La energìa interna es funciòn de
paràmetros extensivos

$$E = E(S, V, N_1, N_2, \ldots, N_r)$$

a cada parámetro extensivo corresponde un parámetro intensivo

$$\left(\frac{\partial E}{\partial S}\right)_{V,N_1,\ldots,N_r} = T$$

$$\left(\frac{\partial E}{\partial V}\right)_{S,N_1,\ldots,N_r} = -P$$

$$\left(\frac{\partial E}{\partial N_j}\right)_{S,V,N_1\ldots,N_{j-1},N_{j+1},\ldots,N_r} = \mu_j$$

Diferencial total

$$dE = \left(\frac{\partial E}{\partial S}\right)_{V,N_1,\ldots,N_r} dS + \left(\frac{\partial E}{\partial V}\right)_{S.N_1,\ldots,N_r} dV + \sum_{j=1}^{r} \left(\frac{\partial E}{\partial N_j}\right)_{S,V,N_1,N_{j-1}.N_{j+1},\ldots.N_r} dN_j$$

$$dE = TdS - PdV + \sum_{j=1}^{r} \mu_j \, dN_j$$

N constante

$$dE = TdS - PdV = \delta Q + \delta W$$

un parámetro extensivo es una función homogénea de primer orden:

$$E(\lambda S, \lambda V, \lambda N) = \lambda E(S, V, N)$$

Si derivamos con respecto a lambda:

$$S\left(\frac{\partial E(\lambda S, \lambda V, \lambda N)}{\partial(\lambda S)}\right)_{V,N} + V\left(\frac{\partial E(\lambda S, \lambda V, \lambda N)}{\partial(\lambda V)}\right)_{S,N} + N\left(\frac{\partial E(\lambda S, \lambda V, \lambda N)}{\partial(\lambda N)}\right)_{S,V} = E(S, V, N)$$

si lambda = 1

$$E = S\left(\frac{\partial E}{\partial S}\right)_{V,N} + V\left(\frac{\partial E}{\partial V}\right)_{S,N} + N\left(\frac{\partial E}{\partial N}\right)_{S,V}$$

$$\boxed{E = TS - PV + \mu N}$$

Forma de Euler de la energía interna

$$E = E(S, V, N_1, \ldots, N_r)$$

Otras funciones de estado:

$$\boxed{dE = TdS - PdV + \sum_{j=1}^{r} \mu_j dN_j}$$

si se trabaja a presión constante:

$$H = H(S, P, N_1, \ldots, N_r) = E + PV = TS + \sum_{j=1}^{r} \mu_j N_j$$

$$\boxed{dH = TdS + VdP + \sum_{j=1}^{r} \mu_j dN_j}$$

a temperatura constante:

$$F = F(T, V, N_1, \ldots, N_r) = E - TS = -PV + \sum_{j=1}^{r} \mu_j N_j$$

$$\boxed{dF = -SdT - PdV + \sum_{j=1}^{r} \mu_j dN_j}$$

en química, se trabaja a menudo a
P y T constantes

$$G = G(T, P, N_1, \ldots, N_r) = E + PV - TS = \sum_{j=1}^{r} \mu_j N_j$$

$$\boxed{dG = -SdT + VdP + \sum_{j=1}^{r} \mu_j dN_j}$$

Gran Potencial:

$$\Psi = F - \mu N = -PV$$

$$\boxed{d\Psi = -SdT - PdV - Nd\mu}$$