- Useful Formulas for quiz #4

- I. Chemical potential:  $\mu_{total} = \mu_{int} + \mu_{ext}$ , where  $\mu_{int}$  depends on the particle density (e.g. through the Ideal Gas relation) and  $\mu_{ext}$  is a potential energy per particle added to the system).

Diffusive equilibrium between systems A and B occurs when  $\mu_{total}^A = \mu_{total}^B$

Chemical potential of ideal gas in 3D:  $\mu = \tau \ln \left( \frac{n}{n_Q} \right)$ , where  $n$  is the concentration of particles and  $n_Q = \left( \frac{M\tau}{2\pi\hbar^2} \right)^{\frac{3}{2}}$  is the quantum concentration.

- II. Grand canonical ensemble: independent variables  $\tau, V, \mu$

Grand Partition function, also called the "Gibbs sum":  $\mathcal{Z} = \sum_{N=0}^{\infty} \sum_{s(N)} e^{[(N\mu - \mathcal{E}_s)/\tau]}$ ,

Grand canonical distribution function (probability):  $P(N, \mathcal{E}) = \frac{e^{[(N\mu - \mathcal{E})/\tau]}}{\mathcal{Z}}$

The numerator of  $P(N, \mathcal{E})$  is called the "Gibbs factor"

Mean *total* number of particles:  $\langle N \rangle = \lambda \frac{d(\ln \mathcal{Z})}{d\lambda}$ , where  $\lambda = e^{\mu/\tau}$  is the absolute activity.