Quantum Prob. $$w_n^{(a)} = e^{-\alpha^{(a)} - \beta E_n^{(a)}}$$

$$\sum_n w_n^{(a)} = 1$$ Petit Ensemble

$$E_{nN}^{(a)}$$

$$w_{nN}^{(a)} = e^{-\alpha^{(a)} - \beta E_{nN}^{(a)} - \gamma N^{(a)}}$$ Grand Ensemble

$$\sum_n \sum_N w_{nN}^{(a)} = 1$$

$$w_n = e^{\frac{F - E_n}{k_B T}}$$ Gibbs Petit

apply Norm

$$F = \frac{1}{\beta} \ln \sum_n e^{-\beta E_n} = Z \; ; Z = \sum_n e^{-\beta E_n}$$

$$F = -\frac{1}{\beta} \ln Z \qquad F = F(V,T)$$
$$Z = Z(V,T)$$

$$S = \left(\frac{\partial F}{\partial T}\right)_V \; ; \; \bar{E} = F + TS$$

$$\bar{E} = k_B T^2 \frac{\partial \ln Z}{\partial T}$$

$$\bar{E} = \sum_n E_n e^{-\beta E_n} \Big/ \sum e^{-\beta E_n}$$

$$W_{nN} = e^{\beta(\Omega + \mu N - E_n)}$$ Grand Ensemble

$$d\Omega = -S\,dT + P\,dV - \bar{N}\,d\mu$$

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$$W_n = A_p e^{-\beta E_n}$$ Petit

$$e^{\beta(\mu N - E_n)}$$

$$W_{nN} = A_G e^{\beta(\mu N - E_n)}$$

$$A_p = e^{\beta F} \qquad A_G = e^{\beta \Omega}$$

Classical Limits

$$\boxed{dw = A_c e^{-\beta E(p,q)} dp\, dq} \; ; \; \prod_s dp_i dq_i = dp\,dq$$ phase space volume

$$\int dw = 1 \Rightarrow A_c = \frac{1}{\int dp\,dq\, e^{-\beta E(p,q)}}$$

Classical Partition Function

$$Z = \int dp\,dq\, e^{-\beta E(p,q)}$$

Average of some f'n f

$$\bar{f} = \frac{\int f(p,q) e^{-\beta E(p,q)} dp\,dq}{\int e^{-\beta E(p,q)} dp\,dq}$$

$$\bar{f} = \int dp\,dq\, f(p,q) e^{-\beta E(p,q)} \Big/ Z$$

$$E(p,q) = K(p) + U(q)$$

$$dw = dw_p\, dw_q \quad \int dw_p = 1 \qquad \int dw_q = 1$$