Chapter 10: Thermal Physics

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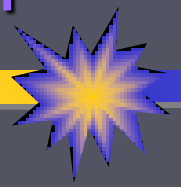
- 10.1. Temperature and the Zeroth law of Thermodynamics
- 10.2. Thermometers and Temperature Scales
- 10.3. Thermal Expansions of Solids and Liquids

Temperature and the Zeroth law of Thermodynamics

Temperature

- A basic physical quantity
- Measure the degree of hotness of a body
- Measure by an instrument called thermometer

But, Understanding the concept of Temp. requires understanding Thermal contact and thermal equilibrium



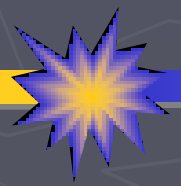
Temperature and the Zeroth law of Thermodynamics

Two objects in **Thermal contact** if energy can exchanged between them due to differences in there temperatures called Heat.

A cup of coffee and a cube of Ice.

Two objects in **Thermal equilibrium** if they are in thermal contact and there is no net exchange of energy.

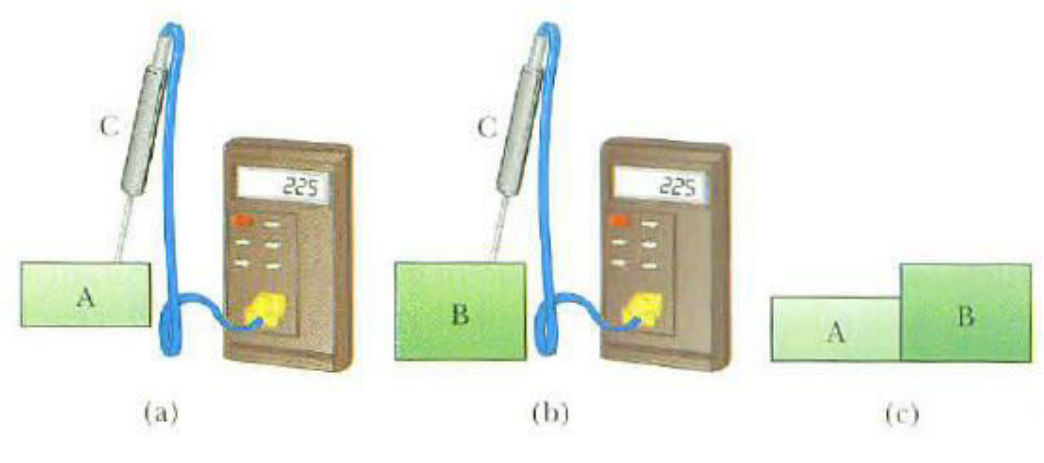
Upon these ideas, Thermometer was developed to measure the temperature.



Temperature and the Zeroth law of Thermodynamics

The Zeroth law of Thermodynamic

If objects A and B are seperately in thermal equilibrium with a third object C, Then A and B are in thermal equilibrium with each other.

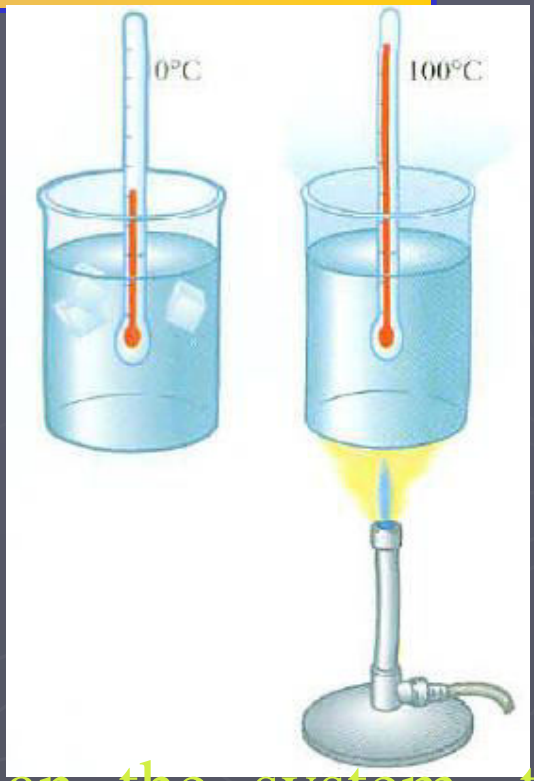


Two objects in thermal equilibrium if they are at the same Temperature

Thermometers and Temperature Scales

Thermometers are devices used to measure the temperature of an object or a system.

When a thermometer is in thermal contact with a system, energy is exchanged until the thermometer and the system are in thermal equilibrium



Thermometer must be much smaller than the system, the energy gains or loses does not significantly affect the energy of the system

Thermometers

All thermometers make use of some physical property that changes with temperature:

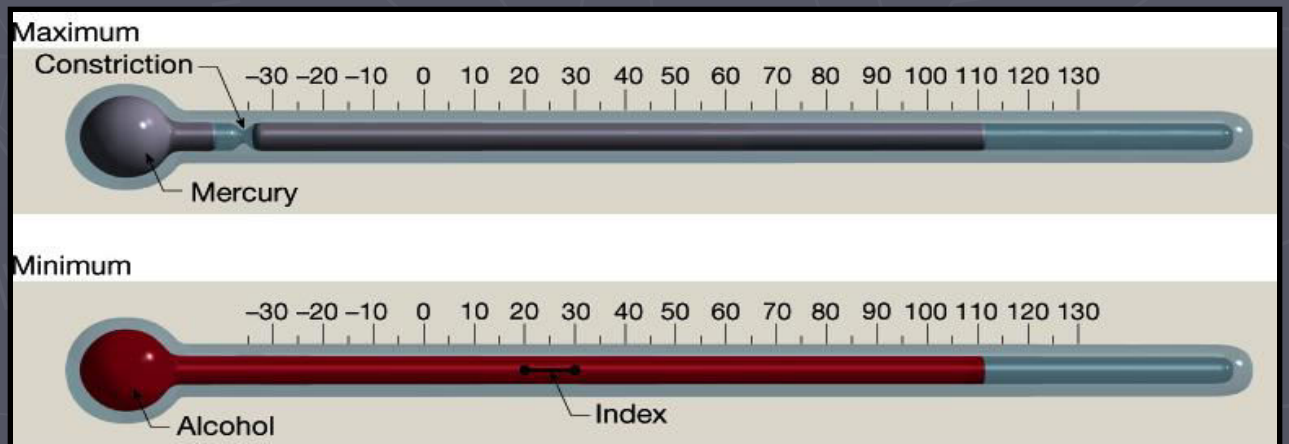
- Volume of a liquid
- Length of a solid
- Pressure of a gas held at constant volume
- Volume of a gas held at constant pressure
- Electric resistance of a conductor
- Color of a very hot object

Different type of thermometers

- liquid-in-glass thermometer
  - mercury-in-glass
  - alcohol-in-glass
  - Why not use water ???

Liquid-in-glass thermometer

- Liquid-in-glass thermometer
  - Capillary tube ensure that a small change in volume causes a large change in length
  - Alcohol
    - range –115°C to 78°C
  - Mercury
    - range –39°C to 357°C



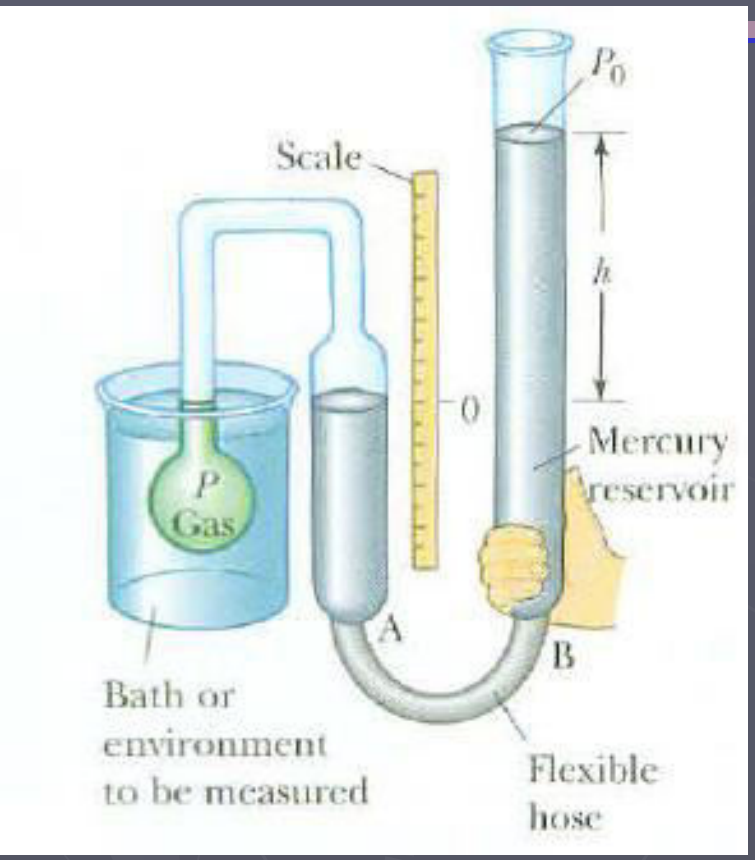
Mercury-in-glass thermometer

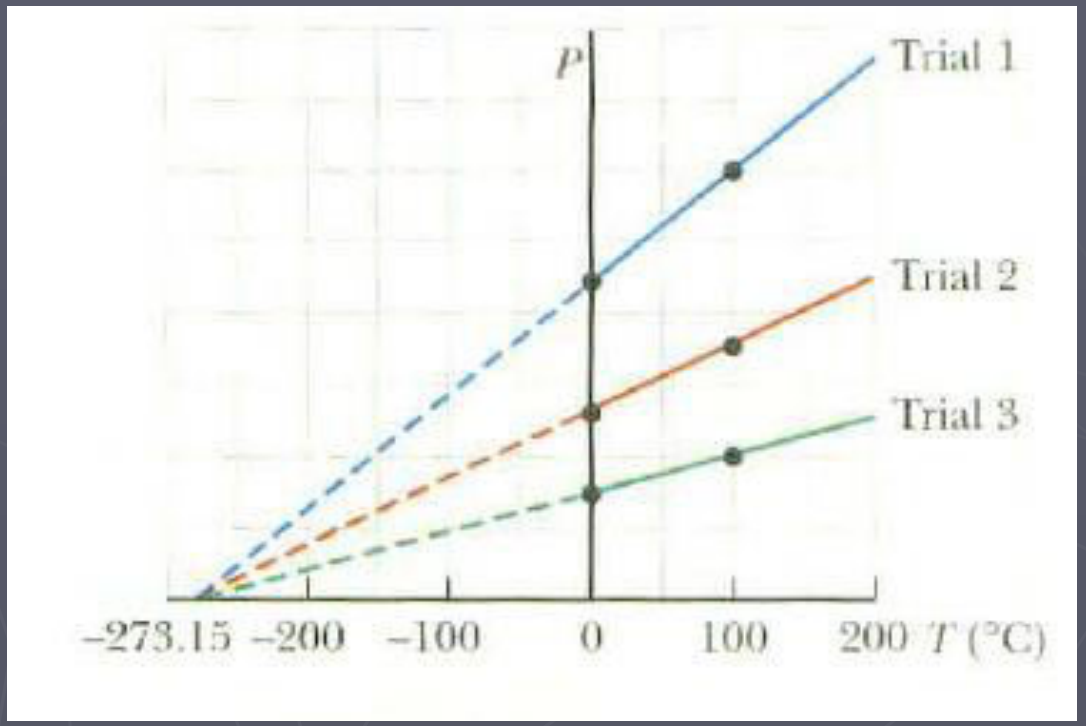
- Advantages
  - Expands evenly on heating
  - Responds quickly to temperature
  - A high boiling point, so used in hot places
- Disadvantages
  - Poisonous
  - Expensive
  - A high freezing point, so not used in cold places

Alcohol-in-glass thermometer

- Advantages
  - Expand evenly on heating
  - A low freezing point, so used in very cold places
  - It is safe
  - It is cheap
- Disadvantages
  - It is dyed
  - It wet the tube
  - A low boiling point, so not used in hot places

Constant volume gas thermometer





$$T_C = T - 273.15$$

Absolute zero temperature

-273.15 ºC

Celsius, Kelvin and Fahrenheit Tem. Scales

The relationship between Fahrenheit and Celsius scales:

$$T_F = \frac{9}{5}T_C + 32$$

OR:

$$T_C = \frac{5}{9}(T_F - 32)$$

The relationship between Kelvin and Celsius scales:

$$T_C = T - 273.15$$

The change in Celsius is equal to the change in Kelvin,. While the change in Celsius and Fahrenheit is

$$\Delta T_F = \frac{9}{5}\Delta T_C$$

Thermal Expansions of Solids and Liquids

As the temperature of a substance increases its volume increases, This phenomenon known as Thermal expansion.

Thermal expansion occurs due to the change in the average seperation between the atoms or molecules of a substance.

Linear Expansion:

$$\Delta L = \alpha L_0 \Delta T$$

$$L - L_0 = \alpha L_0 (T - T_0)$$

Area Expansion:

$$\Delta A = A - A_0 = \gamma A_0 \Delta T$$

Volume Expansion:

$$\Delta V = \beta V_0 \Delta T$$

Thermal Expansions of Solids and Liquids

TABLE 10.1

Average Coefficients of Expansion for Some Materials Near Room Temperature

Material	Average Coefficient of Linear Expansion $[(^\circ C)^{-1}]$	Material	Average Coefficient of Volume Expansion $[(^\circ C)^{-1}]$
Aluminum	24×10^{-6}	Ethyl alcohol	1.12×10^{-4}
Brass and bronze	19×10^{-6}	Benzene	1.24×10^{-4}
Copper	17×10^{-6}	Acetone	1.5×10^{-4}
Glass (ordinary)	9×10^{-6}	Glycerin	4.85×10^{-4}
Glass (Pyrex®)	3.2×10^{-6}	Mercury	1.82×10^{-4}
Lead	29×10^{-6}	Turpentine	9.0×10^{-4}
Steel	11×10^{-6}	Gasoline	9.6×10^{-4}
Invar (Ni-Fe alloy)	0.9×10^{-6}	Air	3.67×10^{-3}
Concrete	12×10^{-6}	Helium	3.665×10^{-3}