TEMPERATURE

Definitions

1) **Temperature** refers to how hot or cold an object is, relative to a standard scale.
2) **Heat** refers to the amount of thermal energy that is being transferred from a hotter region to a colder region.
3) A **thermometric property** is a physical property that varies *continuously* with temperature.
4) The **ice point** is the temperature of pure melting ice at *one atmosphere*, and assigned a value of 0 ℃.
5) The **steam point** is the temperature of steam from water boiling at *one atmosphere*, and assigned a value of 100 ℃.
6) **Responsiveness** is a measure of how rapidly the thermometer can attain object temperature.
7) **Sensitivity** is the amount of change of thermometric property per unit change in temperature.
8) **Range** is the minimum and maximum temperatures that the thermometer can measure.

Types of thermometric properties

Thermometric Properties	Thermometer
Volume of a fixed mass of liquid	Liquid-in-glass thermometer
Electical resistance of a piece of metal	Resistance thermometer
Electrical voltage or electromotive force (emf)	Thermocouple
Expansion of a metal	Bimetallic thermometer
Pressure of a fixed mass of gas at constant volume	Constant volume gas thermometer

Converting Celsius to Kelvins

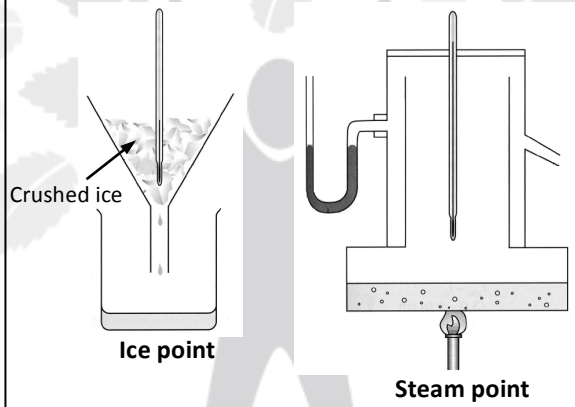
To convert degree Celsius to Kelvins, you add 273 to the value in degree Celsius.

$$\theta\ K = \theta\ ℃ + 273$$

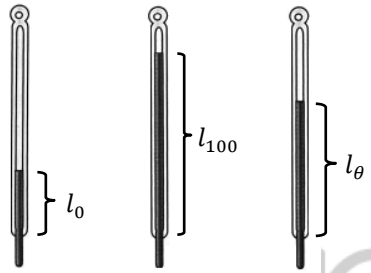
The SI unit for temperature is the **Kelvin (K)**, while the SI unit for heat is the **Joule (J)**.

Steps to construct a Temperature Scale.

1) Choose a suitable thermometric substance.
2) Calibrate the thermometer.
   i. Choose two fixed points (usually ice & steam points).
   ii. Set up the scale by dividing the interval between ice and steam point into 100 equal parts. Each interval now corresponds to 1 ℃.



Liquid-in-glass thermometer after calibration:



The general equation for calculating temperature in Celsius scale is:

$$\theta = \frac{X_\theta - X_0}{X_{100} - X_0} \times 100\ ℃$$

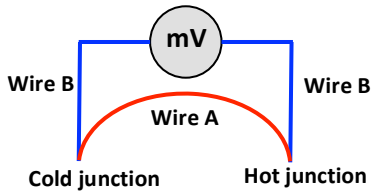
X : Thermometric property (Length/Resistance/Emf/ Pressure)

For example, for liquid-in-glass thermometer:

$$\theta = \frac{l_\theta - l_0}{l_{100} - l_0} \times 100\ ℃$$

Thermocouple

A **thermocouple** consists of two types of wires made of different metals, such as copper and tungsten. The ends of the wires are joined to form two junctions, which produces an emf when there is a temperature difference between them.



$\mathcal{E} \propto \Delta\theta$
$\mathcal{E} = k\Delta\theta$

$\mathcal{E}$: Electromotive force (V)
$\Delta\theta$: Temperature difference between hot and cold junction (℃ or K)

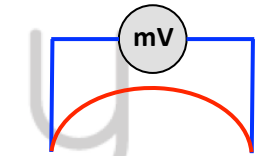
The advantages of a thermocouple

1) Wide range (-250 ℃ to 1500 ℃)
2) Can measure localised temperature points.
3) Can measure rapidly varying temperatures due to the small heat capacity of the probe.

Example

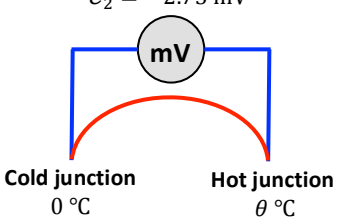
In the thermocouple, an initial reading of $+4.40$ mV was obtained when hot and cold junctions are placed in boiling water and melting ice respectively. A second reading of -2.75 mV was obtained with the hot junction placed in unknown liquid of temperature θ. Find temperature θ.

$\mathcal{E}_1 = 4.40$ mV



$\mathcal{E}_1 = k\Delta\theta$
$+4.40 = k(100 - 0)$
$k = 0.044$

$\mathcal{E}_2 = -2.75$ mV



$\mathcal{E}_2 = k\Delta\theta$
$-2.75 = k(\theta - 0)$
$\theta = \mathbf{-62.5}$ ℃