Module

2

Lecture
1

Asansol Engineering College
Department of Mechanical Engineering

Thermodynamics

Temperature and Zeroth Law of Thermodynamics

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Contents:

- Temperature
- Definition of Thermal equilibrium and Zeroth law
- Temperature scales
- Various Thermometers
- First Law for Cyclic & Non-cyclic processes
- Concept of total energy E
- Various modes of energy, Internal energy and Enthalpy

Objectives:

- To learn about temperature
- To understand thermal equilibrium and zeroth law of thermodynamics
- To learn about thermometer scales and various thermometers
- To understand first law for cyclic & non-cyclic processes
- To learn total energy and various modes of energy, internal energy and enthalpy

Outcomes: After completing this course,

- the students will be able to understand about temperature
- will be able to understand thermal equilibrium and zeroth law of thermodynamics
- can solve problems related to thermometers
- will understand first law for cyclic & non-cyclic processes
- can solve problems related to first law for cyclic & non-cyclic processes

Temperature and Zeroth Law of Thermodynamics

- Temperature is a measure of “hotness” or “coldness,” it is not easy to give an exact definition for it.
- Based on our physiological sensations, we express the level of temperature qualitatively with words like *freezing cold*, *cold*, *warm*, *hot*, and *red-hot.*
- However, we cannot assign numerical values to temperatures based on our sensations alone.
- Furthermore, our senses may be misleading. A metal chair, for example, will feel much colder than a wooden one even when both are at the same temperature.
- several properties of materials change with temperature in a *repeatable* and *predictable* way, and this forms the basis for accurate temperature measurement.

- The commonly used mercury-in-glass thermometer, for example, is based on the expansion of mercury with temperature.
- Temperature is also measured by using several other temperature-dependent properties.
- It is common experience that 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.

Zeroth Law of Thermodynamics

- The **zeroth law of thermodynamics** states that 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.
- By replacing the third body with a thermometer, the zeroth law can be restated as *two bodies are in thermal equilibrium if both have the same temperature reading even if they are not in contact*.
- The zeroth law was first formulated and labeled by R. H. Fowler in 1931.
- As the name suggests, its value as a fundamental physical principle was recognized more than half a century after the formulation of the first and the second laws of thermodynamics.
- It was named the zeroth law since it should have preceded the first and the second laws of thermodynamics.

Explanation of Zeroth Law:

Let us say Ta, Tb and Tc are the temperatures of bodies A,B and C respectively.

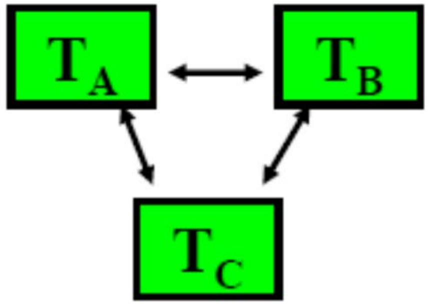
A and C are in thermal equilibrium. Ta=Tc

B and C are in thermal equilibrium. Tb=Tc

By Zeroth law,

A and B will also be in thermal equilibrium ie Ta=Tb

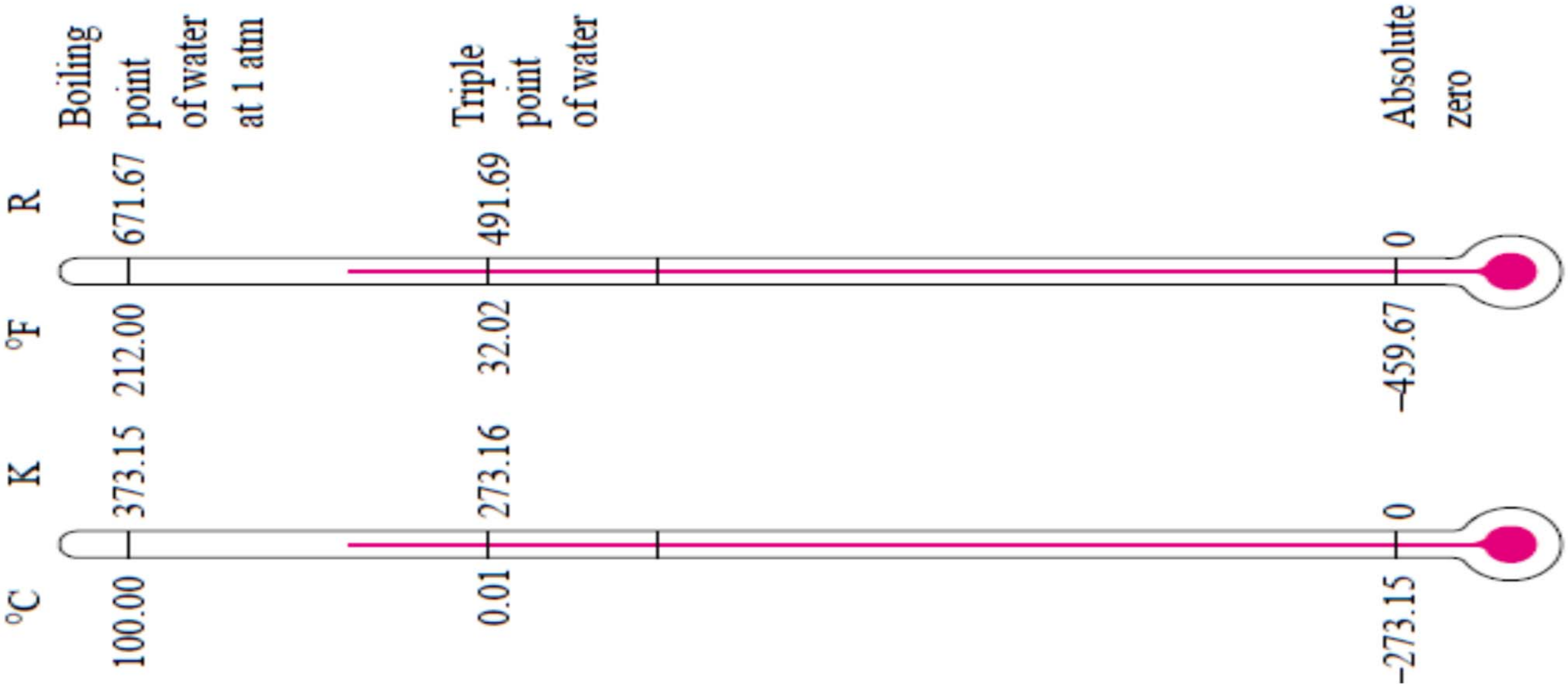
All temperature measurements are based on this LAW



Temperature Scales

- Temperature scales enable us to use a common basis for temperature measurements, and several have been introduced throughout history.
- All temperature scales are based on some easily reproducible states such as the freezing and boiling points of water, which are also called the *ice point* and the *steam point*, respectively.
- A mixture of ice and water that is in equilibrium with air saturated with vapor at 1 atm. pressure is said to be at the ice point, and a mixture of liquid water and water vapor (with no air) in equilibrium at 1 atm. pressure is said to be at the steam point.

- The temperature scales used in the SI and in the English system today are the *Celsius scale* and the *Fahrenheit scale* respectively.
- On the Celsius scale, the ice and steam points are assigned the values of 0 and 100C, respectively. The corresponding values on the Fahrenheit scale are 32 and 212F.
- These are often referred to as *two-point scales* since temperature values are assigned at two different points.



- In thermodynamics, it is very desirable to have a temperature scale that is independent of the properties of any substance or substances. Such a temperature scale is called a *thermodynamic temperature scale*, which is based on second law of thermodynamics.
- The thermodynamic temperature scale in the SI is the *Kelvin scale*, named after Lord Kelvin (1824–1907). The temperature unit on this scale is the *kelvin*, which is designated by K (not °K).
- The lowest temperature on the Kelvin scale is 0 K.
- Using nonconventional refrigeration techniques, scientists have approached absolute zero kelvin (they achieved 0.000000002 K in 1989).
- The Kelvin scale is related to the Celsius scale by

$$T(\mathrm{K}) = T(\mathrm{C}) + 273.15$$

- The thermodynamic temperature scale in the English system is the *Rankine scale*, named after William Rankine. The temperature unit on this scale is the *Rankine*, which is designated by R.
- The Rankine scale is related to the Fahrenheit scale by

$$T(\mathrm{R}) = T(\mathrm{F}) + 459.67$$

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Thank You