

Kittel TP

2.3 (a)

For single system, $\sigma = \ln g(N, n)$

$$= \ln \frac{(N+n-1)!}{n! (N-1)!}$$

using Stirling approx, and treat $N-1 \approx N$,

$$\sigma = (N+n) \ln(N+n) - (N+n) - n \ln n + n - N \ln N + N$$

$$= (N+n) \ln(N+n) - n \ln n - N \ln N$$

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2.3(b).

$$\sigma = (N+n) \ln(N+n) - n \ln n - N \ln N$$

substitute $n = \frac{U}{kT}$

$$\sigma(U, N) = \left(N + \frac{U}{kT}\right) \ln \left[N + \frac{U}{kT}\right] - \frac{U}{kT} \ln \frac{U}{kT} - N \ln N$$

$$\frac{1}{T} = \left(\frac{\partial \sigma}{\partial U}\right)_N$$

$$= \frac{1}{kT} \ln \left[N + \frac{U}{kT}\right] + \left(N + \frac{U}{kT}\right) \left(N + \frac{U}{kT}\right)^{-1} \left(\frac{1}{kT}\right) - \left[\frac{1}{kT} \ln \frac{U}{kT} + \frac{U}{kT} \left(\frac{U}{kT}\right)^{-1} \left(\frac{1}{kT}\right)\right]$$

$$= \frac{1}{kT} \ln \left[N + \frac{U}{kT}\right] + \frac{1}{kT} - \frac{1}{kT} \left[\ln \frac{U}{kT} + \frac{1}{\cancel{kT}}\right]$$

$$\Rightarrow \frac{kT}{T} = \ln \left[N + \frac{U}{kT}\right] + 1 - \ln \frac{U}{kT} - 1$$

$$= \ln \left[\frac{N + \frac{U}{kT}}{\frac{U}{kT}}\right] = \ln \left[\frac{NkT}{U} + 1\right]$$

$$\Rightarrow \exp \left[\frac{kT}{T}\right] - 1 = NkT/U$$

$$U = \frac{NkT}{\exp \left[\frac{kT}{T}\right] - 1}$$

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