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B.Sc. Part II

Paper IV

Current electricity

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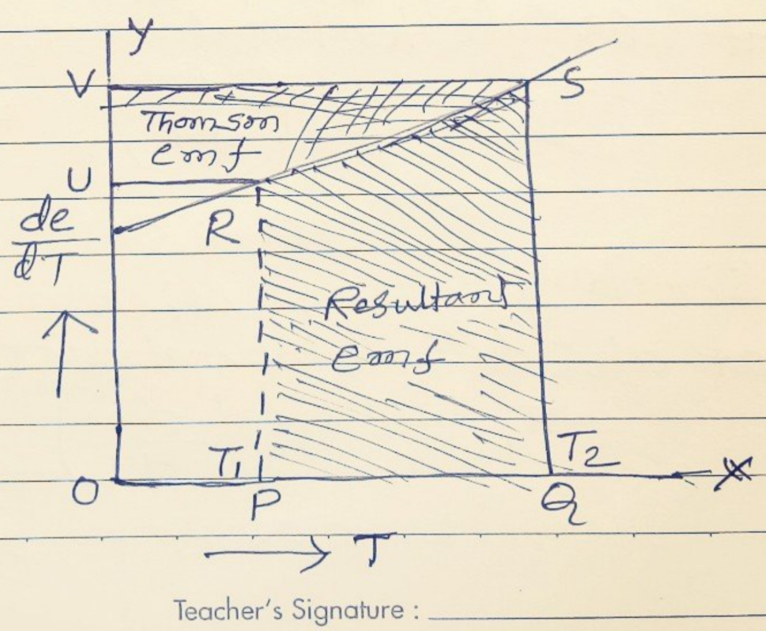
Current electricity.

A diagram indicating the change in potential difference for a fixed difference of temperature between different metals at different temperatures. It is laid out with rectangular coordinates. On one axis temperatures are laid off generally on the axis of abscissas. On the other axis potential differences are marked. Different lines are then drawn, one for each metal, which show the potential difference, say that one degree Centigrade difference of temp. between their junctions produced at the different temperatures marked on the axis of abscissas.

A graph plotted between the thermo-electro power de/dT and the temperature T of the junction is usually a straight line, called the thero-electric diagram or thermo-electric power line.

To construct the thermoelectric diagram for a metal for the thermocouple because Thomson coefficient for lead is zero.



Thermoelectric diagram for Copper wi[th] respect to lead is as shown in figure. We ca[n] represent the total Thermoelectric e.m.f. E, and the e.m.f.'s due to Peltier and the Thomson effect as follows:

1.) Total or resultant Thermo-electric e.m.f.:-

The resultant or total e.m.f. set up in a Thermo-couple with junction at absolute temperatures T_1 and T_2, is given by

$$e = \int_{T_1}^{T_2} \frac{de}{dT} \cdot dT.$$

This integral is the area RSQP below the Thermo-electric diagram between the readings corresponding to T_1 and T_2. The area RSQP thus represents the resultant e.m.f. in the thermo-couple.

(ii) E.M.F. due to Peltier effect:-

The Peltier e.m.f. at the hot junction at absolute temperature T_2 is given by

$$\Pi_2 = T_2 \left(\frac{de}{dT}\right)_{T_2}$$

$$= OQ \times SQ = \text{area } OQSV$$

Similarly, the Peltier e.m.f. at the cold junction at absolute temperature T_1 is given by

$$\Pi_1 = T_1 \left(\frac{de}{dT}\right)_{T_1}$$

$$= OP \times RP = \text{area } OPRU$$

$\therefore$ e.m.f. developed due to Peltier effect

$$= \pi_2 - \pi_1$$

= area OQSV − area OPRU

= area VSQPRU

3) E.M.F. due to Thomson effect :–

The e.m.f. due to Tomson effect corresponding to temperature T_1 and T_2 is $\int_{T_1}^{T_2} (\sigma_a - \sigma_b) dT$

$$= \int_{T_1}^{T_2} T \frac{d^2e}{dT^2} \cdot dT \qquad \left[\because (\sigma_a - \sigma_b) = T \frac{d^2e}{dT^2}\right]$$

$$= \int_{T_1}^{T_2} T \frac{dP}{dT} dT$$

where $P = \frac{de}{dT}$ and $\frac{dP}{dT}$ is the rate of change of Thermo electric Power with temp.

Hence Thomson e.m.f. $\int_{T_1}^{T_2} T \frac{dP}{dT} dT = \int_{P_1}^{P_2} T dP$

The area VSRU thus represents the Thomson e.m.f.

Thus all the component e.m.f.'s in a Thermo couple may be represented on a Thermo-electric diagram. From the diagram.

Area RSQP = area VSQPRU − area VSRU

i.e. $e = (\pi_2 - \pi_1) - \int_{T_1}^{T_2} (\sigma_a - \sigma_b) dT$