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✓ * Some thermodynamical Potential

لِغَضِّ تَبَاقُصِ الدِّينَا مَكِينَةِ الْحَرَارَةِ

* Negative Temperature $T < 0$

درجۃ الحرارة سلبية مطلق

اصغر من الصفر مطلق!

كجيب و غريب ماعنى!

① Thermodynamical Potentials

$$dU = Tds - PdV + \mu dN$$

↑ ↑ ↑

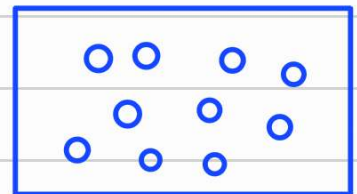
 work chemical potential.

Number of Particles

قانون الادل

$N=10$

→



$U(S, V, N)$ ← One of Thermodynamical Potentials
 الطاقة الداخلية
 Internal Energy
 Legendre Transformation
 القانون

$$F(T, V, N)$$

① $U(S, V, N) \longrightarrow F(T, V, N)$

الإنتروبيا
 مجموع
 تعداد

$$F(T, V, N) = U(S, V, N) - S \left. \frac{\partial U}{\partial S} \right|_{V, N}$$

② $F(T, V, N) = U(S, V, N) - S T$

Helmholtz

Free Energy

The Second

type of

Thermodynamical

Potential

$$dF = dU - dS T - S dT$$

$$= T ds - P dv + \mu dN - dS T - S dT$$

$$dF = -P dv + \mu dN - S dT \quad F(T, V, N)$$

$$dU = -P dv + \mu dN + T ds \rightarrow U(S, V, N)$$

Free Energy الطاقة الحرة

الحرارة

③ $H(S, P, N) = \text{Enthalpy}$

$$= U(S, V, N) - V \frac{\partial U}{\partial V} \Big|_{S=cts, N=cts}$$

$$U(S, V, N)$$

↓ ↓

④ $G(T, P, N) = U(S, V, N) - \underbrace{S \frac{\partial U}{\partial S}} - \underbrace{V \frac{\partial U}{\partial V}}$

Gibbs potential.

$$\textcircled{5} \quad \Phi(T, V, \mu) = U(S, V, N) - S \frac{\partial U}{\partial S} - N \frac{\partial U}{\partial N}$$

$\uparrow \quad \uparrow$
 $U(S, V, N)$

Grand Potential

$$\textcircled{6} \quad \mathcal{L}(T, P, \mu) = U(S, V, N) - S \frac{\partial U}{\partial S} - V \frac{\partial U}{\partial V} - N \frac{\partial U}{\partial N}$$

$\downarrow \quad \downarrow \quad \downarrow$
 $U(S, V, N)$

$= 0$

$$dU = T dS - P dV + \mu dN$$



$$S dT - V dP + N d\mu = 0$$



Gibbs-Duhem Relation

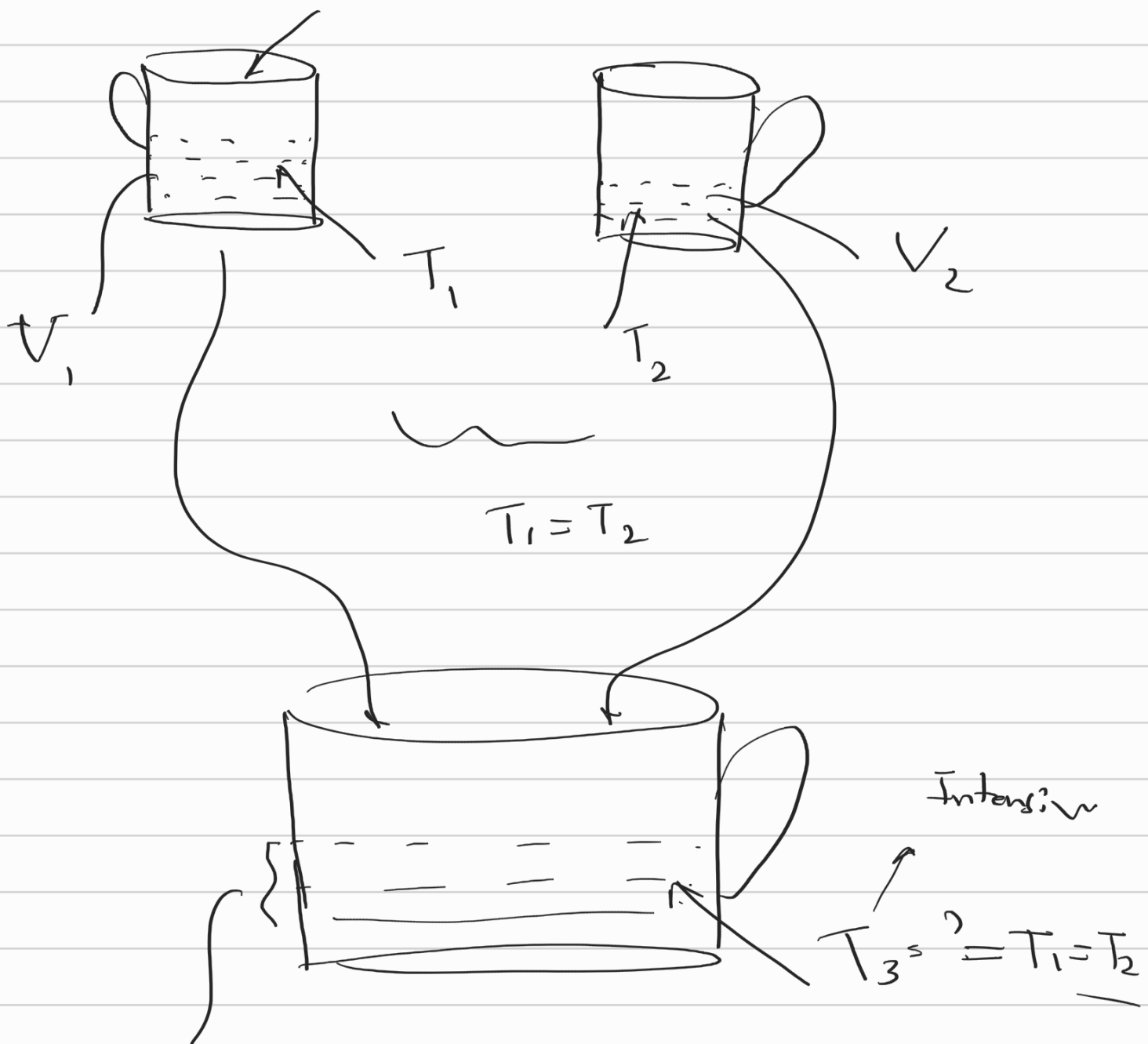
S : Extensive, T : Intensive

V : Extensive

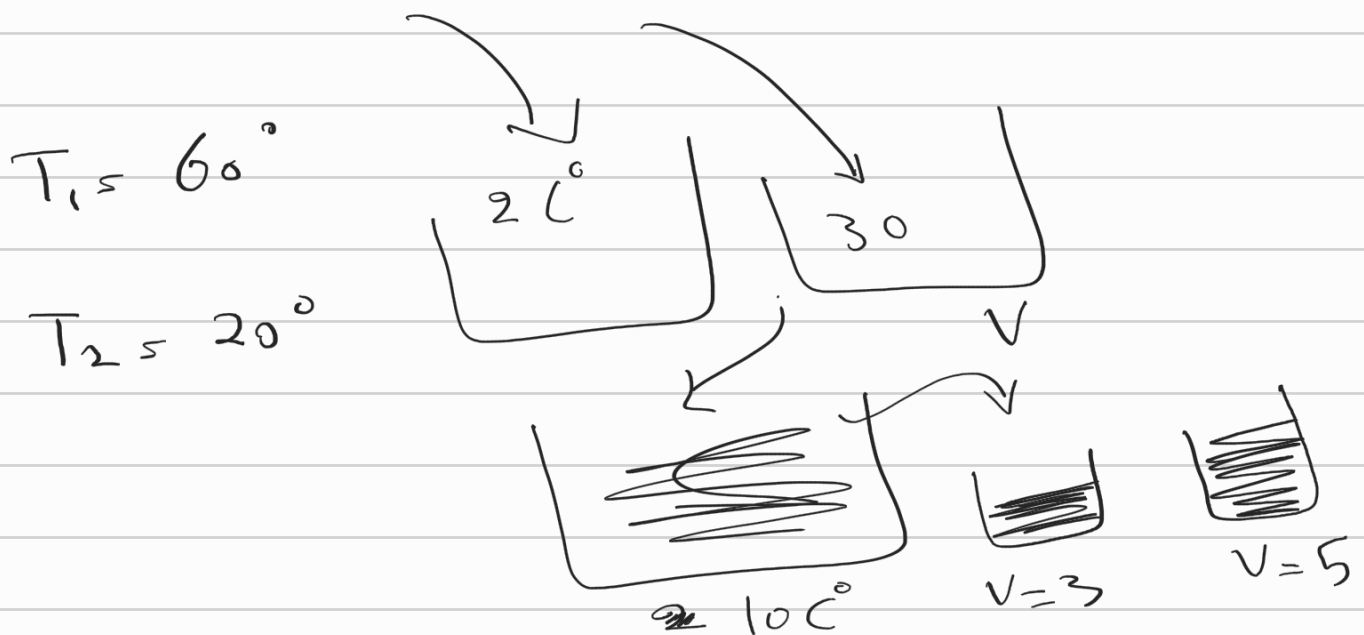
P : Intensive

N : Extensive

μ : Intensive.



$$V_3 = V_1 + V_2 \rightarrow \text{Extensive}$$



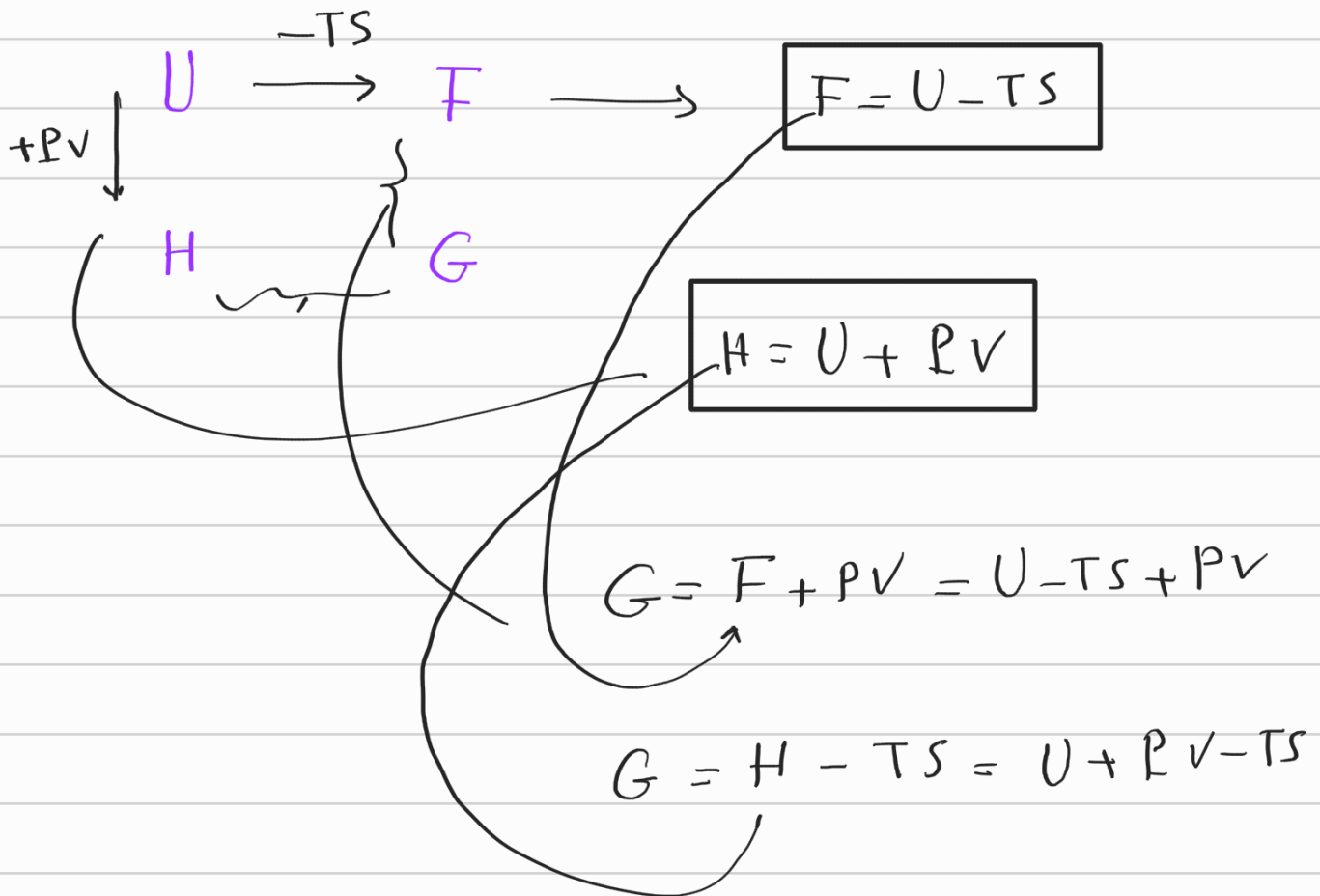
Summary

جمع نبدي

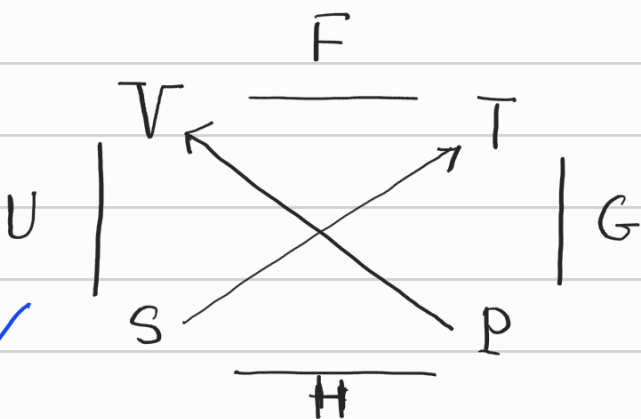
Rules For القواعد thermodynamics.

Maxwell Relation in thermodynamics

القاعدة الأولى (الاولى)



القاعدة الثانية



$$\frac{\partial U}{\partial S} = +T$$

$$\frac{\partial H}{\partial P} = +V$$

$$\frac{\partial H}{\partial S} = +T$$

$$\frac{\partial U}{\partial V} = -P$$

$$+\left.\frac{\partial P}{\partial S}\right|_V = -\left.\frac{\partial T}{\partial V}\right|_S \quad , \quad +\left.\frac{\partial P}{\partial S}\right|_V = +\left.\frac{\partial T}{\partial V}\right|_S$$