

Notes for B.Sc. Part-I Paper - 2nd By Dr. Bharat Singh Deptt of Physics

"Absolute scale of temperature"

The efficiency of reversible Carnots engine depends only upon the two temperatures between which it works and is independent of the properties of the working substance. Thus there is a property which absolutely depends on temperature and on nothing else. Hence if a temperature scale is defined utilizing this property of working of Carnots engine, it is an absolute scale of temperature. Because it does not depend upon the particular property of any substance as in the case of other thermometric scales. Lord Kelvin worked out the theory of such an absolute scale, called the kelvins work and showed that it agrees with the ideal gas scale.

Theory: - Suppose a reversible engine takes in a quantity of heat Q1 at temperature T1 and rejects a quantity of heat Q2 at temp T2, then since the efficiency of the engine is a function of these two temperatures.

eta = 1 - Q2/Q1 = f(T1, T2)

Q1/Q2 = 1 / (1 - f(T1, T2)) = F(T1, T2) ----- (1)

Similarly if the reversible engine works between a pair of temperature T2 and T3 (T2 > T3) absorbing a heat Q2 and rejecting Q3, we have

Q2/Q3 = F(T2, T3) ----- (2) Also if it works between T1 and T3 (T1 > T3) then Q1/Q3 = F(T1, T3) ----- (3)

Multiplying eq. (1) and (2) we have,

(Q1/Q2) * (Q2/Q3) = Q1/Q3 = F(T1, T2) * F(T2, T3)

Comparing this equation with equation (3) we have (P.T.O)

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$$F(\theta_1, \theta_3) = F(\theta_1, \theta_2) \times F(\theta_2, \theta_3) \quad \text{---} \rightarrow \textcircled{4}$$

Called the functional equation. It does not contain θ_2 on the left-hand side. Therefore function F should be so chosen that θ_2 disappears from the right-hand side also. This is

Possible if

$$F(\theta_1, \theta_2) = \frac{\phi(\theta_1)}{\phi(\theta_2)} \quad \text{and} \quad F(\theta_2, \theta_3) = \frac{\phi(\theta_2)}{\phi(\theta_3)}$$

where ϕ is another unknown function of temperature.

for this equation $\textcircled{4}$ gives -

$$F(\theta_1, \theta_3) = \frac{\phi(\theta_1)}{\phi(\theta_2)} \times \frac{\phi(\theta_2)}{\phi(\theta_3)} = \frac{\phi(\theta_1)}{\phi(\theta_3)}$$

Equation $\textcircled{1}$ can now be written as -

$$\frac{Q_1}{Q_2} = F(\theta_1, \theta_2)$$

$$\propto \frac{Q_1}{Q_2} = \frac{\phi(\theta_1)}{\phi(\theta_2)}$$

since $\theta_1 > \theta_2$ and $Q_1 > Q_2$, the function $\phi(\theta_1) > \phi(\theta_2)$
 Thus function $\phi(\theta)$ is a linear function of θ and can be used to measure temperature. If we suppose that $\phi(\theta)$ represents a temperature T (some multiple of θ) on a new scale, then -

$$\frac{Q_1}{Q_2} = \frac{T_1}{T_2} \quad \text{---} \rightarrow \textcircled{5}$$

This equation $\textcircled{5}$ defines the Kelvin's absolute thermodynamic scale of temperature.

The ratio of any two temperatures on this scale is equal to the ratio of the heats absorbed and rejected by a Carnot reversible engine working between these two temperatures and hence this scale is known as absolute scale of temperature.