Thermodynamics (ESC-S202)

Lecture- 6

The Zeroth Law Of Thermodynamics

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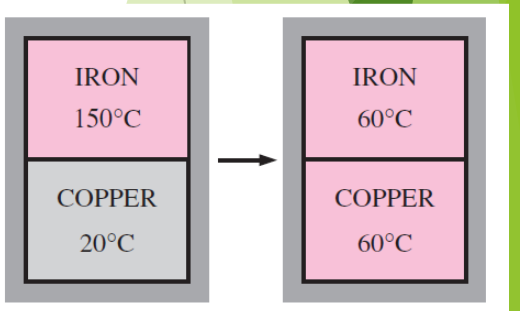
Temperature

- We are familiar with temperature as a measure of “hotness” or “coldness”.
- Based on our physiological sensations, we express the level of temperature qualitatively with words like freezing cold, cold, warm, hot, and red-hot.

Thermal Equilibrium

- When a body is brought into contact with another body that is at a different temperature, heat is transferred from the body at higher temperature to the one at lower temperature until both bodies attain the same temperature.

- At that point, the heat transfer stops, and the two bodies are said to have reached thermal equilibrium. The equality of temperature is the only requirement for thermal equilibrium.



Two bodies reaching thermal equilibrium after being brought into contact in an isolated enclosure.

Zeroth Law of Thermodynamics

- If two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other.
- It serves as a basis for the validity of temperature measurement.

Thermometric Property

- In order to obtain a quantitative measure of temperature, a reference body is used , and a certain physical characteristics of this body which changes with temperature is selected. The changes in the selected characteristic may be taken as an indication of changes in temperature. The selected characteristic is called the thermometric property.

Thermometer

- The reference body which is used in the determination of temperature is called the thermometer.

Types of Thermometer

S. No.	Thermometer	Thermometric Property	Symbol
1.	Constant volume gas thermometer	Pressure	p
2.	Constant pressure gas thermometer	Volume	V
3.	Electric resistance thermometer	Resistance	R
4.	Thermocouple	Thermal e.m.f.	Ɛ
5.	Mercury in glass thermometer	Length	L

Temperature Measurement with two fixed points (Before 1954)

- Before 1954 there were two fixed points:

(i) The ice point

(ii) The steam point

$$\theta(X) = \frac{\theta(X_1) - \theta(X_2)}{X_1 - X_2} X$$

Where

$\theta(X)$ = temperature to be measured at X thermometric property.

$\theta(X_1)$=standard system temperature at X_1 thermometric property.

$\theta(X_2)$= standard system temperature at X_2 thermometric property.

- Limitations of this Method

(i) The difficulty of achieving equilibrium between pure ice and air standard water.

(ii) Extreme sensitiveness of the steam point to the change in pressure.

Temperature Measurement with Single fixed points (After 1954)

- Since 1954, only one fixed point has been in use: the triple point of water.
- Triple point is a state at which ice, liquid water and water co-exist in equilibrium.
- Triple point of water=273.16 K.

$$\theta = 273.16 \frac{X}{X_t}$$

Where

- θ= temperature to be measured at X thermometric property.
- X_t= thermometric property at triple point temperature.

- The temperature of the triple point of water, which is an easily reproducible state, is now the standard fixed point of thermometry.

Thermometers

1.	**Constant volume gas thermometer**	$\theta = 273.16 \frac{p}{p_t}$
2.	Constant pressure gas thermometer	$\theta = 273.16 \frac{V}{V_t}$
3.	Electric resistance thermometer	$\theta = 273.16 \frac{R}{R_t}$
4.	Thermocouple	$\theta = 273.16 \frac{\varepsilon}{\varepsilon_t}$
5.	Liquid in glass thermometer	$\theta = 273.16 \frac{L}{L_t}$

Problem for Practice

Q.1 The limiting value of the ratio of the pressure of gas at the steam point and at the triple point of water when the gas is kept at constant volume is found to be 1.36605. What is the ideal gas temperature of the steam point?