$$z = e^{-\alpha} = e^{\frac{\mu}{kT}}$$

$$Q_N(V,T) = \frac{1}{N!}\left[Z_1(V,T)\right]^N$$

$$Z_1(V,T) = Vf(T)$$

$$\mathcal{Z}(z,V,T) = \sum_{N_r=0}^{\infty} z^{N_r} Q_{N_r}(V,T) = \sum_{N_r=0}^{\infty} z^{N_r}\left[\frac{1}{N_r!}\left(Vf(T)\right)^{N_r}\right]$$

$$= \sum_{N_r=0}^{\infty} \frac{1}{N_r!}\left[zVf(T)\right]^{N_r}$$

exponentzialaren definizioa

$$\boxed{\mathcal{Z}(z,V,T) = e^{zVf(T)}}$$

$$q \equiv \ln \mathcal{Z}(z,V,T) \Rightarrow \boxed{q = zVf(T)} \qquad q = e^{\frac{\mu}{kT}}\cdot Vf(T)$$

$$p = \frac{kT}{\cancel{V}} z\cancel{V}f(T) \Rightarrow \boxed{p = kTzf(T)}$$

$$N = \cancel{kT}\frac{1}{\cancel{kT}} e^{\frac{\mu}{kT}} Vf(T) \Rightarrow N = e^{\frac{\mu}{kT}} Vf(T) \Rightarrow \boxed{N = zVf(T)}$$

$$U = kT^2 V\left(\cancel{\frac{\partial z}{\partial T} f(T)} + z\frac{\partial f(T)}{\partial T}\right) = kT^2 V\left(\cancel{e^{\frac{\mu}{kT}}\frac{\mu}{k}\left(\frac{-1}{T^2}\right)f(T)} + e^{\frac{\mu}{kT}} f'(T)\right)$$

$$\boxed{U = zVkT^2 f'(T)}$$

$$F = -kT\left(zVf(T) - N\ln z\right) \Rightarrow \boxed{F = NkT\ln z - kTzVf(T)}$$

$$Z_N(V,T) = \left[Z_1(V,T)\right]^N$$

$$Z_1(V,T) = \phi(T)$$

$$\mathcal{Z}(z,V,T) = \sum_{N_r=0}^{\infty} z^{N_r} Z_{N_r}(V,T) = \sum_{N_r=0}^{\infty} z^{N_r}\left(\phi(T)\right)^{N_r} = \sum_{N_r=0}^{\infty}\left(z\phi(T)\right)^{N_r}$$

Konbergentzia izateko

$$z\phi(T) < 1$$

$$\boxed{\mathcal{Z}(z,V,T) = \frac{1}{1 - z\phi(T)}}$$

$$q = -\ln\left(1 - z\phi(T)\right)$$

$$q \equiv \ln \mathcal{Z}(z,V,T) \Rightarrow \boxed{q = \ln\frac{1}{(1 - z\phi(T))}} \qquad q = \ln\left[\frac{1}{(1 - e^{\frac{\mu}{kT}}\phi(T))}\right]$$

$$p = \frac{kT}{V}\ln\frac{1}{(1 - z\phi(T))} \Rightarrow \boxed{p = -\frac{kT}{V}\ln\left(1 - z\phi(T)\right)}$$

$$N = kT\left(-\frac{1}{(1 - z\phi(T))}\right)\left(-\phi(T)\right) \Rightarrow N = \frac{\cancel{kT}\phi(T)}{(1 - z\phi(T))}\frac{1}{\cancel{kT}}z \Rightarrow \boxed{N = \frac{z\phi(T)}{(1 - z\phi(T))}}$$

$$U = kT^2 - \frac{1}{(1 - z\phi(T))}(-z)\phi'(T) \Rightarrow \boxed{U = \frac{zkT^2\phi'(T)}{1 - z\phi(T)}}$$