TEMPERATURE

Temperature:

$$\frac{1}{2} m \langle c^2 \rangle = \frac{3}{2} KT$$

$$\langle E_K \rangle = (\text{constant})\, T$$

$$\boxed{T \propto \langle E_K \rangle}$$

Def: It is the average kinetic energy of particles of matter.

P.S Scalar

Units: Kelvin (K) or Centigrade / Celsius ($^\circ C$)

Significance:- It determines the direction of flow of heat ie from hot end to cold end.

Heat:-

Def. Total Kinetic energy of particles of matter.

Symbol: Q

Unit J

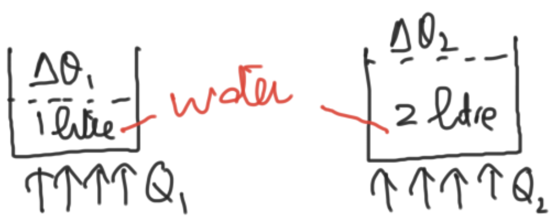
P.S Scalar

Relationship b/w heat and temperature:

$$\text{Average } E_K = \frac{\text{Total } E_K}{\text{no. of particles}}$$

$$\text{Temperature} \downarrow = \frac{\text{Heat}}{N \uparrow}$$

i.e. Heat = Constant



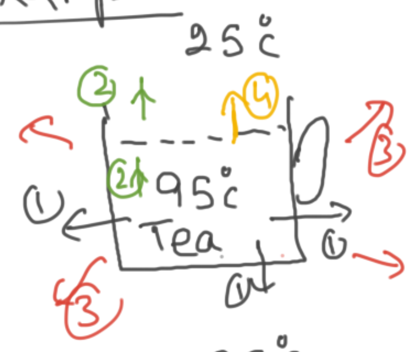
$(Q_1 = Q_2)$

ie $\Delta\theta_2 < \Delta\theta_1$ due to different no. of particles.

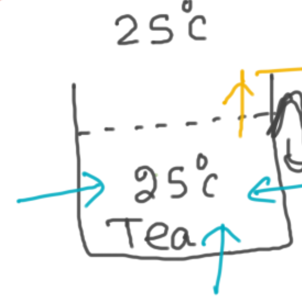
Thermal equilibrium:

Def Two objects are said to be in thermal equilibrium if there is no net transfer of heat energy in between them.

Example



1- Conduction
2- Convection
3- Radiation
4- Evaporation



Evaporation (Q_1)

Q_2 (transfer of heat)

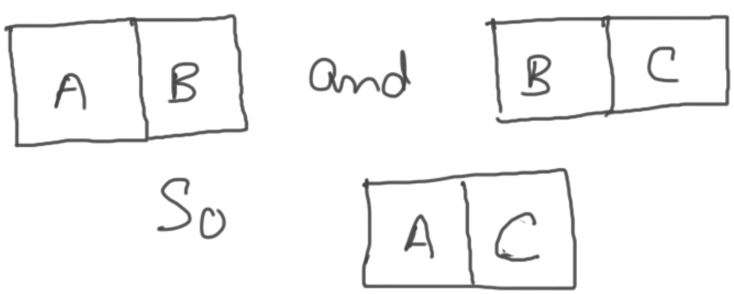
$Q_1 = Q_2$

$$Q_{Lost} = Q_{gained}$$

$$\Delta Q = Q_{Lost} - Q_{gained} = 0$$

<u>Result</u>: Tea particles are in thermal equilibrium with surrounding.

Zeroth law of thermodynamics



<u>Statement</u>: If an object A is in the thermal equilibrium with another object B and B is in thermal equilibrium with C. So objects A and C are also in thermal equilibrium.

<u>Example</u>

Tea is in thermal equilibrium with cup and lid, cup and lid are also in thermal equilibrium with surrounding. Hence tea and atmosphere are also in thermal equilibrium.

Scales of thermometer :-

Fixed point :- Constant temp. at which two states of matter co-exist. ie

* Lower fixed pt → M.P. of ice (ice + water)

* upper fixed pt → B.P. of water (water + steam)

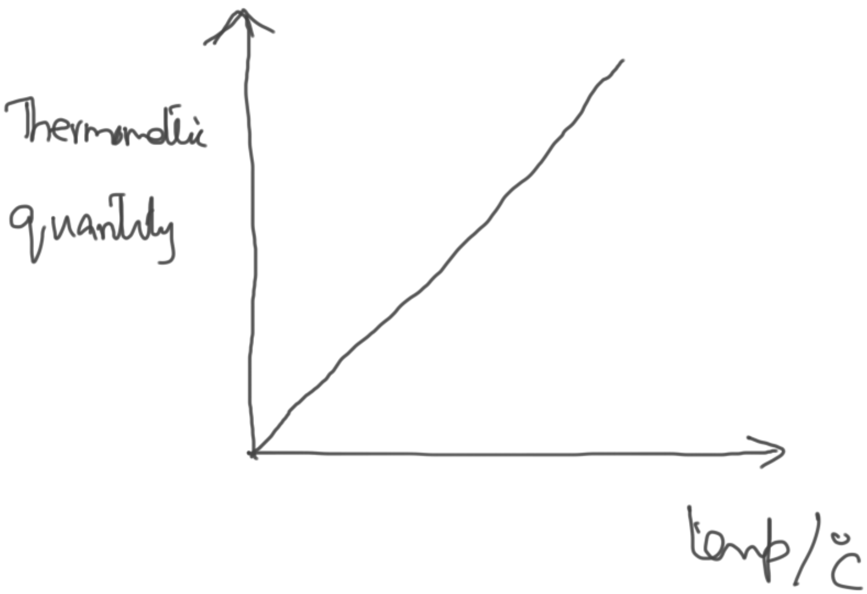
Scale	Lower fixed pt	upper fixed pt	Fundamental interval
Centigrade or Celsics	$0^\circ C$	$100^\circ C$	100 − 0 = 100
Absolute or Kelvin scale	273.15 K	373.15 K	373.15 − 273.15 = 100

Relationship :

$$T/K = \theta/^\circ C + 273.15$$

Linearity law of thermometry:

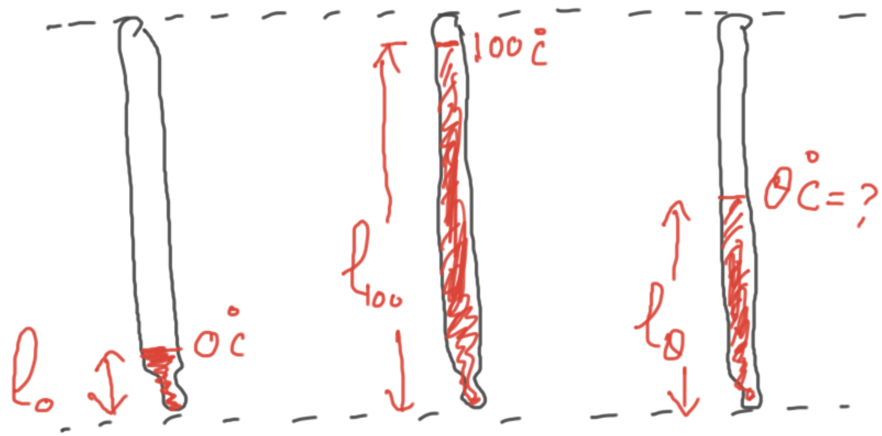
Statement:– change in the thermometric quantity is directly proportional to the rise in temperature



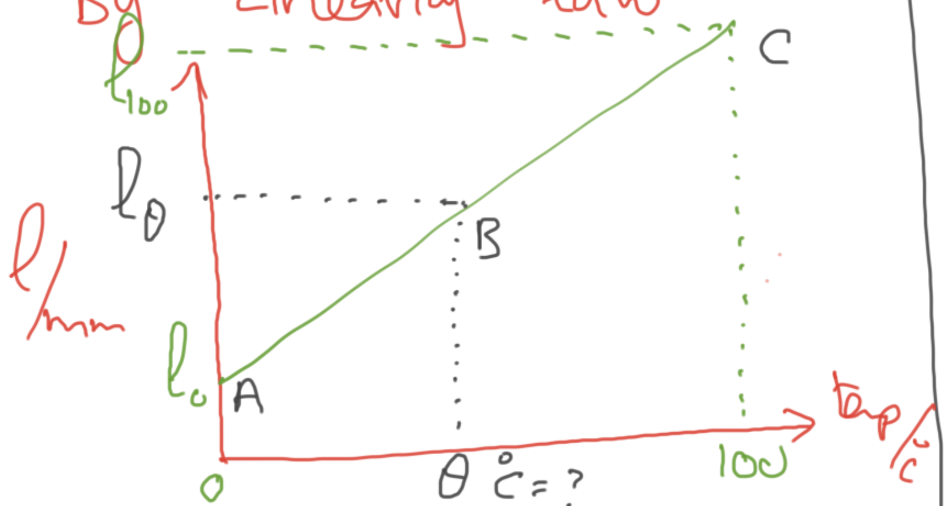
Example

Thermometer	Empirical quantity
Liquid-in-glass	$\Delta l \propto \Delta \theta$
Thermocouple 	$\Delta(e.m.f) \propto \Delta \theta$
Resistance	$\Delta R_{metal} \propto \Delta \theta$
Gas Thermometer	$\Delta(\text{Pressure}) \propto \Delta \theta$ at constant volume

Formula analysis:



By Linearity law



Since ABC is a straight line

Gradient of AB = Gradient of AC

$$\frac{l_\theta - l_0}{\theta - 0} = \frac{l_{100} - l_0}{100 - 0}$$

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

$$\boxed{\theta = \left(\frac{l_\theta - l_0}{l_{100} - l_0}\right)100}$$

For any empirical thermometric quantity X.

$$\boxed{\theta\,°C = \left(\frac{X_\theta - X_0}{X_{100} - X_0}\right)100}$$

Types of thermometers:

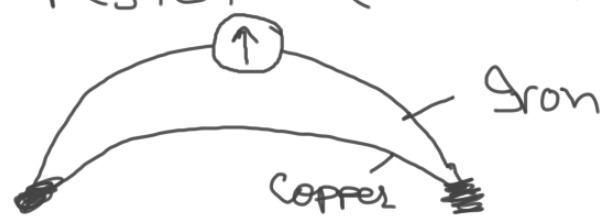
(a) **Thermocouple thermometer:**

Def: Thermometer used to measure rapid change of temperature.

Reason: The rapid change of temperature is measured due to lesser specific heat capacity of metallic wire used. (C↓, Δθ↑)

Symbol:

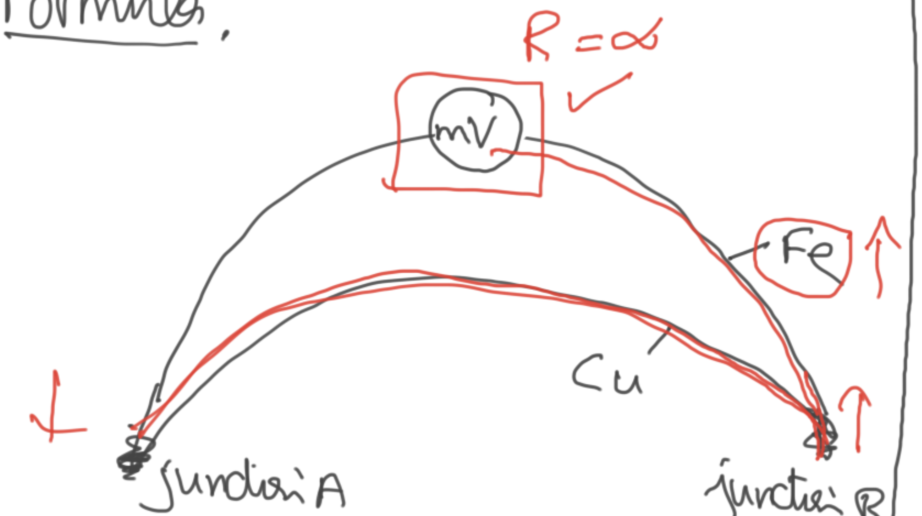
Construction: Two metallic wires of different material/nature joined together at the ends to form junction. A milli-voltmeter or a Galvanometer is connected to high resistance wire.



Principle: e.m.f. developed b/w two junctions if they are at different temperature.

$$\Delta E \propto (\theta_{hot} - \theta_{cold})$$

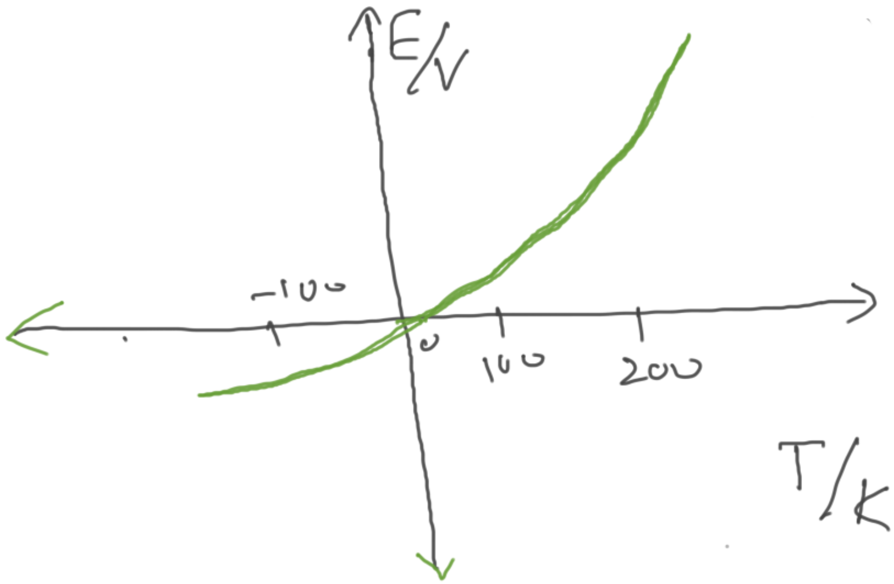
Formula.



junction A	junction B	e.m.f
Melting ice	Melting ice	E_0
"	Steam	E_{100}
"	Unknown Temp.	E_θ

By Linearity law

$$\theta/^{\circ}C = \left(\frac{E_\theta - E_0}{E_{100} - E_0}\right)100$$



Tripple point of water:-

Constant temperature at water co-exist in its all three states ie ice, water and steam and is determined by using special apparatus known as tripple point cell.

Value: 273.16K

Thermodynamic Scale of temperature:-

This a theoretical scale scale which is independent of any empirical thermo-metric quantity which varies with temperature and is based used ideal gas eq. $PV = nRT$.

Formula:

$$T/K = \frac{PV}{(PV)_{tr}} \times 273.16$$

Here

PV - Product of pressure and volume at unknown temperature T.

$(PV)_{tr}$ - Product of pressure and volume at tripple point of water ie 273.16K.

Comparison between thermistor and thermocouple thermometer:

Features	Thermistor thermistor	Thermocouple thermometer
Range	Narrow range	wide range
Sensitivity	Sensitive at low temperature	Can be made sensitive if appropriate metallic wires are chosen
Robust nature (solid state)	very robust	Robust but lesser than thermistor thermometer

Feature	Thermistor	Thermocouple
Response	Slower response time due to larger sp. heat capacity of Thermistor	Faster range due to lesser specific heat capacity of metallic wires used.
Size	Large	Small
Linearity	Approximately linear over narrow range	Non-linear at all range of temperatures, so Calibrations are required
Accuracy	Accurate	Less accurate