VISUAL PHYSICS

SHORT NOTES

CHAPTER

Heat And Temperature

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Heat & Temperature

Heat → form of energy which appears when two bodies at different temperature come into contact

→ Heat flow from body with higher temperature to lower temperature

→ It is energy in transit

→ Not a property of a system, a system can give out or absorb heat, but does not contain heat.

→ SI unit Joule

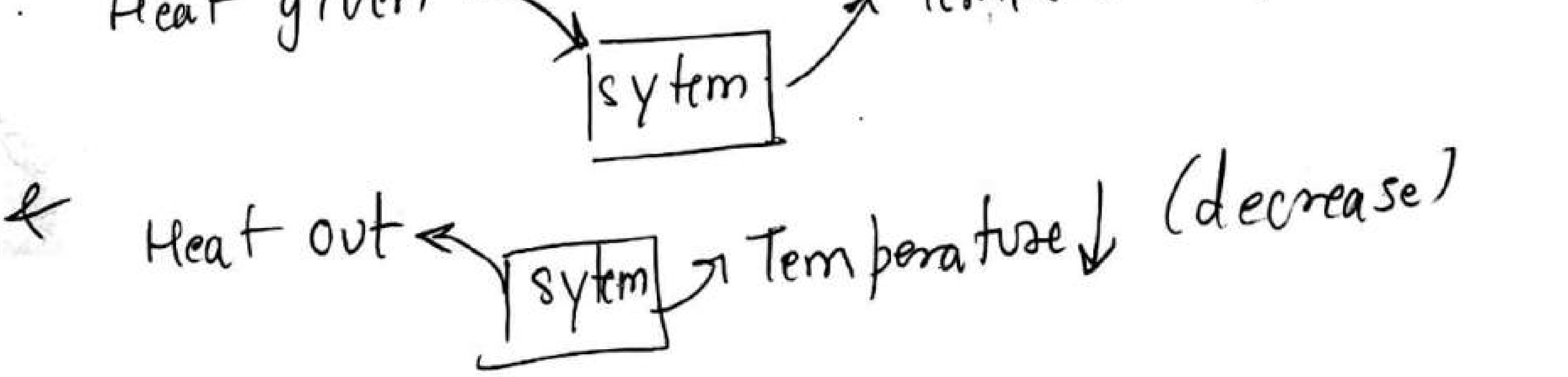
Temperature → By zeroth law of thermodynamics

if A & B are in thermal equilibrium with C then A & B are also in thermal equilibrium with each other (equality of temperature)

→ Temperature is one of seven fundamental quantity.

→ scalar quantity with SI unit kelvin

→ Temperature can be regarded as the effect of cause 'Heat'.



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Heat given → [sytem] → Temperature ↑ (increase)

& Heat out ← [sytem] → Temperature ↓ (decrease)

→ NTP or STP → 273.15 K

→ Temperature is measured by value of the thermodynamic property of a substance.
A property which varies linearly with temperature
e. two-fixed' points are needed

Triple point = 273.16 K or 0.01°C

↳ when all three states of water can exist

<u>Thermometer</u> → Instrument used to measure temperature of a body is called thermometer

The linear variation in some physical property of substance with change of temperature

→ Thermometric property (x)

(i) length of liquid in capillary
(ii) pressure of gas at constant volume
(iii) volume of gas at constant pressure.

Now thermometric property at temperature 0°C, 100°C & T_c°C is x_0, x_{100} & x_t

so, $T_c = ax + b$

$$\Rightarrow \frac{T_c - 0}{100 - 0} = \frac{x - x_0}{x_{100} - x_0}$$

$$\boxed{T_c = \frac{x - x_0}{x_{100} - x_0} \times 100°C}$$

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→ There are different systems of measurements of temperature.

Lower fix point (LFP) & Upper fix point (UFP)

System of units	Units	Lower point	Upper point	Difference
Degree Celcius	°C	0°C	100°C	100
Kelvin scale	K	273.15K	373.15K	100
Fahrenheit	°F	32°F	212°F	180

$$\frac{C-0}{100} = \frac{F-32}{180} = \frac{K-273}{100} = \frac{\theta-\theta_0}{n}$$

θ_0 → lower point of a scale

n → difference of the scale

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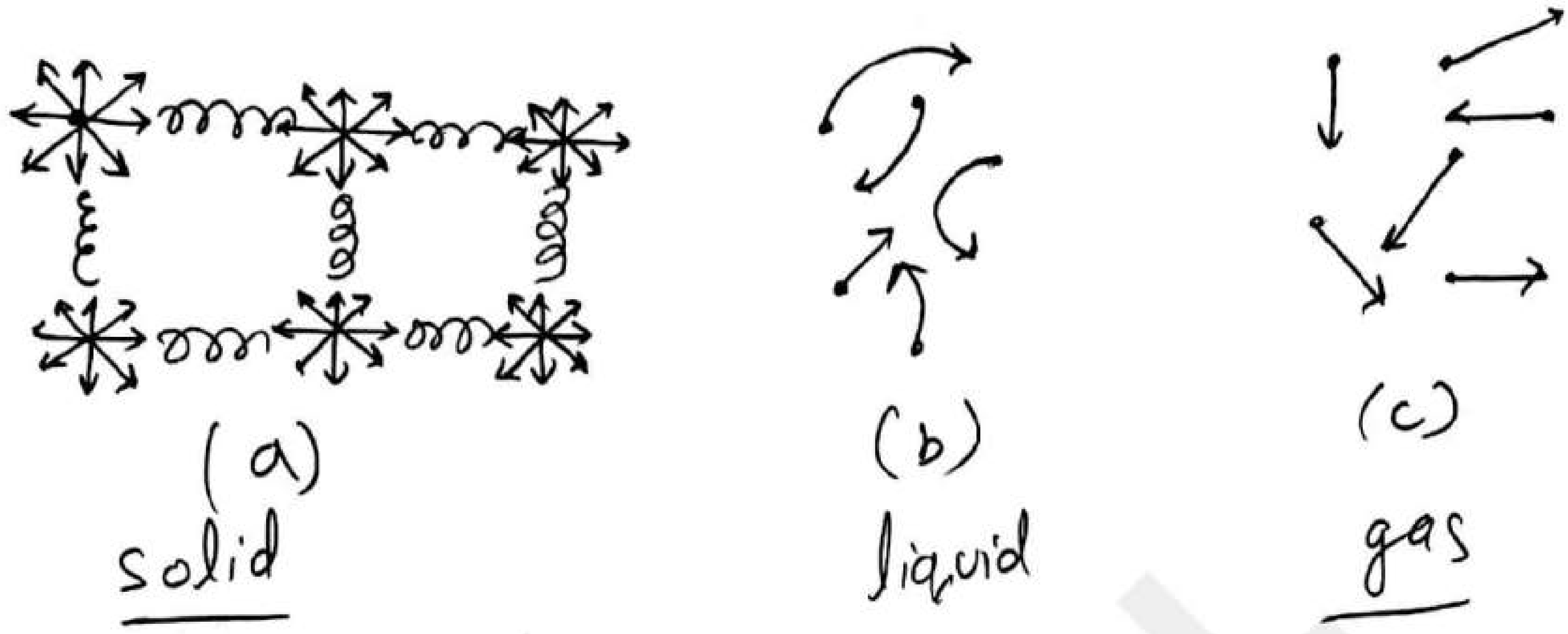
Thermal expansion

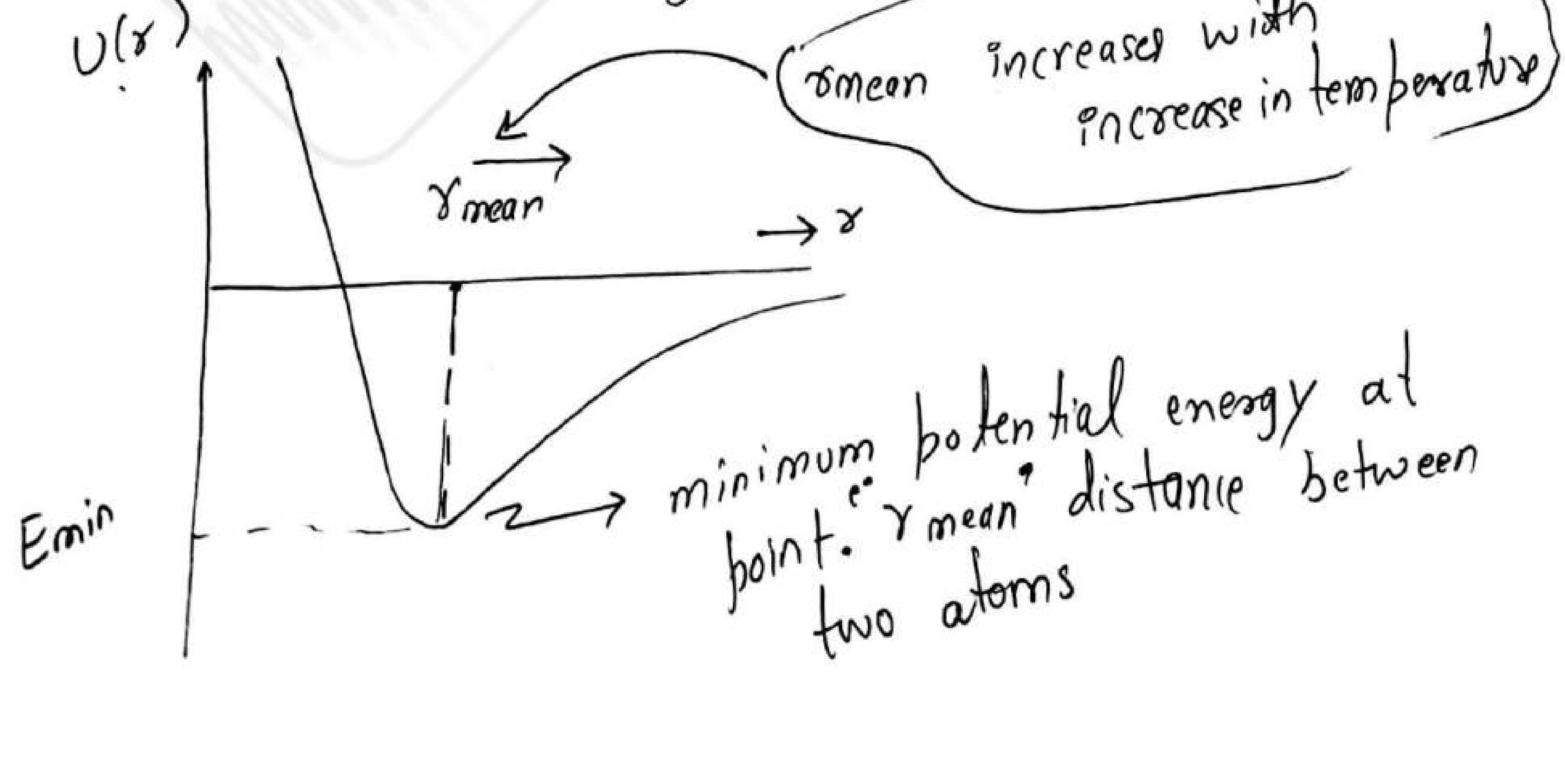


→ a,b,c shows molecules of solid, liquid and gas respectively

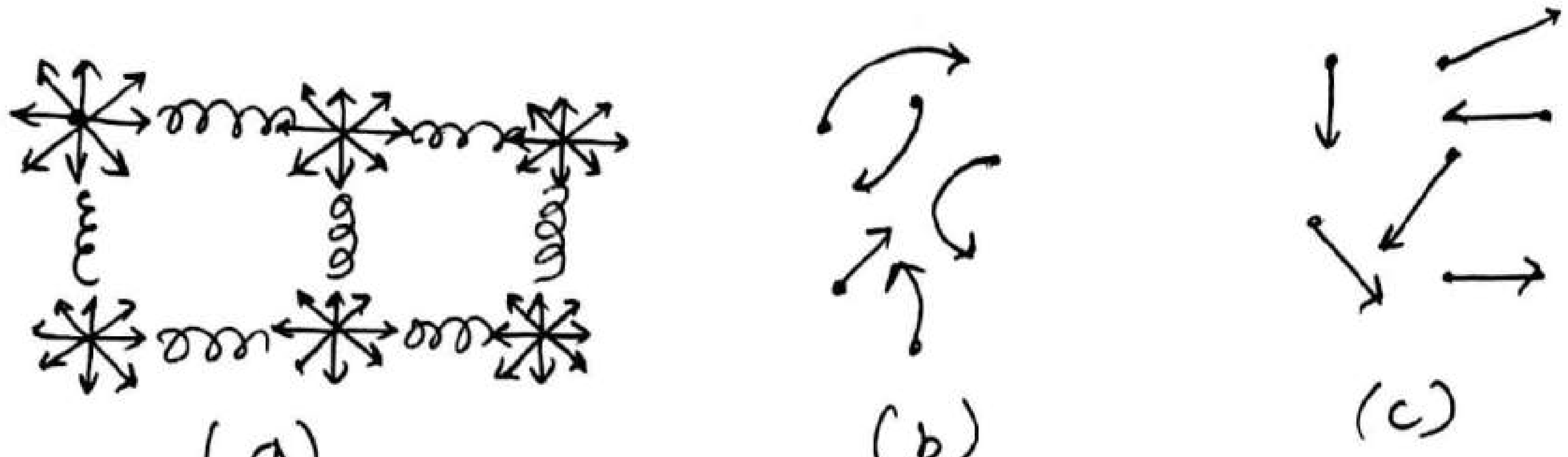
→ Most substances expands when their temperature raised & contract when cooled.

exception to this statement: water contracts when temperature goes from 0°C → 4°C

→ Atoms in solids are in close contacts; the forces between them allows the atoms to vibrate but not to move freely.



Thermal expansion



(a) solid | (b) liquid | (c) gas

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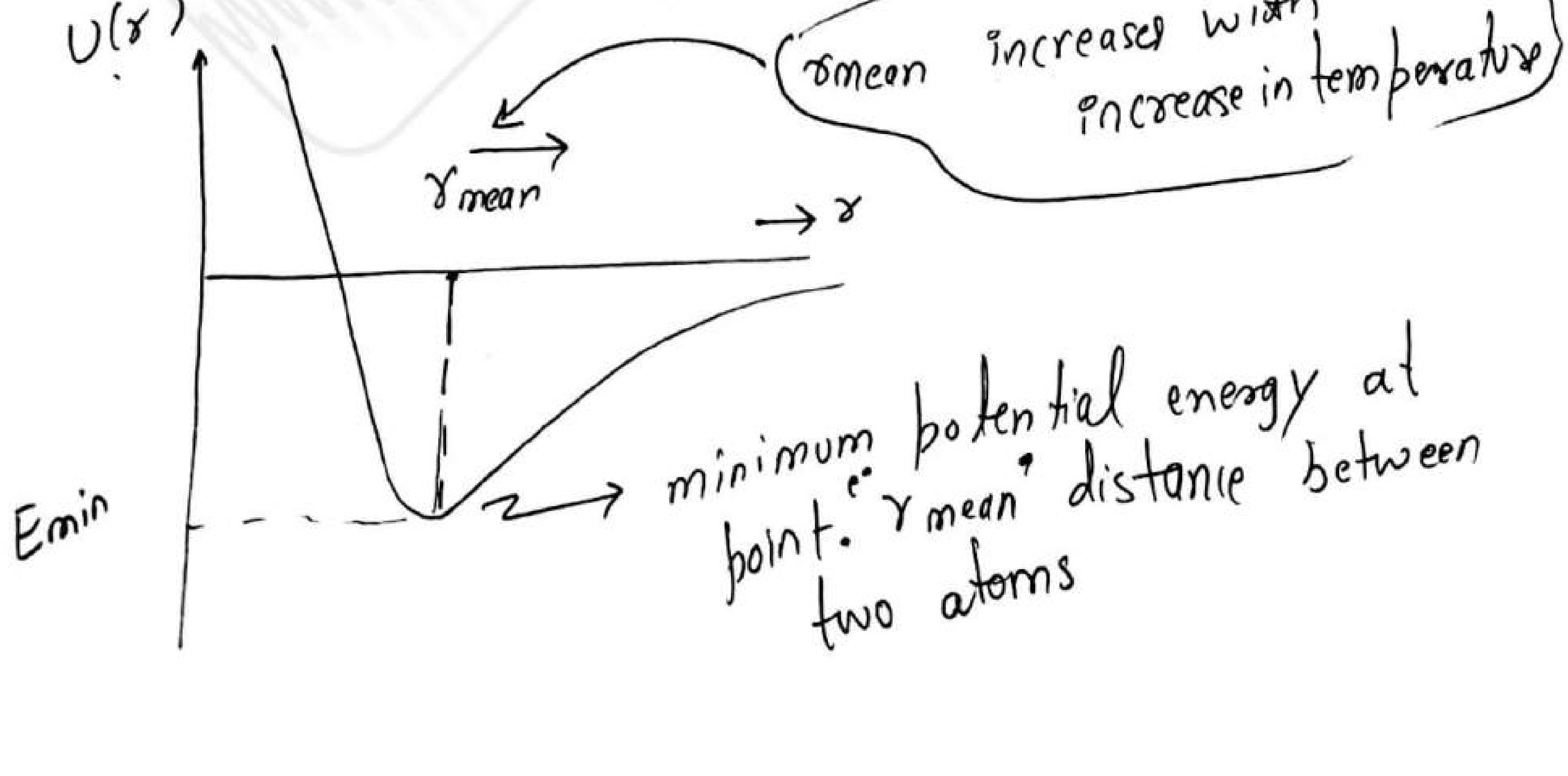

hence using the potential energy curve we can say that :

$\uparrow T \rightarrow \uparrow r_{mean}$ (because of high intermolecular force)

Thermal expansion is minimum in solids & maximum in gases. (because of lowest intermolecular force)

* solid can expand in one dimension (linear Expansion) two dimension (superficial expansion) & three dimension (volume expansion)
* liquid & gases usually suffers changes in volume only.

$$\alpha = \frac{\Delta L}{L} \times \frac{1}{\Delta T}$$

α → coefficient of linear expansion; ΔL → change in length; L → initial length; ΔT → change in Temp.

$$\beta = \frac{\Delta A}{A} \times \frac{1}{\Delta T}$$

β → coefficient of superficial expansion; ΔA → change in Area; A → Initial area

$$\gamma = \frac{\Delta V}{V} \times \frac{1}{\Delta T}$$

γ → coefficient of volume expansion; ΔV → change in volume; V → initial volume hence using the potential energy curve we can say that :

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Relation between α, β, γ

As, $\Delta L = L\alpha\Delta T$

$$\Delta A = A\beta\Delta T$$

$$\Delta V = V\gamma\Delta T$$

$$L' = L + \Delta L = L + L\alpha\Delta T$$

$$L' = L(1+\alpha\Delta T)$$

& $A' = A(1+\beta\Delta T)$

$$V' = V(1+\gamma\Delta T)$$

Now assuming square plate of side L

$$\Rightarrow \frac{A'}{A} = \left(\frac{L'}{L}\right)^2 = (1+\alpha\Delta T)^2 = (1+2\alpha\Delta T)$$

using Binomial as $\alpha\Delta T << 1$

$$\Rightarrow \boxed{\beta = 2\alpha}$$

for assuming cube of side L

$$\frac{V'}{V} = \left(\frac{L'}{L}\right)^3 = (1+\alpha\Delta T)^3 = (1+3\alpha\Delta T)$$

using Binomial

$$\Rightarrow \boxed{\gamma = 3\alpha}$$

$$\Rightarrow \boxed{\alpha : \beta : \gamma = 1 : 2 : 3}$$

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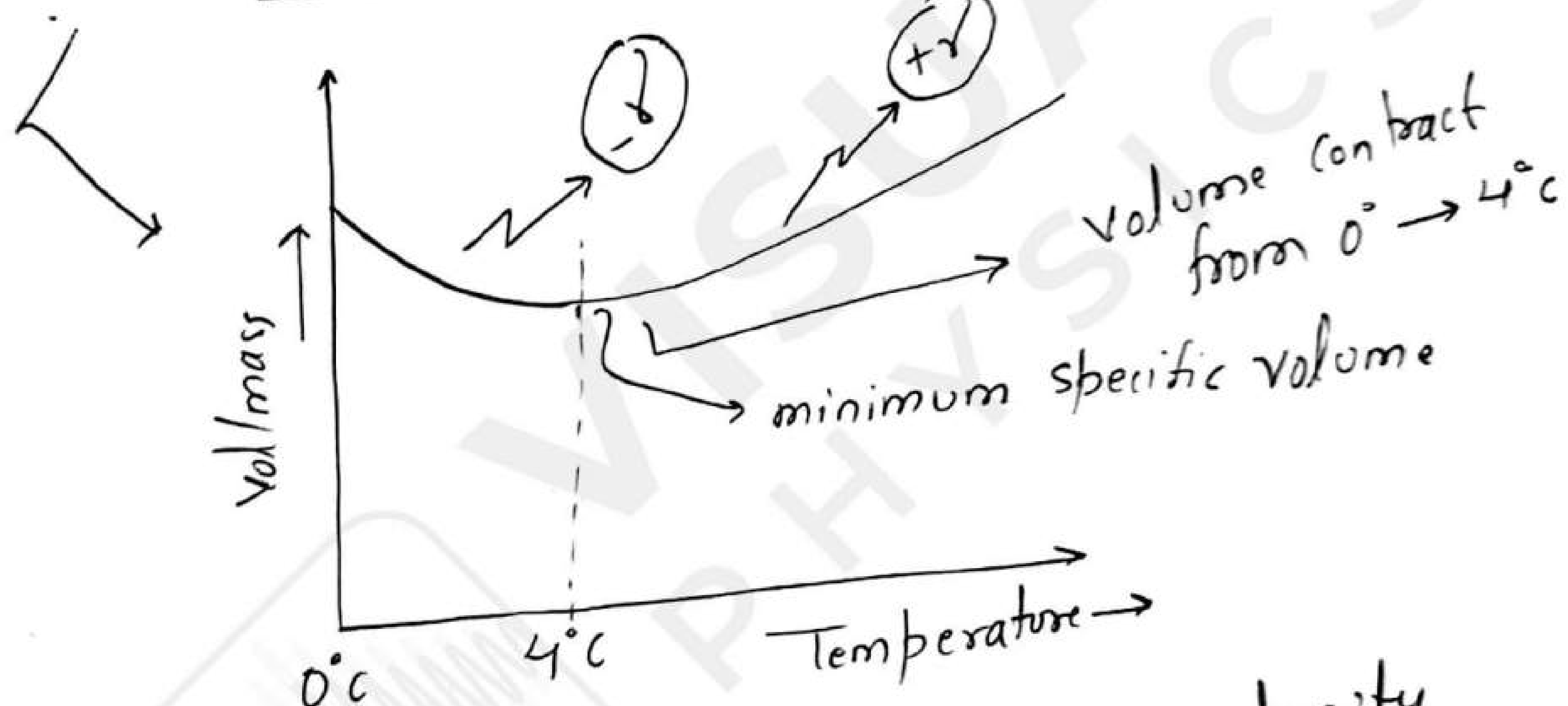
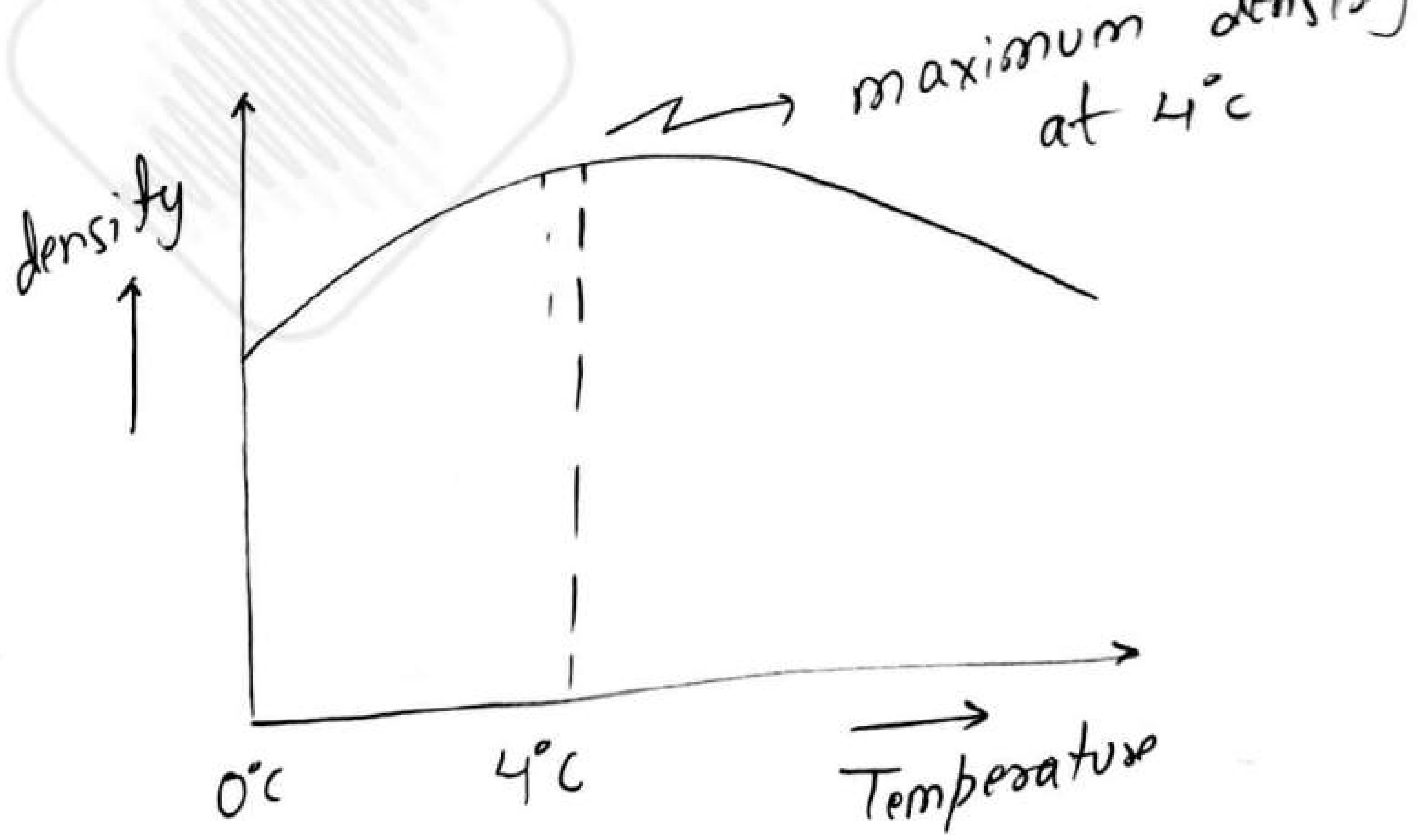
Bi-metallic strip:

↳ Two strips of equal lengths but of different materials. (different coefficient of linear expansion) when joined together we get 'bi-metallic strip'.

→ when heated it bends on cooling and heating because of unequal linear expansion.

And Anomalous Expansion of water:





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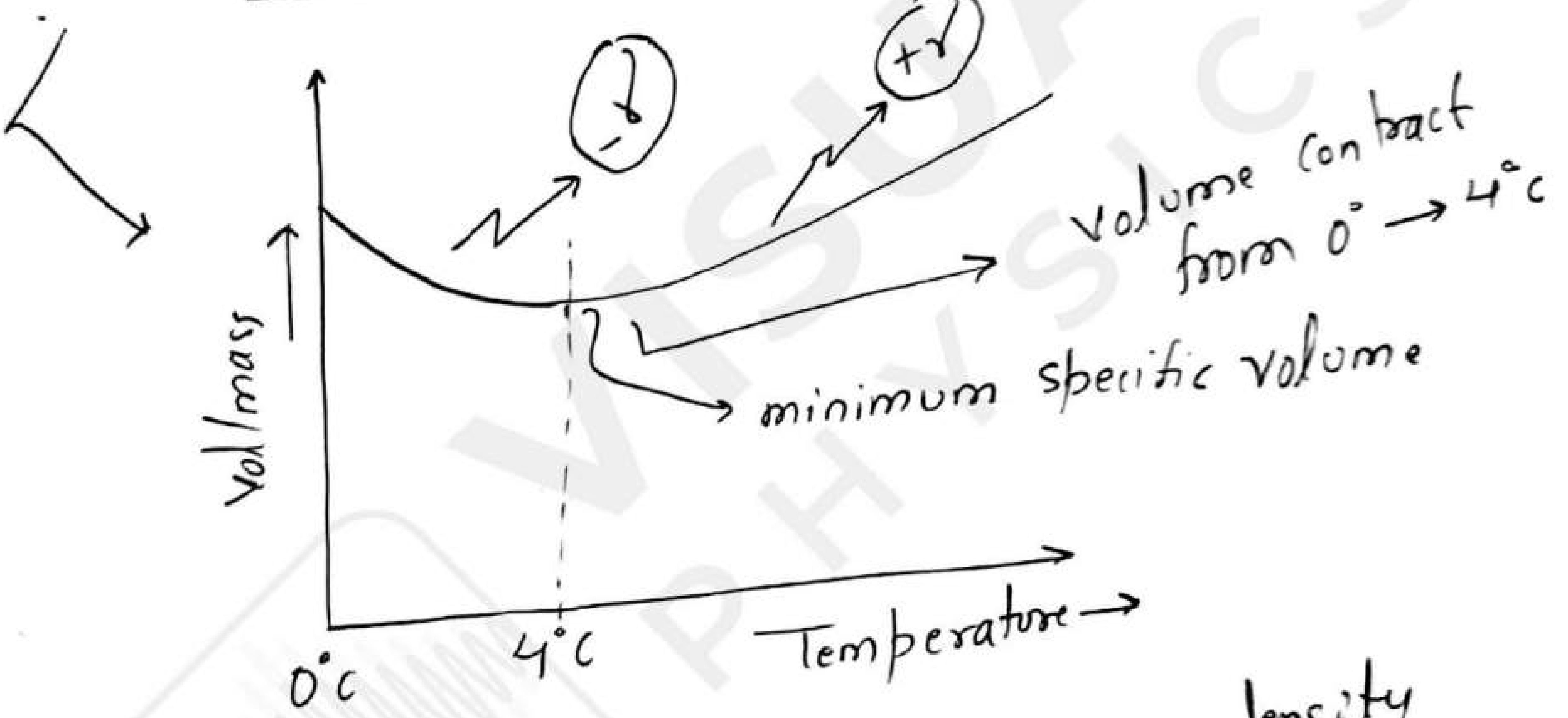

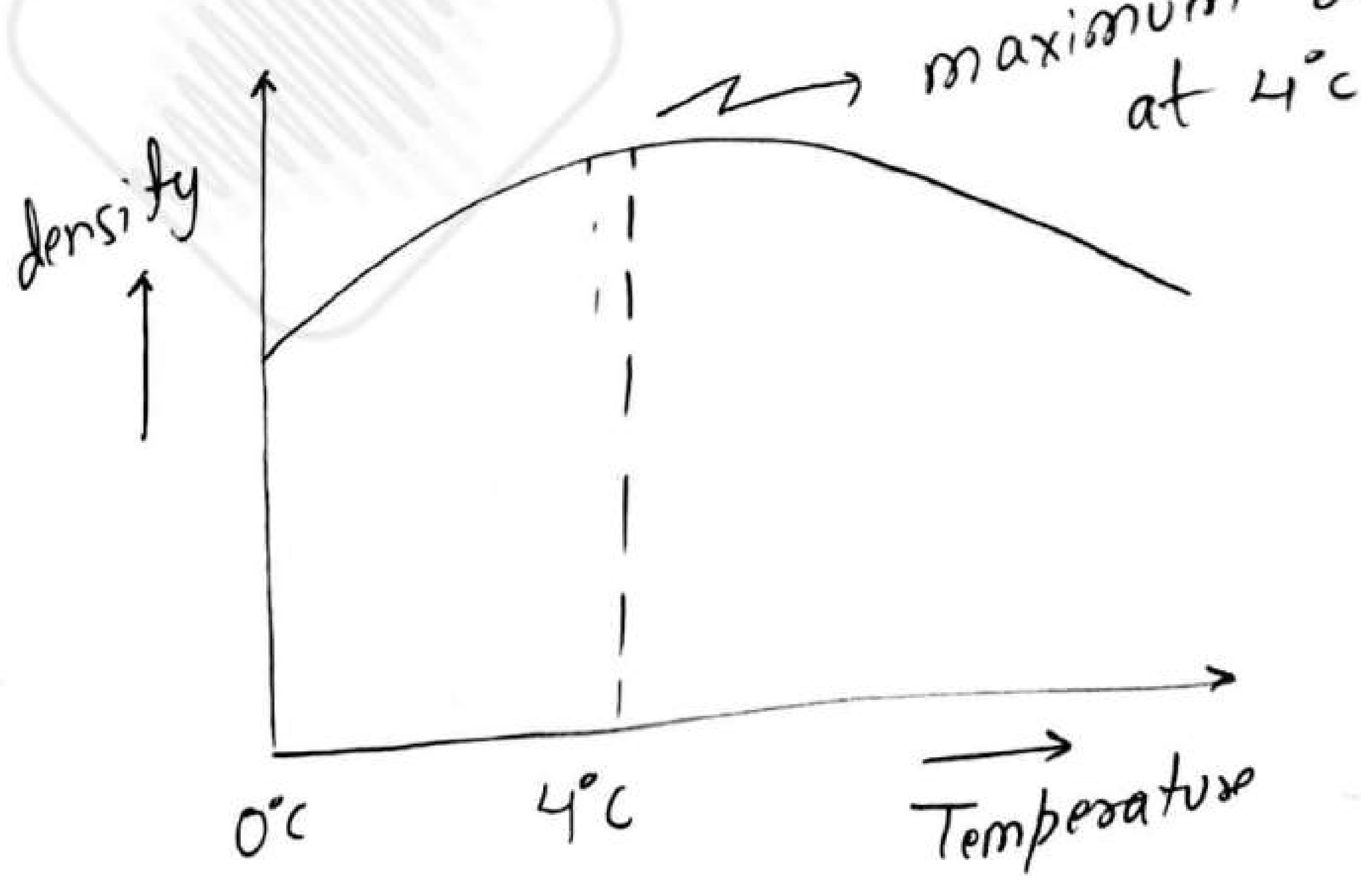

CALORIMETRY :

↳ Branch of heat transfer deals with the measurement of (Heat)

It measured in calories

(One calorie) : Heat required to raise 1 g of water by 1°c

↳ Heat required to raise 1 g of water to 1°c

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Mechanical Equivalent of Heat (J)

According to Joule, work may be converted into heat & vice versa.

Work done / heat produce = Constant

$$\frac{W}{Q} = \text{Contant} = 4.18$$

$$\Rightarrow \quad 1\,J = \frac{1}{4.18}\,cal$$

or $\boxed{1\,cal = 4.18\,J}$

Thermal capacity & Water Equivalent:

→ Thermal capacity $= \frac{Q}{\Delta T}$ → heat given; ΔT → change in Temperature

OR heat required to change temperature by 1°C or 1K

Dimension $[ML^2T^{-2}\theta^{-1}]$ J/K (SI)

→ Water equivalent:

" mass of water which would absorb or evolve same amount of heat as a body of mass m by changing to temperature ΔT "

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Specific heat

- Specific heat → Gram Specific heat
- Specific heat → Molar Specific heat

→ **Gram Specific heat:**

$$S = \frac{Q}{m \Delta T}$$ J/(kg k)

- S → Gram Specific heat
- Q → heat given or released
- m → mass
- ΔT → change in Temperatur

→ heat required per unit mass per unit Temperature (1°c or 1k)

→ **Molar Specific heat:**

$$C = \frac{Q}{\mu \Delta T}$$

- C → molar specific heat
- μ → number of moles

★ heat required to increase 1°c or 1k temperature of 1 mole of substance.

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so, **water equivalent = mS** (if S is in cal/kg K)

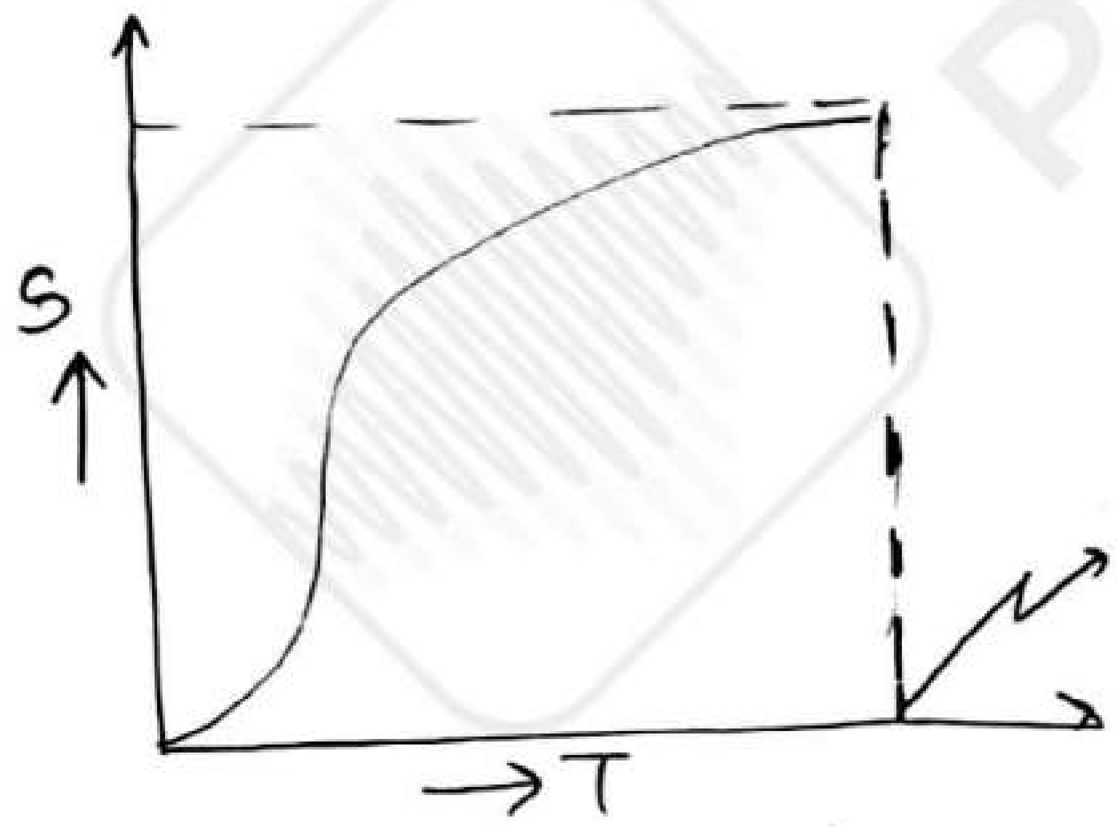
(for S in J/kg K)

water equivalent = mS/4.18

Specific Heat of solids:

when solid heated → very less change in volume

Hence Specific heat is known as specific heat at const volume



debye Temperature → S becomes constant after that temperature

Now for most of solids

Debye temperature is close to room temperature

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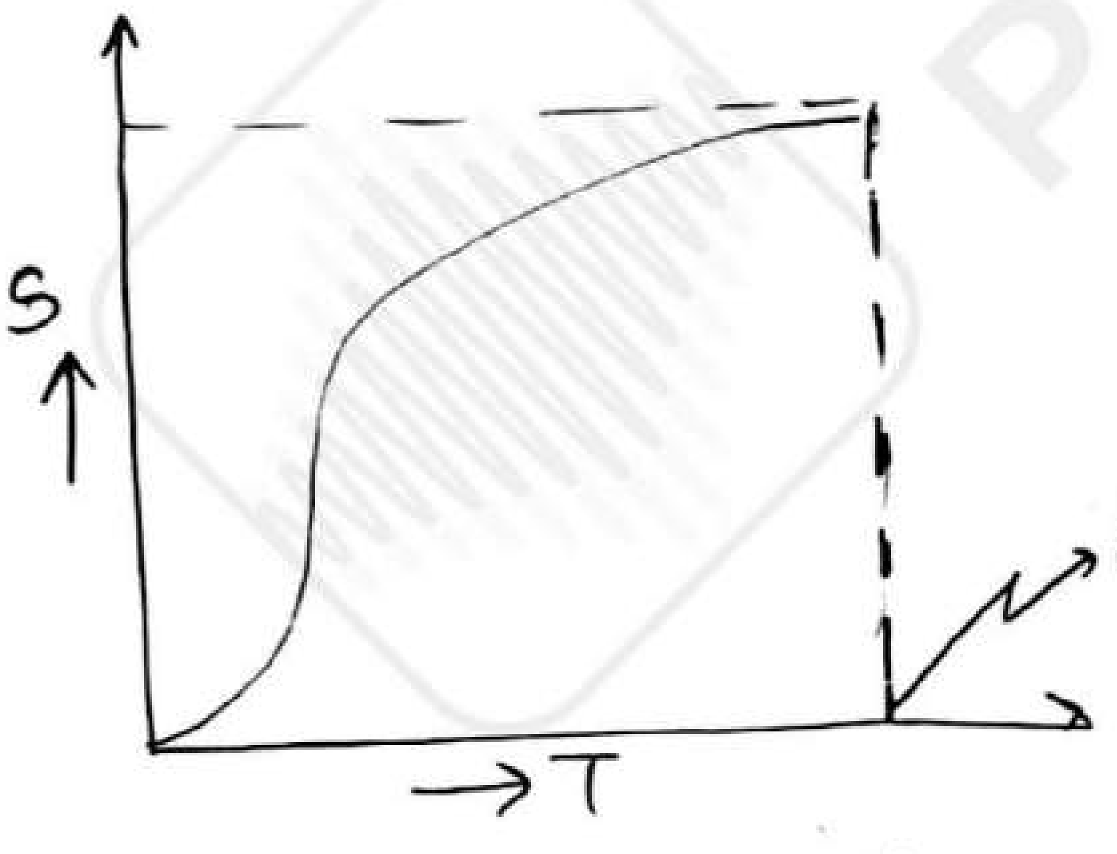

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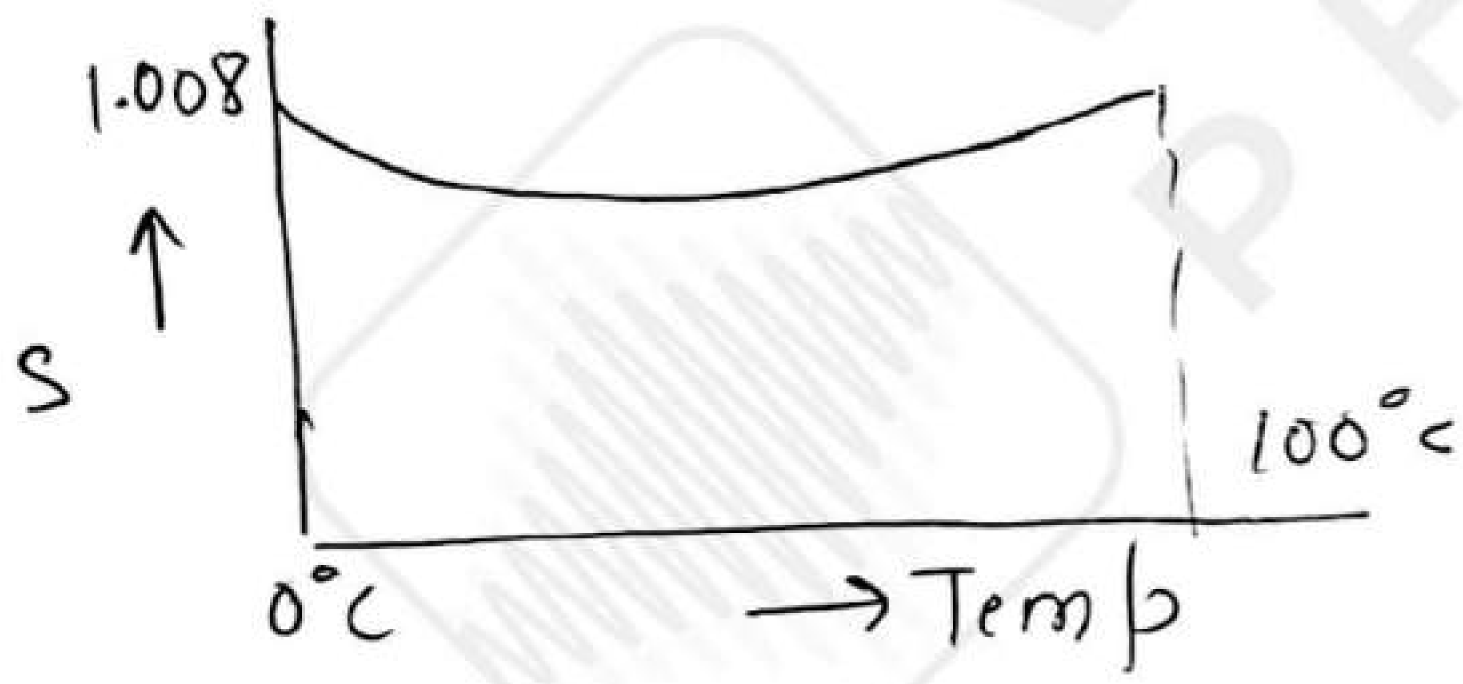
Specific heat of water : Almost constant.
And very large as well : 1 cal/g°C
or 4.18 J/g°C

hence used as collant in radiator



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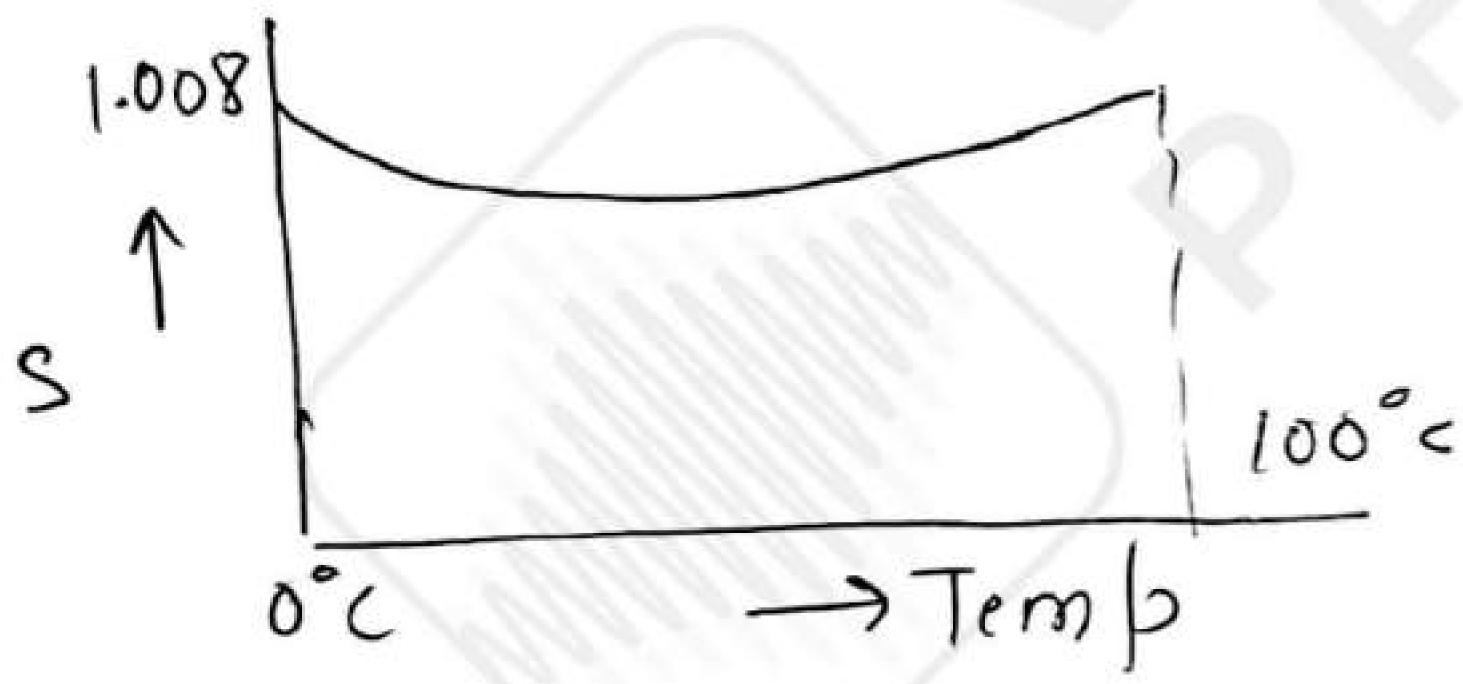

Latent heat:

→ When substance changes its state heat is either liberated or absorbed.

→ No change in Temperature during this transition

→ $$L = \frac{Q}{m}$$

- Q → heat liberated or absorbed
- m → mass
- L → Latent heat

unit cal/g or J/kg [SI]

Latent heat → heat liberated or absorbed per unit mass

→ <u>Latent heat of fusion:</u>

heat required for changing 1kg of solid into liquid state.

→ <u>Latent heat of vaporization:</u>

heat required for changing 1kg of substance from liquid state to gaseous state.

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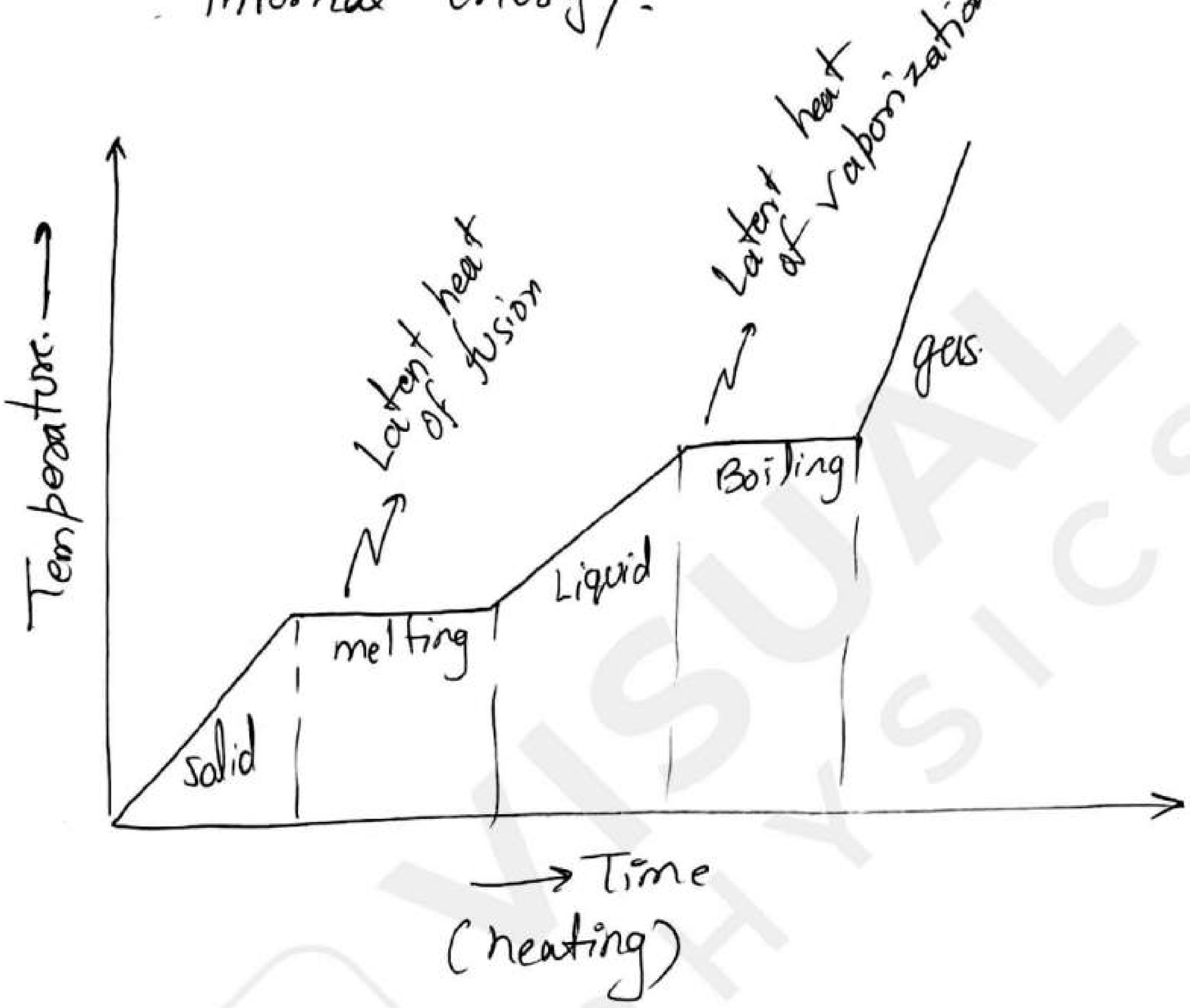

principle of calorimetry:

When two bodies comes in contact (in isolated system) at different temperature, one body losses heat and same amount of heat will be gained by other body.

i.e. **Heat gained = heat released**

(system is isolated)

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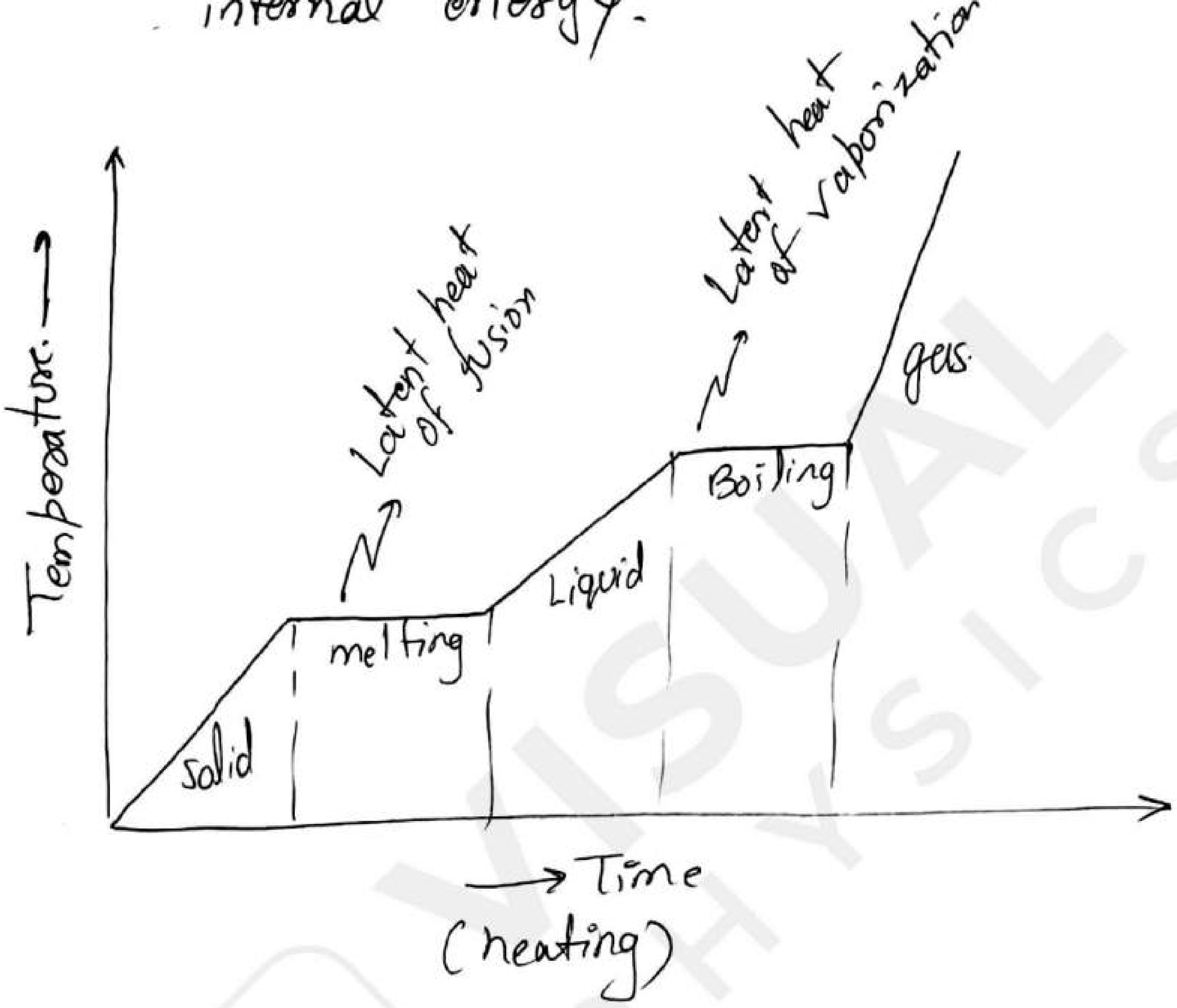

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→ final Temperature ⇒ $T_L \leq T_f \leq T_H$ → higher temperature

lower temp (T_L), final temp (T_f)

→ state of body changes at constant Temperature

$$Q = mL$$

→ $m_1 c_1 (T_1 - T) = m_2 c_2 (T - T_2)$

$$T = \frac{m_1 c_1 T_1 + m_2 c_2 T_2}{m_1 c_1 + m_2 c_2}$$

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(T_L → lower temp; T_f → final temp)

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