Dr. Usha Kumari
physics

MJC III
& MIC III

Date 24/10/24

ZEROTH LAW OF THERMODYNAMICS

If two systems are separately in thermal equilibrium with a third system, then they are also in thermal equilibrium with one another.

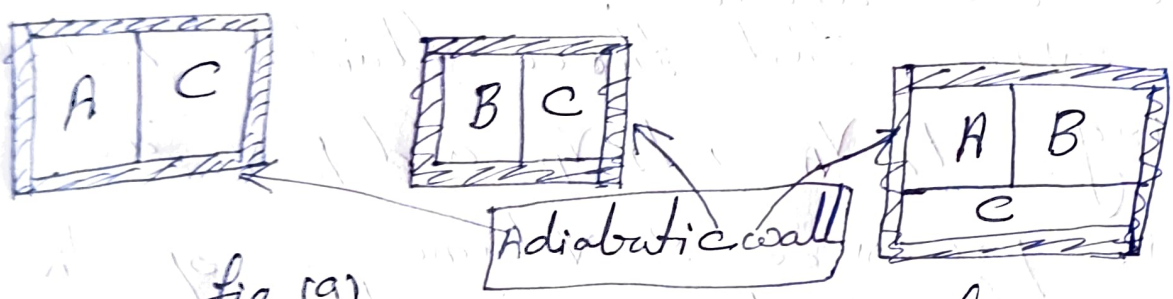

Fig (a)

Fig B.

Let us suppose that three systems A, B and C at temperatures T_A, T_B and T_C respectively. The system A and B are ~~also~~ individually in equilibrium with the system C. That means

$$T_A = T_C \quad \text{---------- (1)}$$

and

$$T_B = T_C \quad \text{---------- (2)}$$

Comparing equn (1) & (2) we have

$$T_A = T_B$$

This shows that the system A & B

are also in thermal equilibrium with each other.

Conversely the Law can be stated as follows :-

If three or more systems are in thermal contact each to each, by means of diathermal walls and are all in thermal equilibrium together, then any two systems taken separately are in thermal equilibrium with one another.

Let us suppose that three fluids A, B, C having $P_A V_A$, $P_B V_B$ and $P_C V_C$ are their pressure & volume respectively then if A & B are in thermal equilibrium,

$$\phi_1 (P_A V_A) = \phi_2 (P_B V_B)$$

or $$F_1 (P_A, V_A, P_B, V_B) = 0 \quad \text{——— (i)}$$

$$P_B = f_1 (P_A, V_A, V_B) \quad \text{——— (ii)}$$

If B & C are in thermal equilibrium

$$\phi_2 (P_B, V_B) = \phi_3 (P_C V_C)$$

or $$F_2 (P_B, V_B, P_C, V_C) = 0$$

$$P_B = f_2 (V_B, P_C, V_C) \quad \text{——— (iii)}$$

from eqn (ii) & (iii) for A & C to be in thermal equilibrium separately,

$$f_1(P_A, V_A, V_B) = f_2(V_B, P_C, V_C) \quad \text{---(iv)}$$

If A & C are in thermal equilibrium with B seperately, then according to the zeroth law, A & C are also in thermal equilibrium with one another. ---(v)

$$\therefore f_3(P_A, V_A, P_C, V_C) = 0$$

from eqn (iv) & (v) ---(vi)

$$\phi_1(P_A V_A) = \phi_3(P_C, V_C)$$

In general $\phi_1(P_A, V_A) = \phi_2(P_B, V_B) = \phi_3(P_C, V_C)$ ---(vii)

These three functions have the same numerical value though the parameters (P, V) of each are different. This numerical value is termed as temperature(T) of the body

$$\therefore \phi(P,V) = T \quad \text{---(viii)}$$

Let T_A, T_B & T_C are temp of three system A, B & C, & if A & C and B & C are in thermal equilibrium with each other then

$$T_A = T_C \quad \text{---(ix)}$$

$$T_B = T_C \quad \text{---(x)}$$

Hence $T_A = T_B$ ---(xi)

i.e systems A & B are also in thermal equilibrium with each other.

---x---