$$C_B = \left(\frac{\partial U}{\partial T}\right)_{N,B} = Nk \frac{(\mu B/kT)^2}{\cosh^2(\mu B/kT)}$$

$$\mu = \frac{eh}{4\pi m_e} = 9.27 \times 10^{-24}\ J/T$$

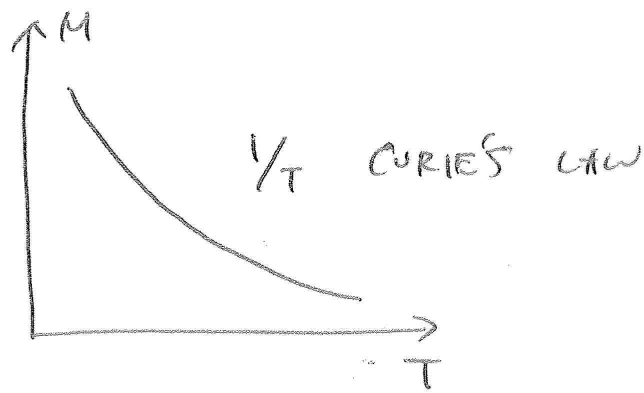
AT 1T $\mu B = 9.27 \times 10^{-24}\ J = 5.79 \times 10^{-5}\ eV$

$kT = 1/40$ @ RT

AS $x \to 0$ $\tanh x = x$

$$M = N\mu\left(\frac{\mu B}{kT}\right) = \frac{N\mu^2 B}{kT}$$

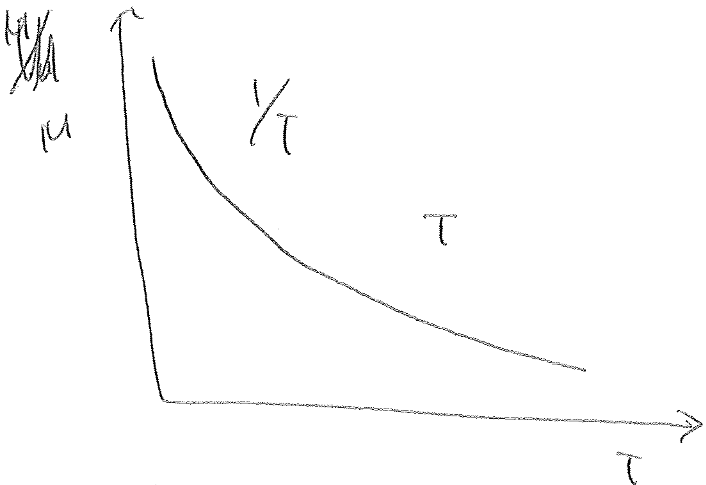
$M \sim \frac{1}{T}$

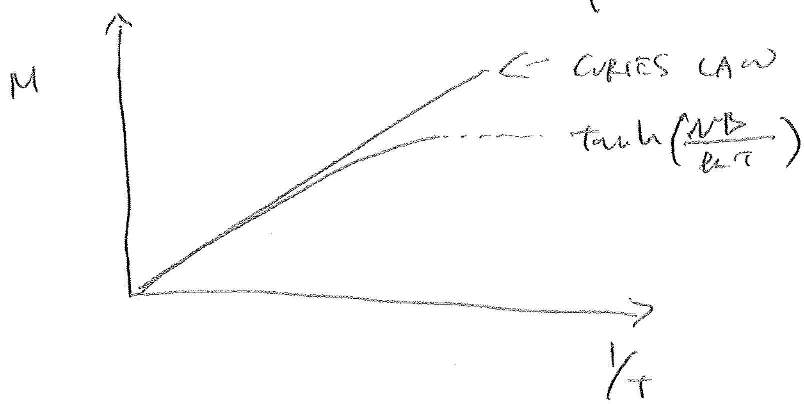


$x \to 0$

$$\cancel{C_B} = \cosh x = \frac{e^x + e^{-x}}{2} = \frac{1+x+(1-x)}{2} = 1$$

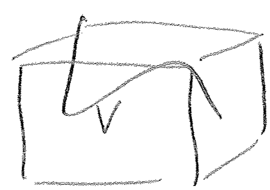
$$C_B = Nk\left(\frac{\mu B}{kT}\right)^2 = \frac{Nk\mu^2 B^2}{k^2 T^2} \sim \frac{1}{T^2}$$



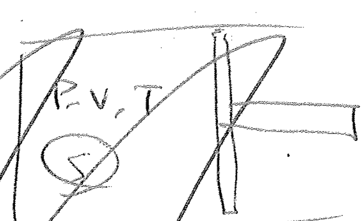


PV = nRT   S(
Ω KNOWN

$$\frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_V$$



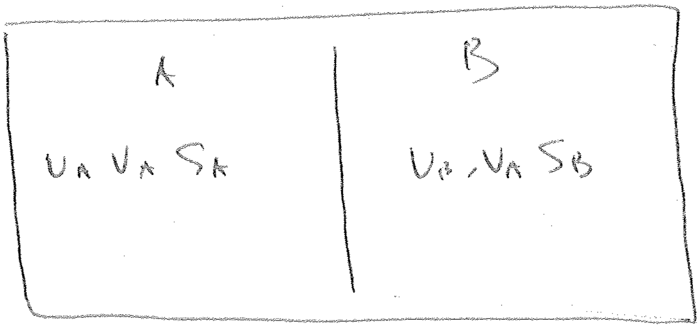
$$\frac{\partial S_{TOTAL}}{\partial U_A} \qquad \frac{\partial S}{\partial U_A} = 0$$



S(V, U)

$S_{\text{IDEAL GAS}} = Nk \ln V + \frac{3}{2} Nk \ln U + k\, n(N)$

IF N CONSTANT $\Rightarrow$ $S = S(U, V)$



AT EQUILIBRIUM

$P_A = P_B$

$T_A = T_B$

$PV = nRT$

$$\frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_V$$

$\partial U = T \partial S \,\big|_V$ $\qquad \Delta U = Q + W$

$PV =$ $\qquad 0 = TdS + pdV$

$$\frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_V$$

IF $S = S(U_A, V_A)$ THEN

$\frac{\partial S}{\partial V_A} = 0$ AT THERMAL EQUILIBRIUM

THEN BECAUS $\partial V_A = -\partial V_B$

$$\frac{\partial S_{\text{TOTAL}}}{\partial V_A} = \frac{\partial S_A}{\partial V_A} + \frac{\partial S_B}{\partial V_A} = \frac{\partial S_A}{\partial V_A} - \frac{\partial S}{\partial V_B}$$

$\frac{\partial S_A}{\partial V_A} = \frac{\partial S}{\partial V_B}$ AT THIS POINT

$$S = Nk \ln V + \frac{3}{2} Nk \ln U + k \ln f(N)$$

$$\frac{\partial S}{\partial V} = \frac{Nk}{V} = \frac{P\cancel{V}}{\cancel{V}T} \Rightarrow \boxed{P = T\left(\frac{\partial S}{\partial V}\right)_{U,N}}$$

TURNS OUT TO BE CORRECT

$$S = S(V, U)$$

$$dS = \left(\frac{\partial S}{\partial V}\right)_U dV + \left(\frac{\partial S}{\partial U}\right)_V dU$$

$$dS = \frac{1}{T} P\, dV + \frac{1}{T} dU$$

$$T dS = p dV + dU \Rightarrow \boxed{dU = T dS - p dV}$$

IF $dU = 0$ $\qquad \underline{T dS = p dV}$

$dU = Q + W$

~~Q~~ ~~$W = -pdV$~~ IF

$dU = Q + W$

$dU = TdS - pdV$

(i.e. IF $W = -pdV$)

IF WORK IS DONE QUASI STATICALLY THEN

$W = -pdV$

$dU = TdS = Q$

$$dS = \frac{Q}{T}$$

A LITER OF WATER IS BOILED AT 100 °C

HEAT ADDED = 2200 kJ

$$\Delta S = \frac{2260\,\text{kJ}}{373\,\text{K}} = 6060\ \text{J/K}$$

ISOTHERMAL : SAME TEMPERATURE

ADIABATIC : NO HEAT FLOWS OUT

QUASISTATIC : $W = -p\,dV$ i.e. PRESSURE HAS TIME TO RESPOND TO CHANGE IN VOLUME

$$\frac{1}{T} = \left(\frac{\partial S}{\partial U}\right)_{V,N}$$

$$\frac{p}{T} = \left(\frac{\partial S}{\partial V}\right)_{U,N}$$

BUT

$$S(V,U,N) = Nk \ln V + \frac{3}{2} Nk \ln U + f(N)$$

$$\left(\frac{\partial S}{\partial N}\right)_{V,U} ?$$