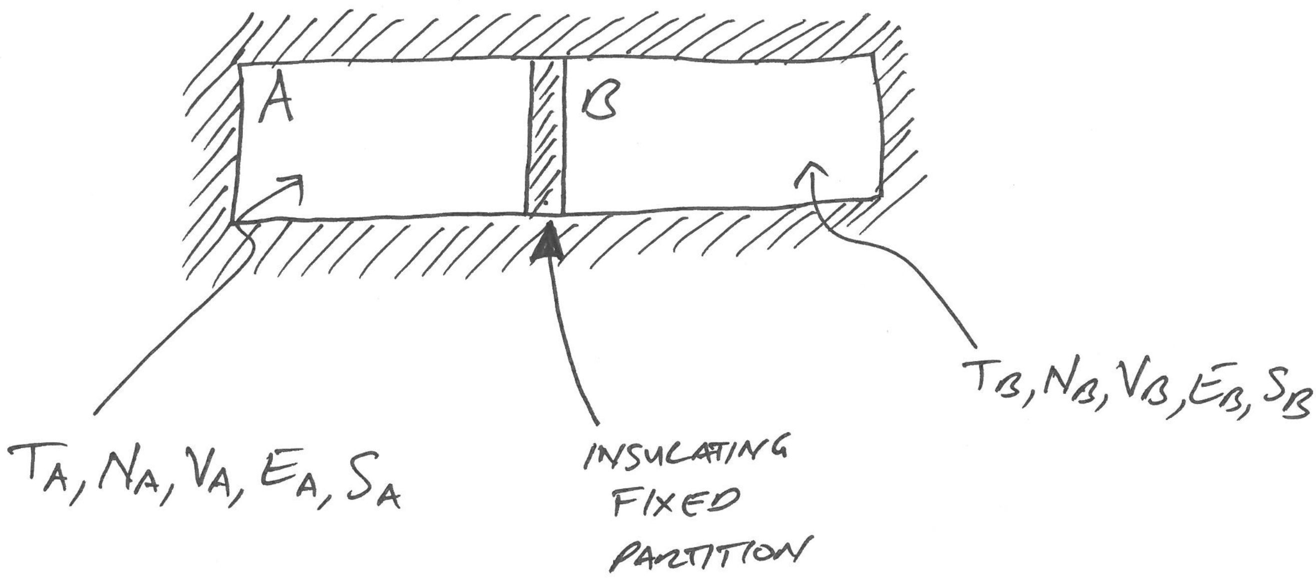
DIRECTION OF HEAT FLOW IN AN ISOLATED SYSTEM

CONSIDER AN ISOLATED SYSTEM WHICH CONSISTS OF TWO SUBSYSTEMS A & B



SUPPOSE WE MAKE THE PARTITION CONDUCTING AND AN AMOUNT OF HEAT SPONTANEOUSLY FLOWS FROM B TO A (BUT N_A, V_A, N_B & V_B ALL REMAIN FIXED).

<u>NOTE</u>: $E_{TOTAL} = E_A + E_B = \text{CONSTANT}$

$$\Rightarrow \quad dE_{TOTAL} = dE_A + dE_B = 0$$

$$\Rightarrow \quad \boxed{dE_B = -dE_A} \quad (*)$$

WE ARE ASSUMING $dE_A > 0$

<u>ALSO NOTE</u>:

$$S_{TOTAL} = S_A + S_B$$

$$\left.\begin{aligned} S_A &= S_A(E_A, V_A, N_A) \\ S_B &= S_B(E_B, V_B, N_B) \end{aligned}\right\} \quad N_A, N_B, V_A, V_B \text{ ALL FIXED}$$

$$\Rightarrow \quad dS_{TOTAL} = dS_A + dS_B$$

BUT FOR AN ISOLATED SYSTEM, FOR SPONTANEOUS CHANGE TO OCCUR WE REQUIRE THE TOTAL ENTROPY TO INCREASE

$$dS_{TOTAL} > 0$$

$$\Rightarrow \quad dS_A + dS_B > 0$$

$$\Rightarrow \quad \frac{\partial S_A}{\partial E_A} dE_A + \frac{\partial S_B}{\partial E_B} dE_B > 0$$

$$\xrightarrow{(*)} \quad \left(\frac{\partial S_A}{\partial E_A} - \frac{\partial S_B}{\partial E_B} \right) dE_A > 0$$

AND FOR $dE_A > 0$

$$\Rightarrow \quad \boxed{\frac{\partial S_A}{\partial E_A} > \frac{\partial S_B}{\partial E_B}} \quad (**)$$

BUT RECALL

$$\boxed{\frac{\partial S}{\partial E} = \frac{1}{T}}$$

So (**) BECOMES

$$\frac{1}{T_A} > \frac{1}{T_B}$$

$$\Longrightarrow \quad \boxed{T_B > T_A}$$

ie FOR ENERGY TO FLOW AS HEAT FROM B TO A SPONTANEOUSLY $T_B > T_A$.

WHEN THE TEMPERATURES BECOME EQUAL $T_A = T_B$, NO FURTHER INCREASE IN ENTROPY IS POSSIBLE

$\Longrightarrow$ HEAT FLOW STOPS

$\Longrightarrow$ EQUILIBRIUM IS ESTABLISHED