



VISUAL
PHYSICS

SHORT NOTES

C H A P T E R

Heat & 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.

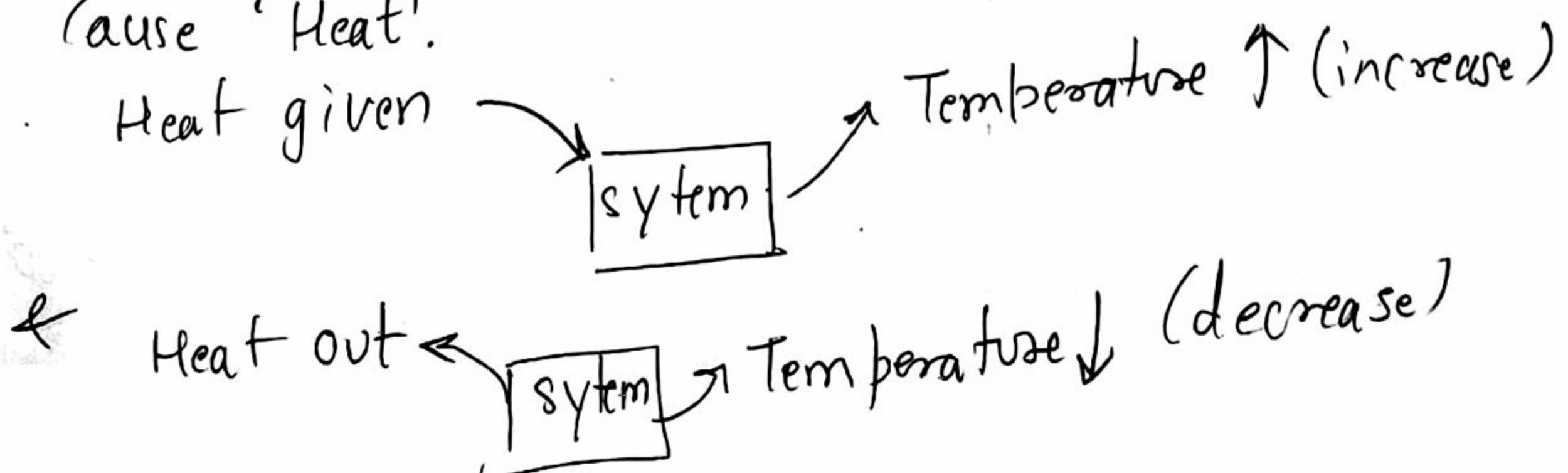
→ SI unit Joule

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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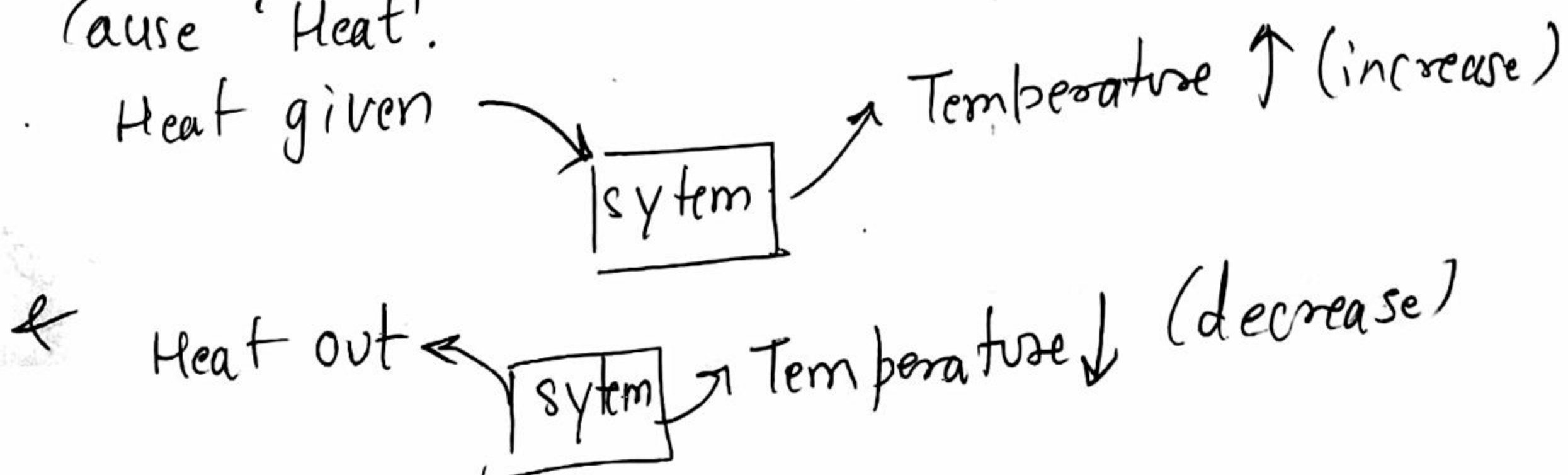
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→ NTP or STP → 273.15 K

→ Temperature is measured by value of the thermodynamic property of a substance.

A property which varies linearly with temperature
• 'two-fixed' points are needed

Triple point = 273.16 K or 0.01°C

↳ When all three states of water can exist

Thermometer → 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, $T_c = ax + b$

$$\Rightarrow \frac{T_c - 0}{100 - 0} = \frac{x - x_0}{x_{100} - x_0} \quad \left| \quad T_c = \frac{x - x_0}{x_{100} - x_0} \times 100^\circ\text{C} \right|$$

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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 Celsius	$^{\circ}\text{C}$	0°C	100°C	100
Kelvin scale	K	273.15K	373.15K	100
Fahrenheit	$^{\circ}\text{F}$	32°F	212°F	180

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

$\theta_0 \rightarrow$ lower point of a scale

$n \rightarrow$ difference of the scale

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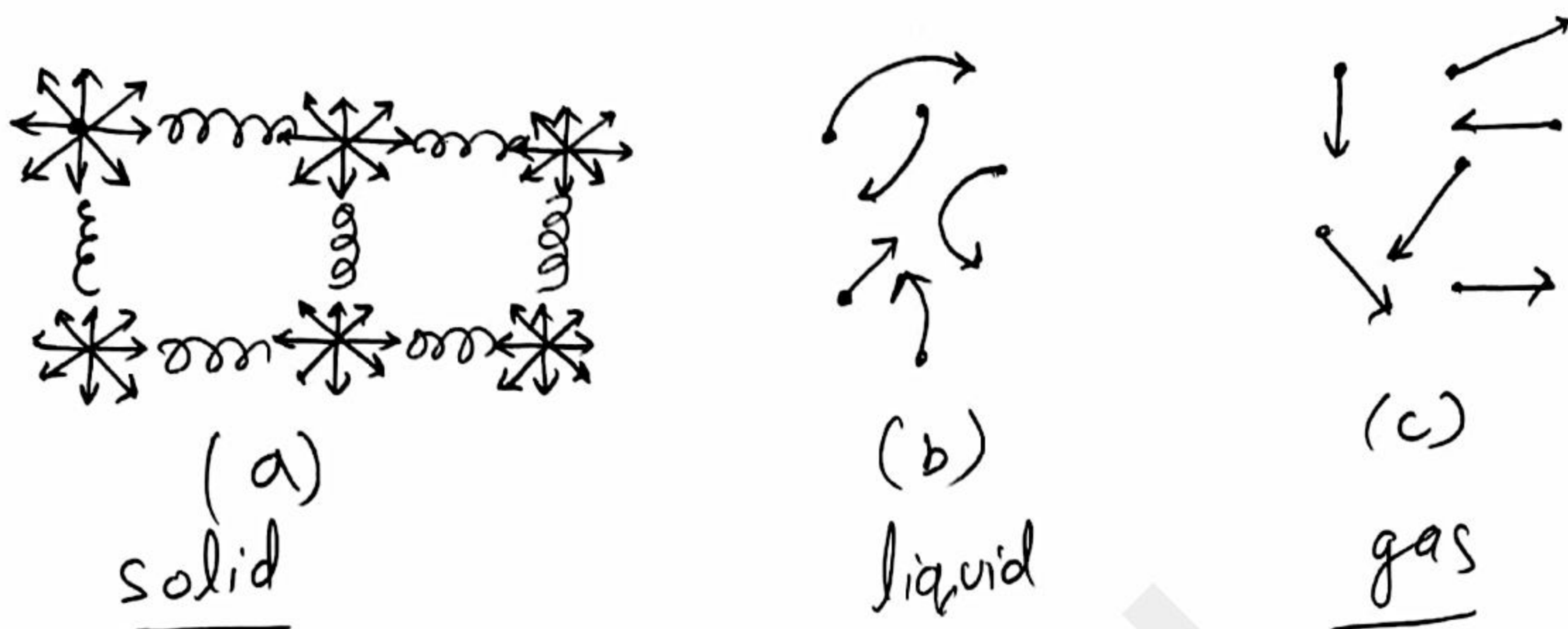
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Thermal expansion

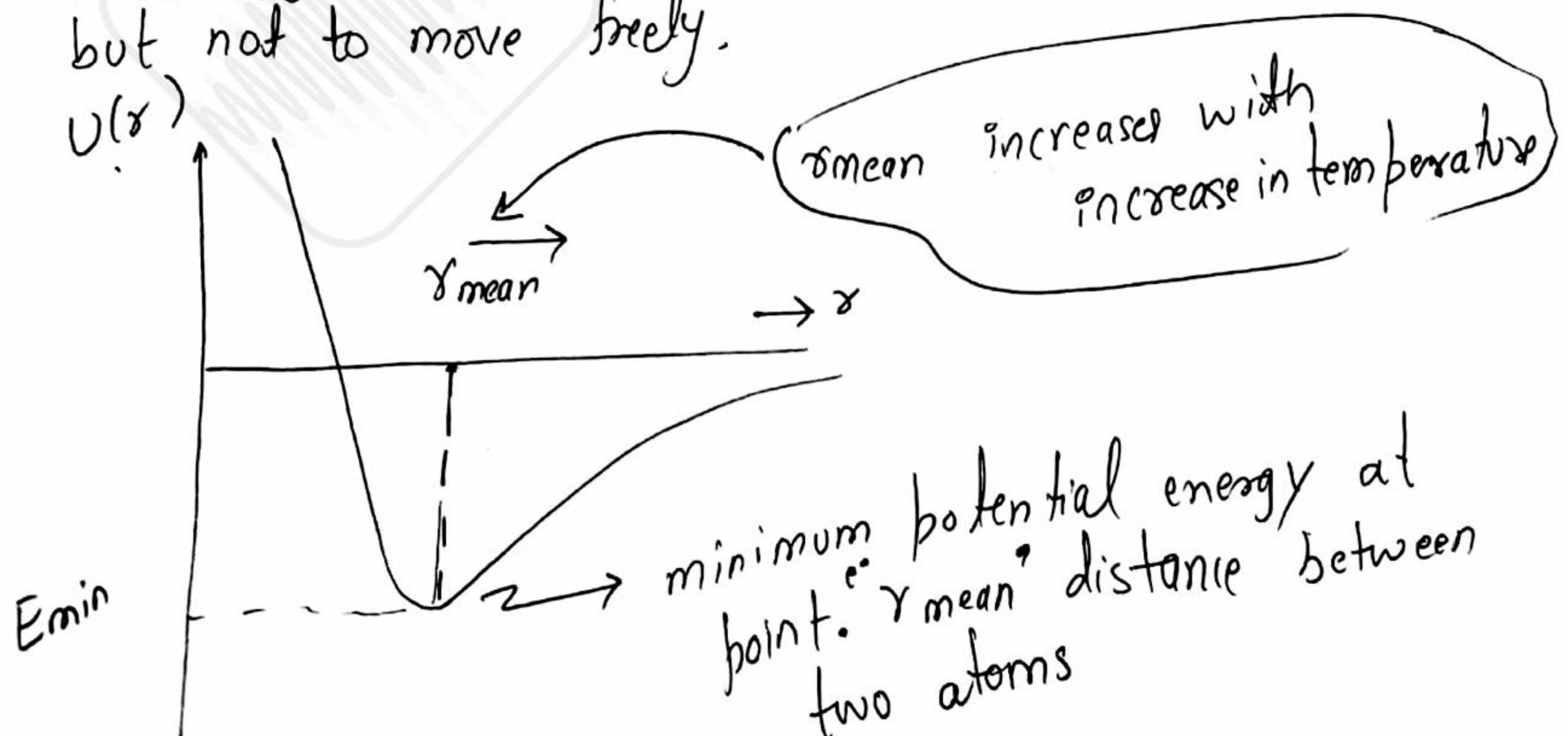


→ a, b, c shows molecules of solid, liquid and gas respectively

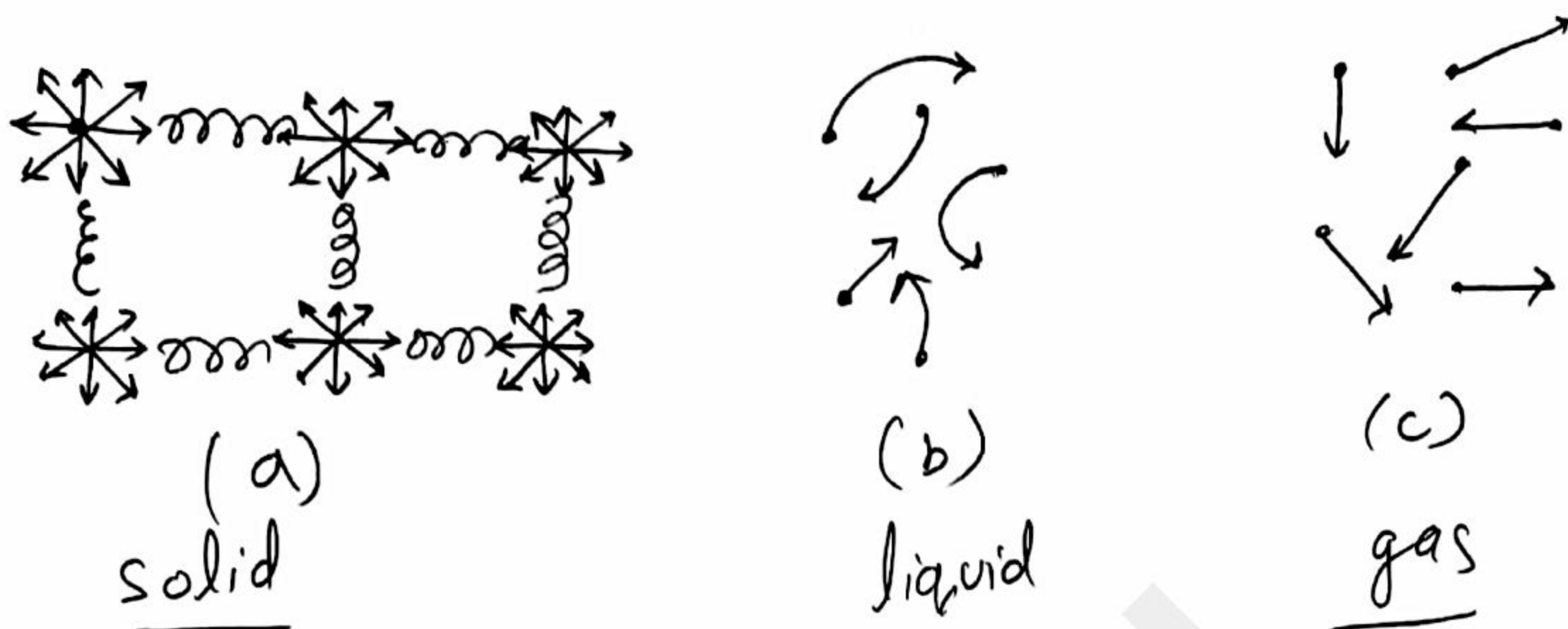
→ Most substances expands when their temperature raised & contract when cooled.

exception to this statement: water contracts when temperature goes from $0^{\circ}\text{C} \rightarrow 4^{\circ}\text{C}$

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



Thermal expansion

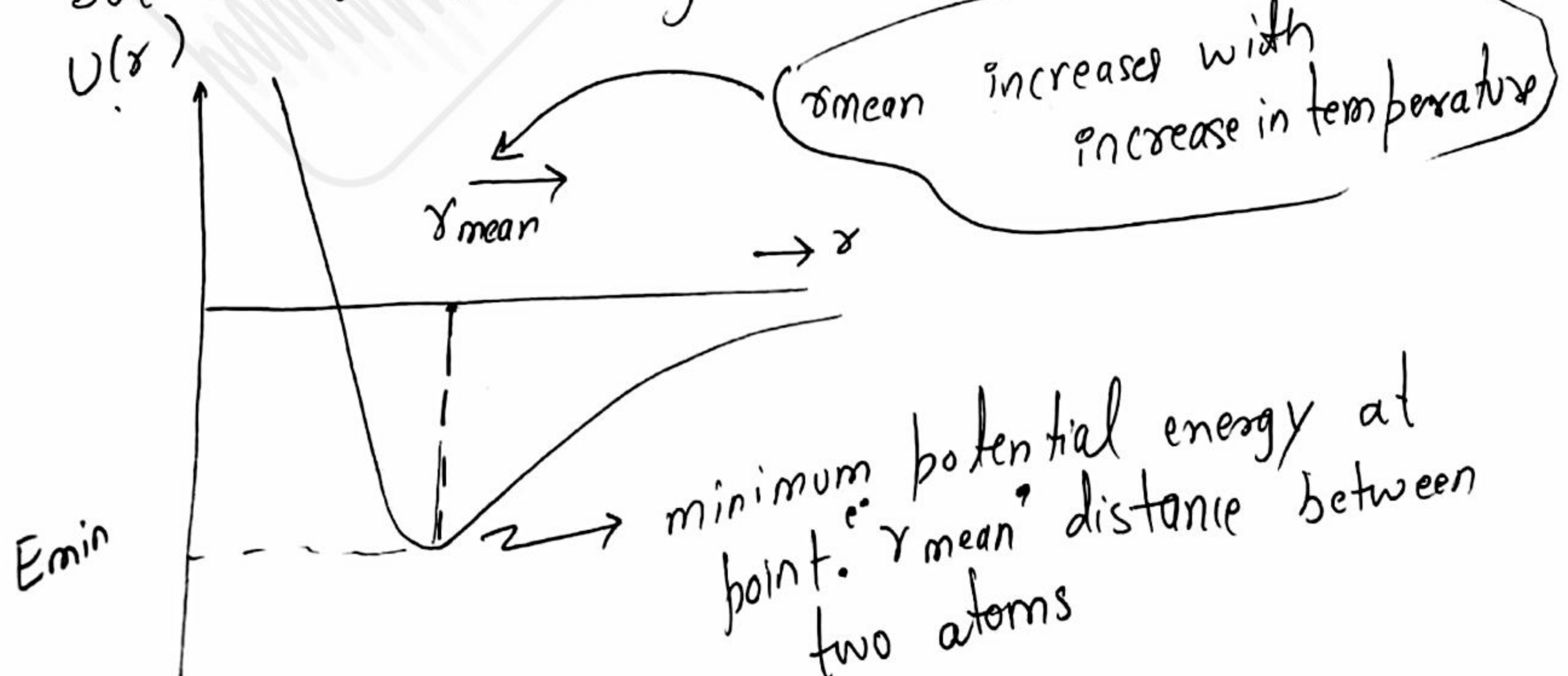


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hence using the potential energy curve we can say that:

$$\boxed{\uparrow T \rightarrow \uparrow x_{\text{mean}}}$$

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.

change in length

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

coefficient of linear expansion

initial length

change in Temp.

change in Area

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

coefficient of superficial expansion

initial area

change in volume

change in volume

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

coefficient of volume expansion

initial volume

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coefficient of linear expansion initial length change in Temp.

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coefficient of superficial expansion initial area

change in volume

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

coefficient of volume expansion initial volume

Relation between α, β, γ

$$\begin{aligned}\text{As, } \Delta L &= L \alpha \Delta T \\ \Delta A &= A \beta \Delta T \\ \Delta V &= V \gamma \Delta T\end{aligned}$$

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

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

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

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

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 $\alpha \Delta T \ll 1$

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

for assuming cube of side L

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

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

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

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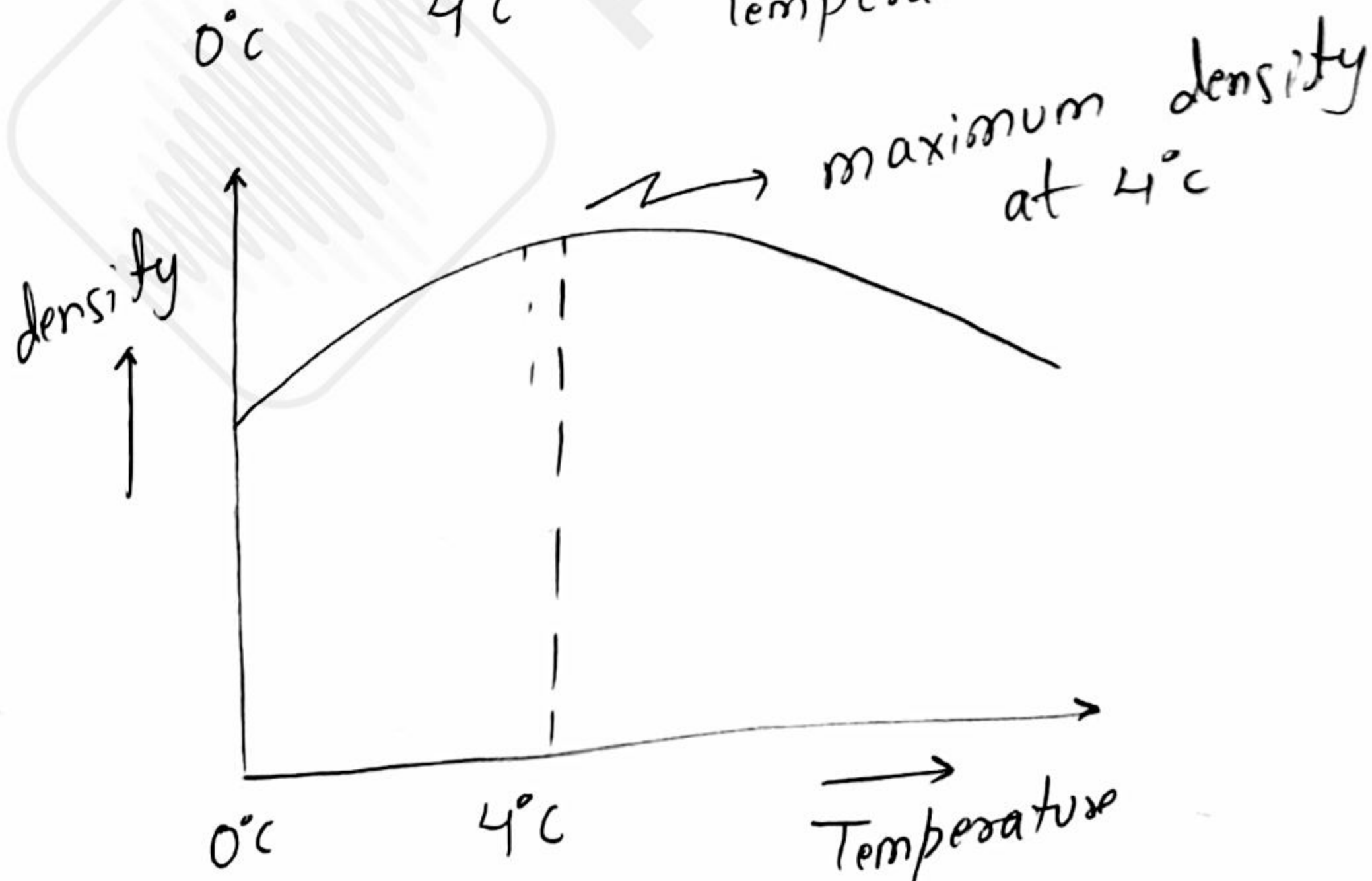
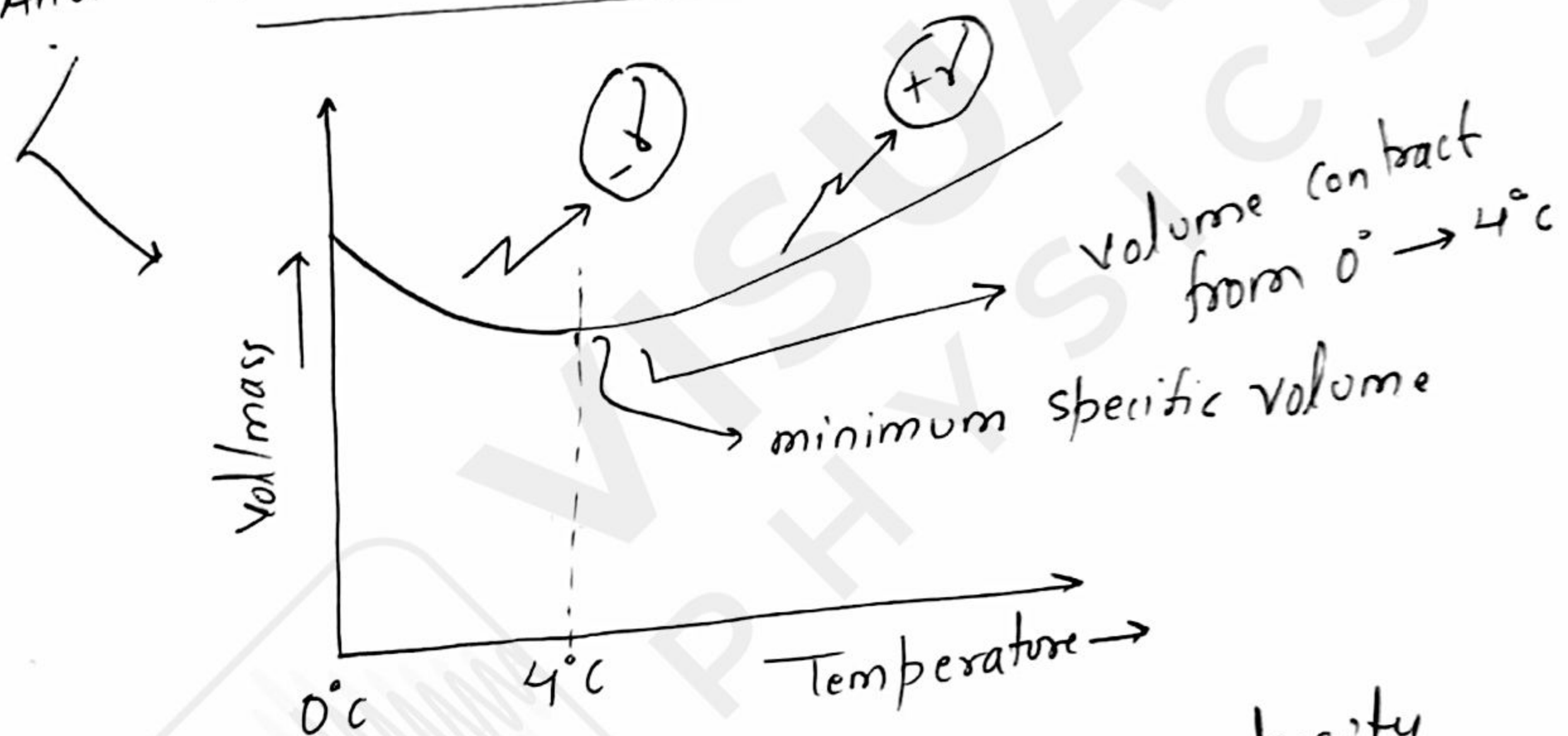
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Bi-metallic strip:

↳ 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:

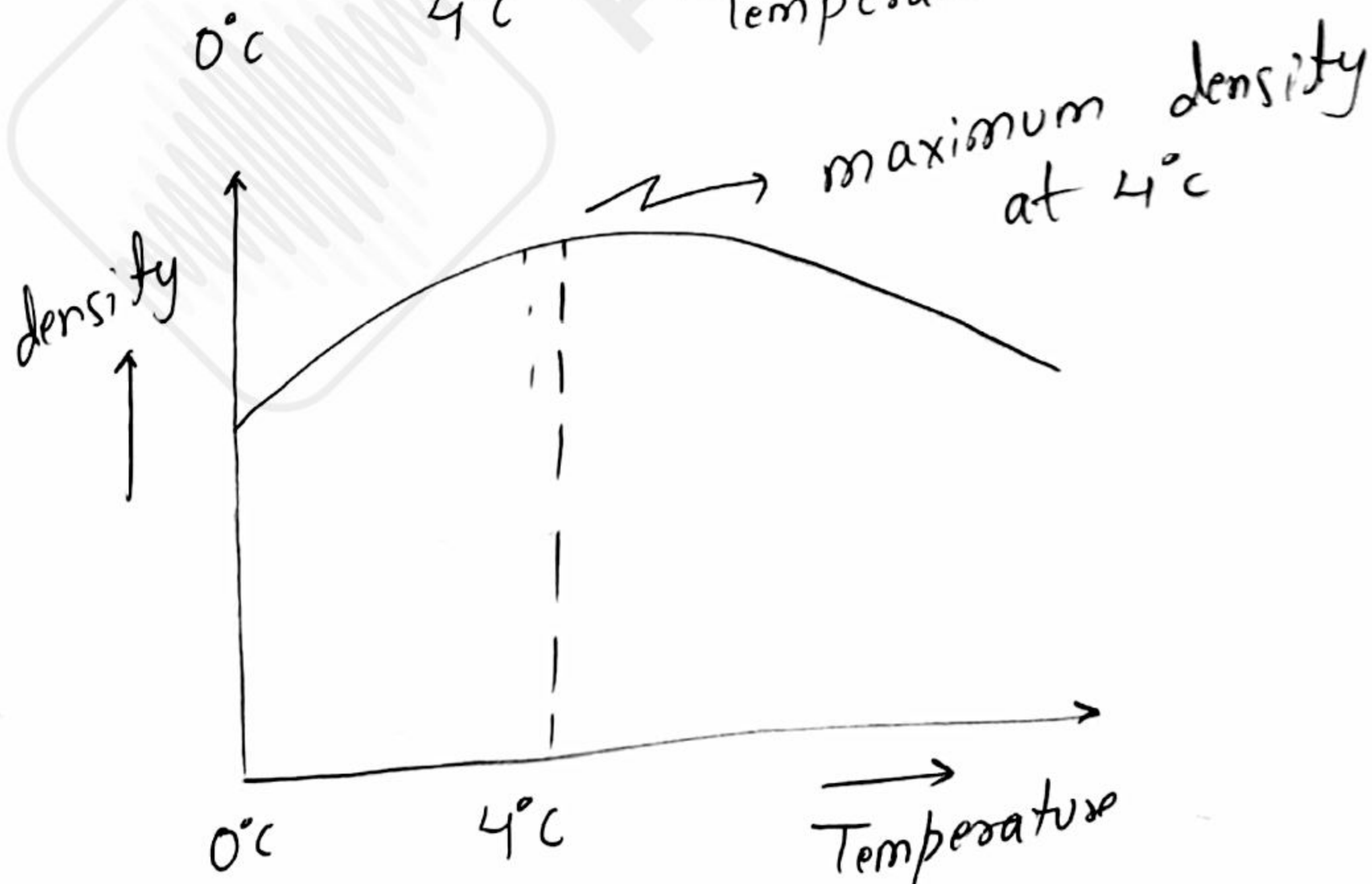
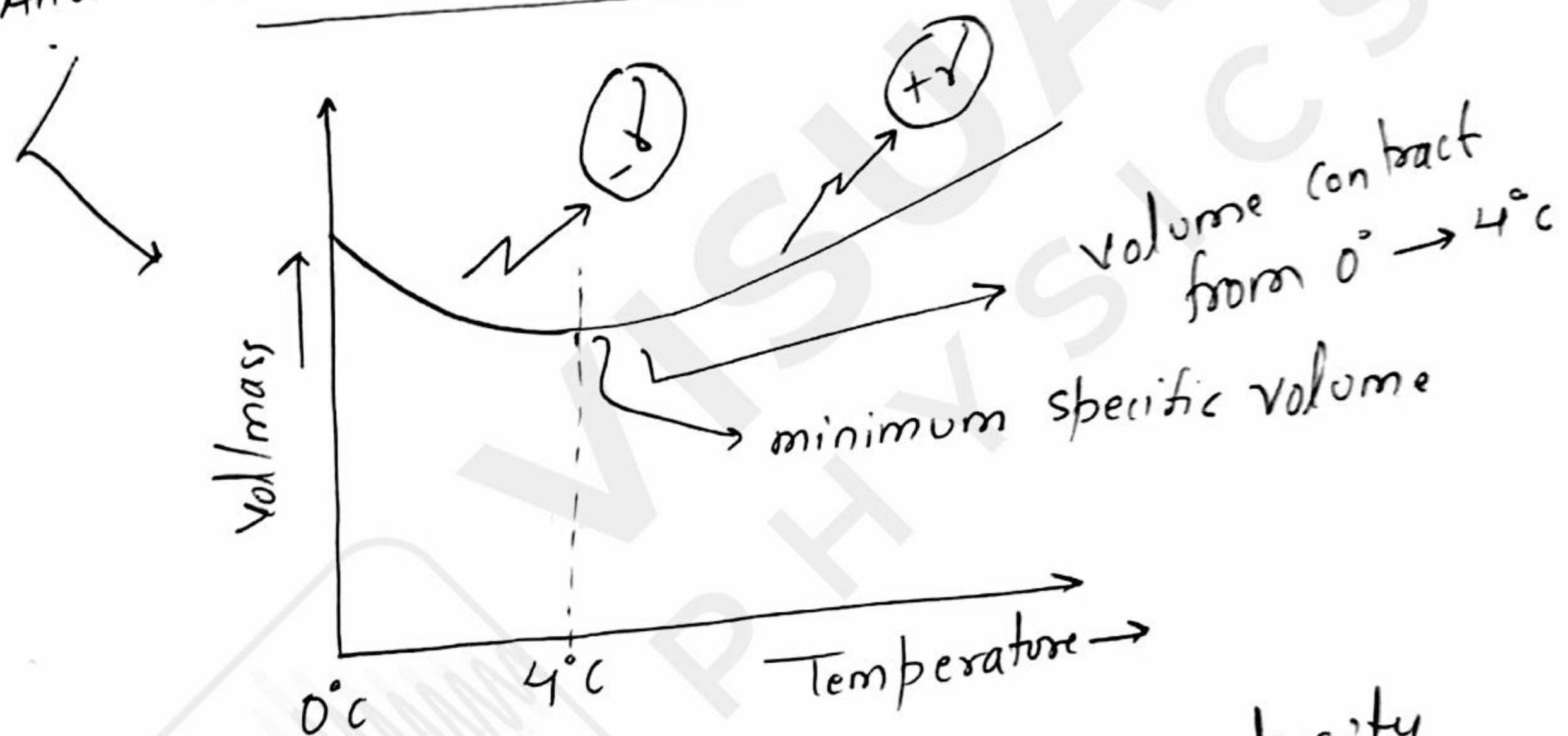


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CALORIMETRY:

↳ Branch of heat transfer deals with the measurement of Heat

It is measured in calories

One calorie: Heat required to raise 1 g of water by 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

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

$$\Rightarrow 1 \text{ J} = \frac{1}{4.18} \text{ cal}$$

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

Thermal capacity & Water Equivalent:

$$\rightarrow \text{Thermal capacity} = \frac{Q}{\Delta T} \quad \begin{array}{l} \rightarrow \text{heat given} \\ \rightarrow \text{change in Temperature} \end{array}$$

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

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

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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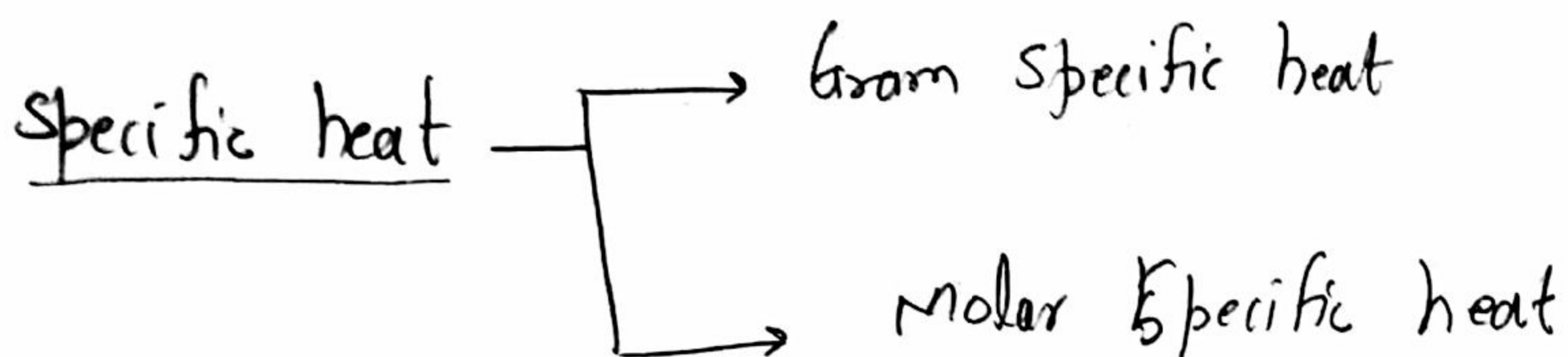
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→ Gram specific heat:

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

$\swarrow$ Gram Specific heat $\nearrow$ heat given or released
 $\downarrow$ mass $\downarrow$ change in Temperature

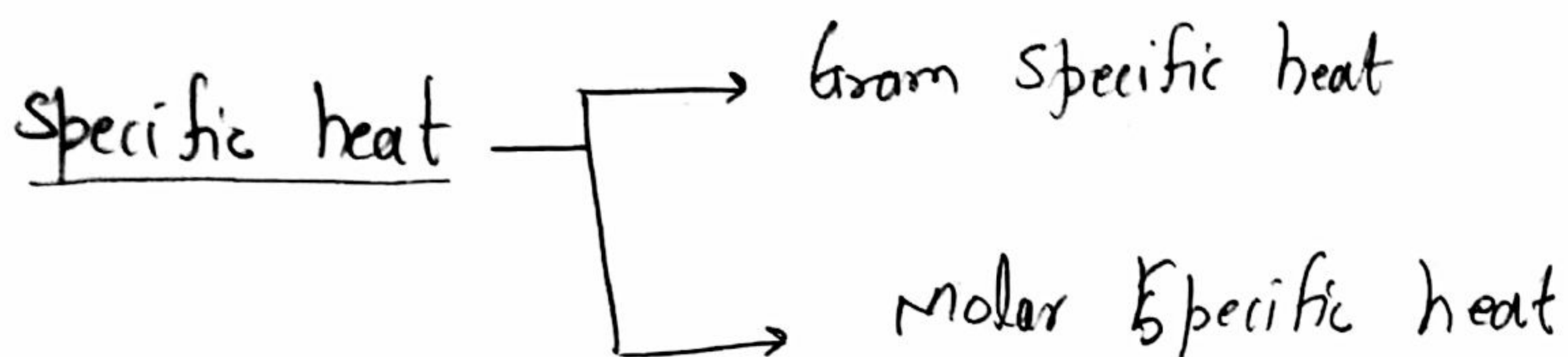
→ heat required per unit mass per unit Temperature (1°C or 1K)

→ molar Specific heat:

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$\swarrow$ molar specific heat $\downarrow$ number of moles

* heat required to increase 1°C or 1K temperature of 1 mole of substance.



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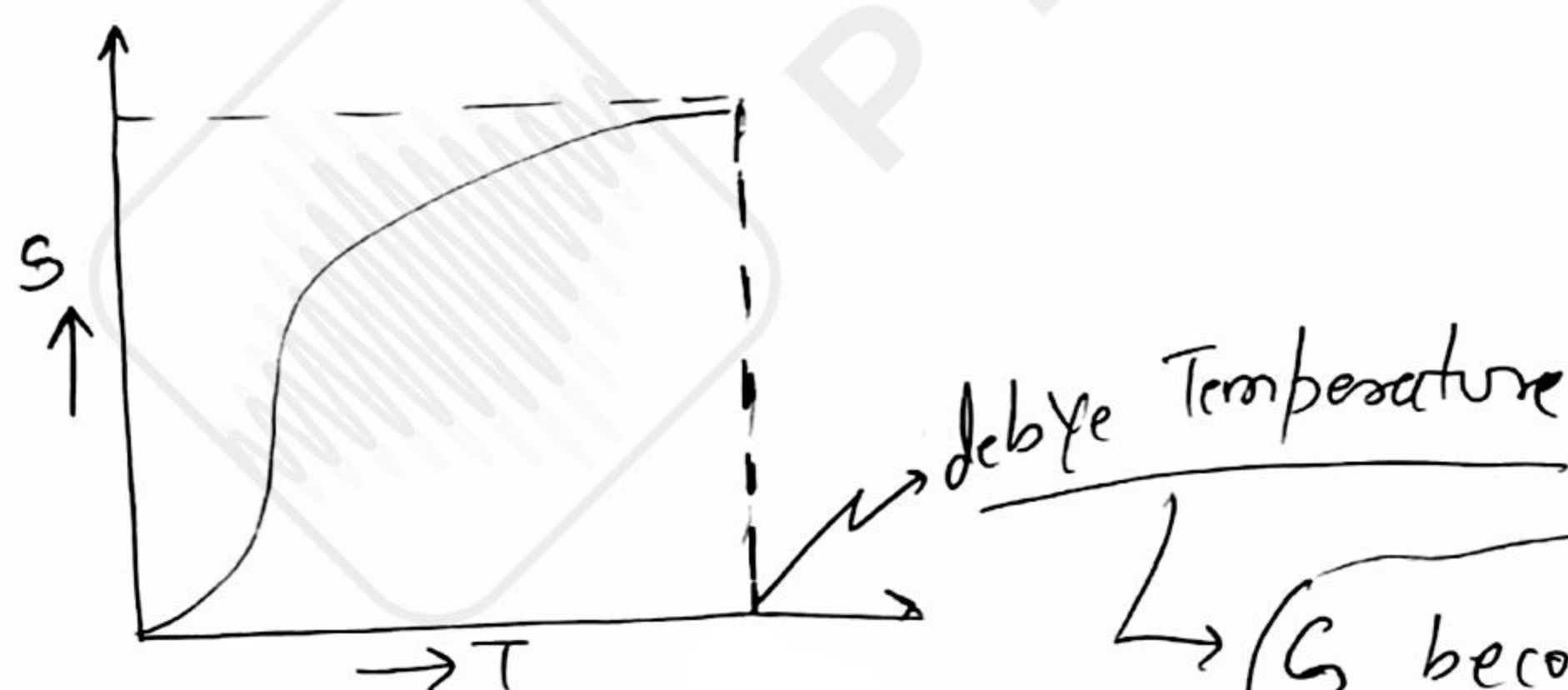
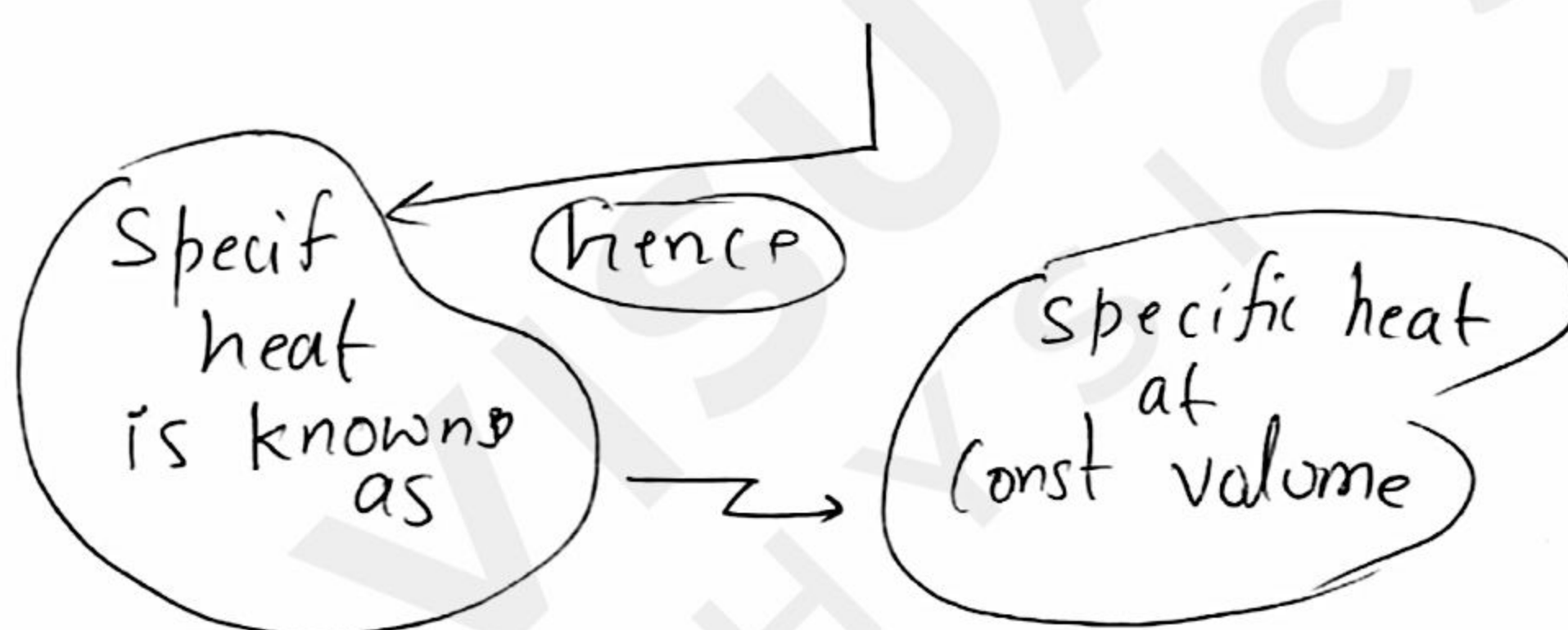
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so, $\boxed{\text{water equivalent} = mS}$ ←
 (if S is in cal/kg K)
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specific Heat of solids:

when solid heated → very less change in volume



S becomes constant after that temperature

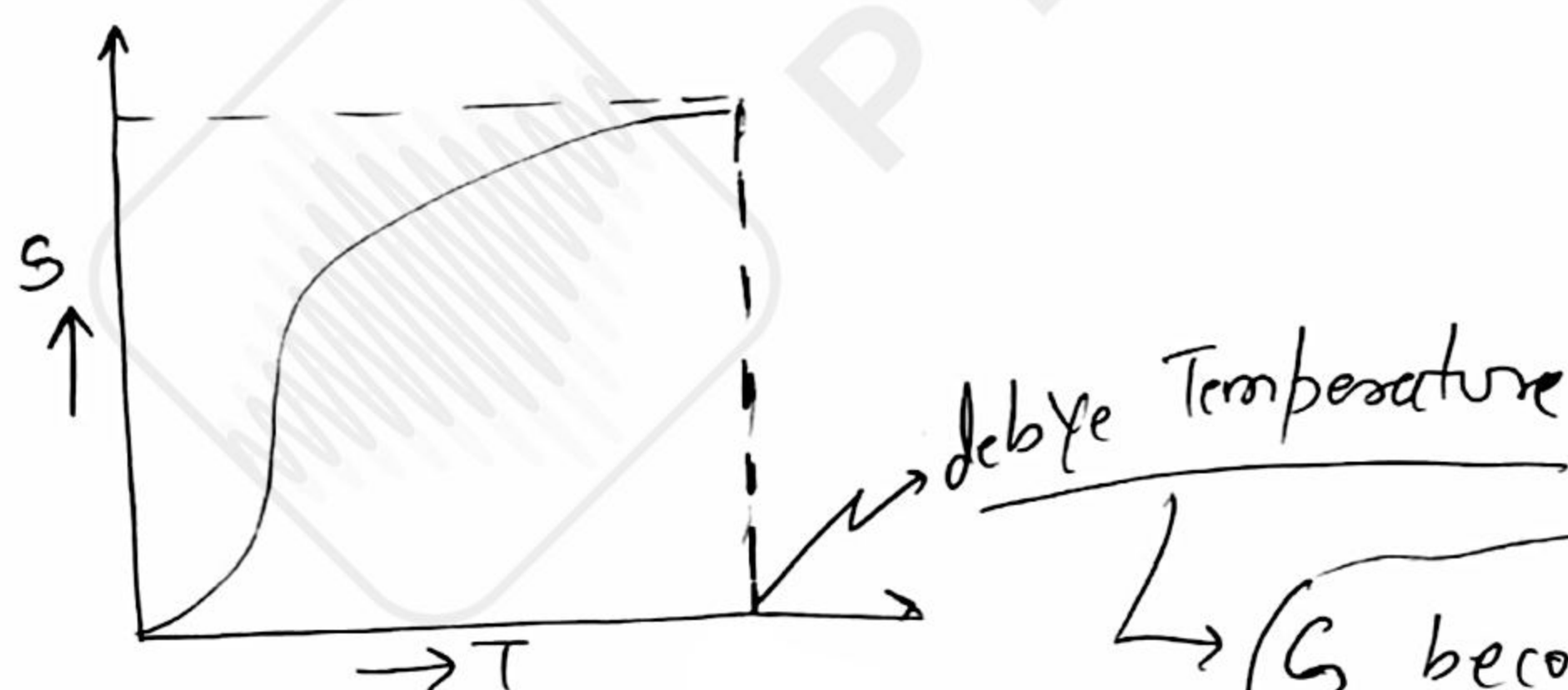
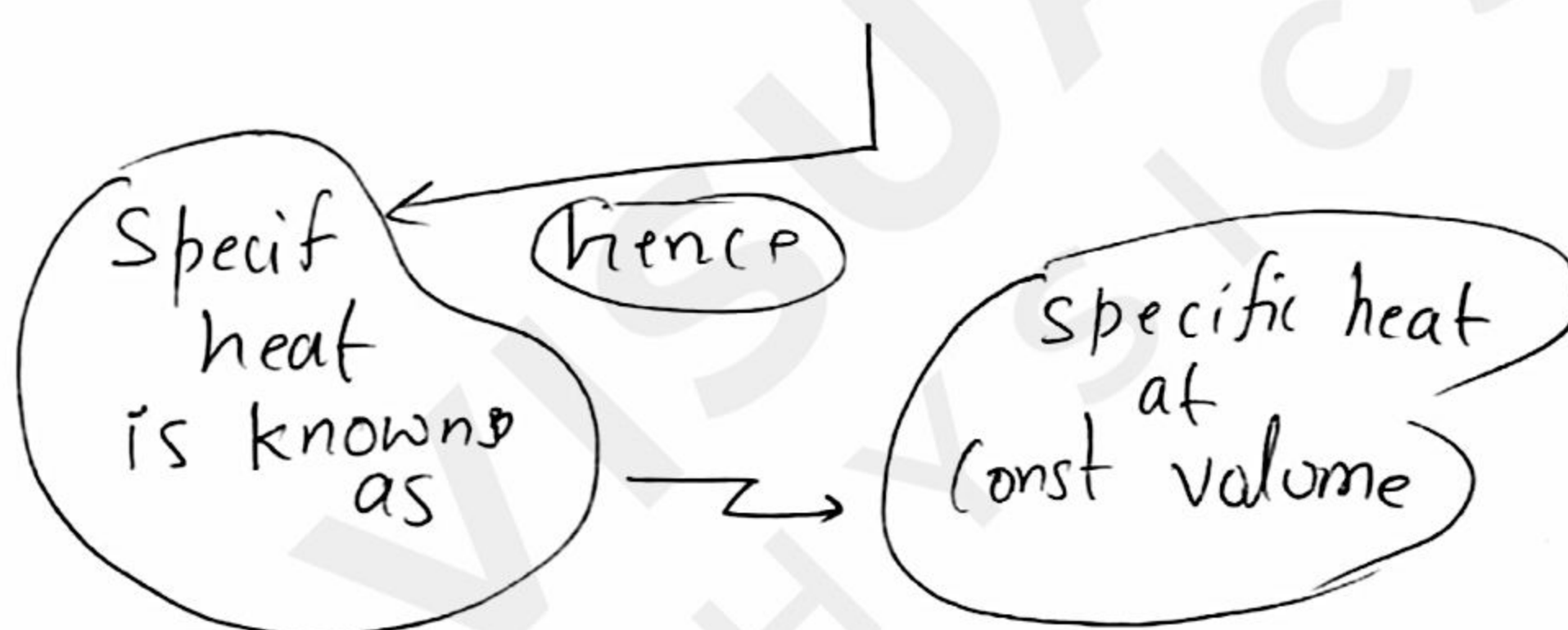
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Debye temperature is close to room temperature

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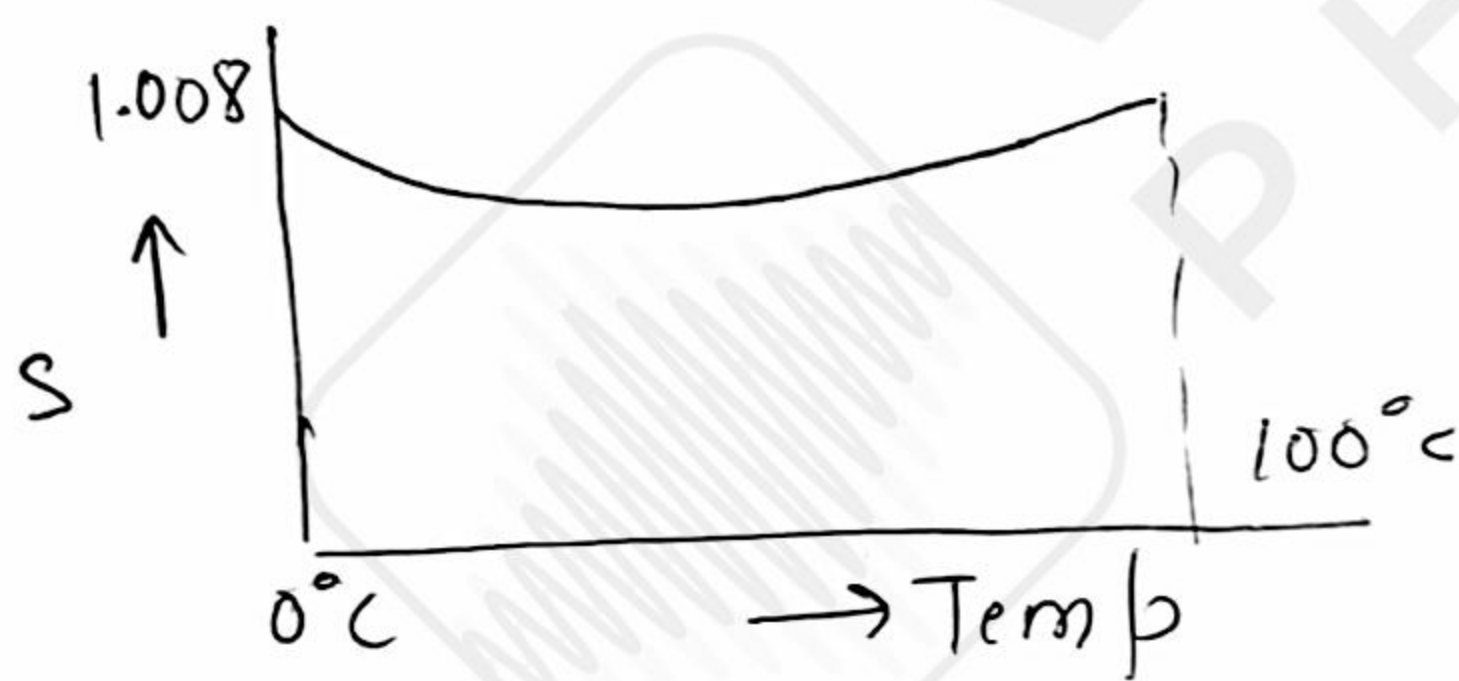
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And very large as well : $1 \text{ cal/g}^\circ\text{C}$
 $\approx 4.18 \text{ J/g}^\circ\text{C}$

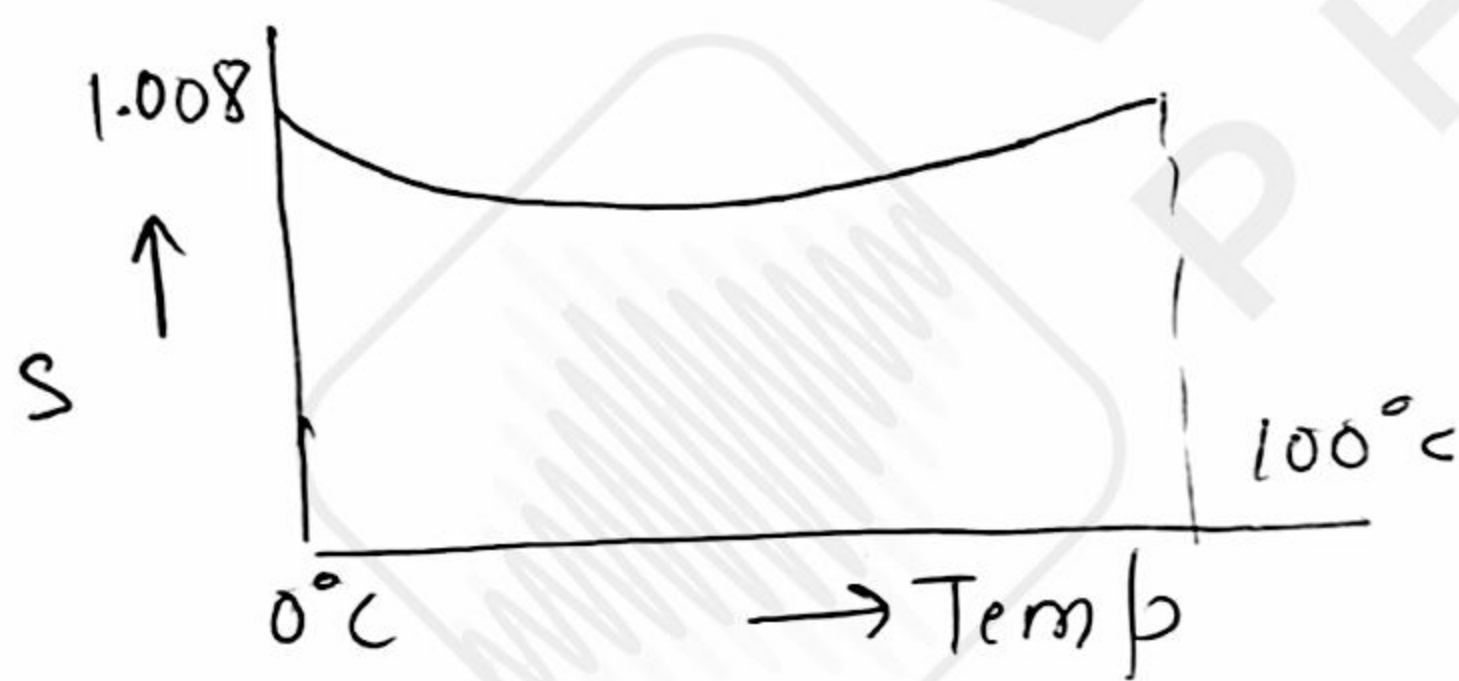
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Latent heat:

- When substance changes its state heat is either liberated or absorbed.
- No change in Temperature during this transition.

→
$$L = \frac{Q}{m}$$
 → heat liberated or absorbed
→ mass

Latent heat

unit cal/g or J/kg [SI]

heat liberated or absorbed per unit mass

→ Latent heat of fusion:

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

→ Latent heat of vaporization:

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

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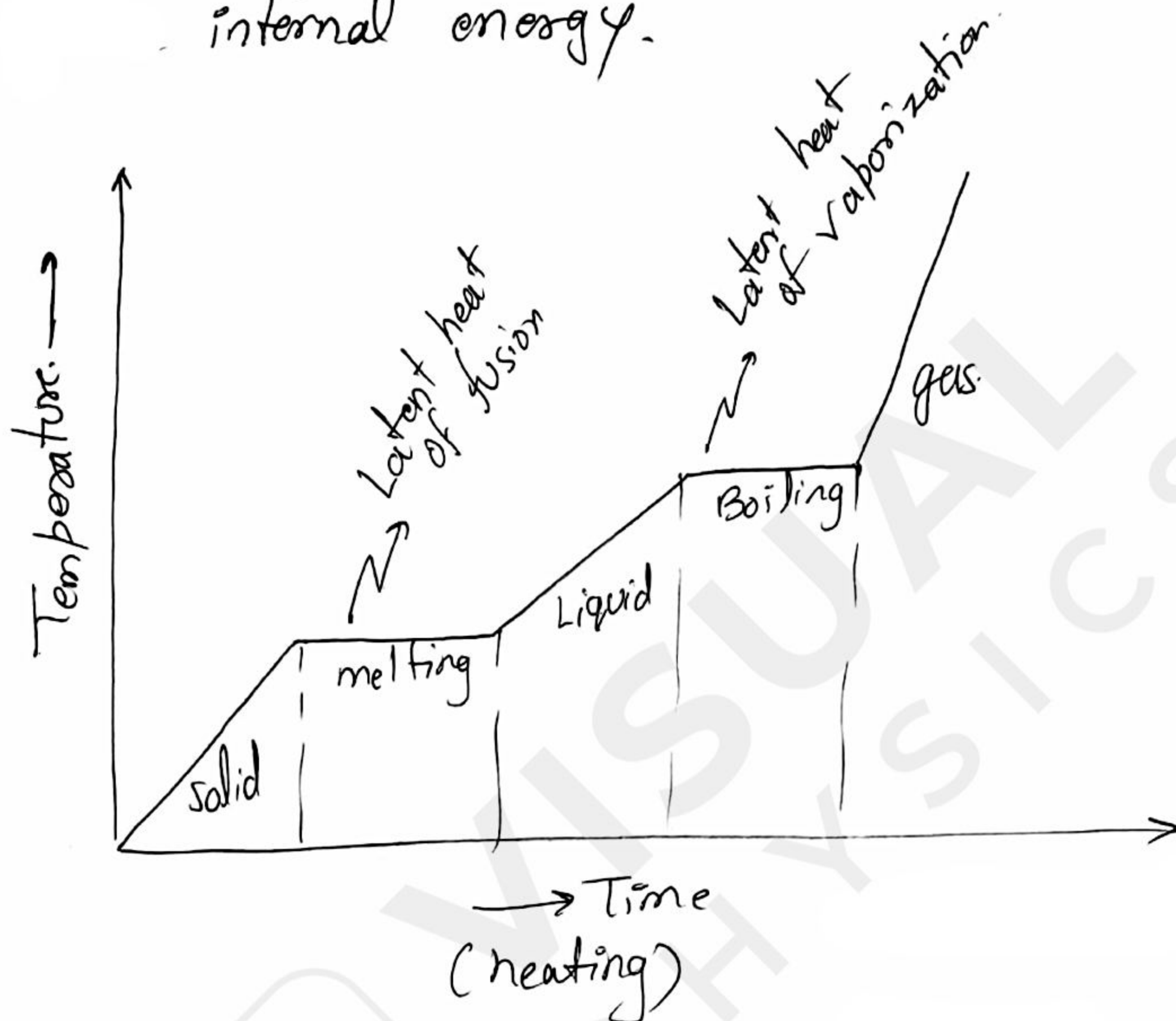
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principle of calorimetry:

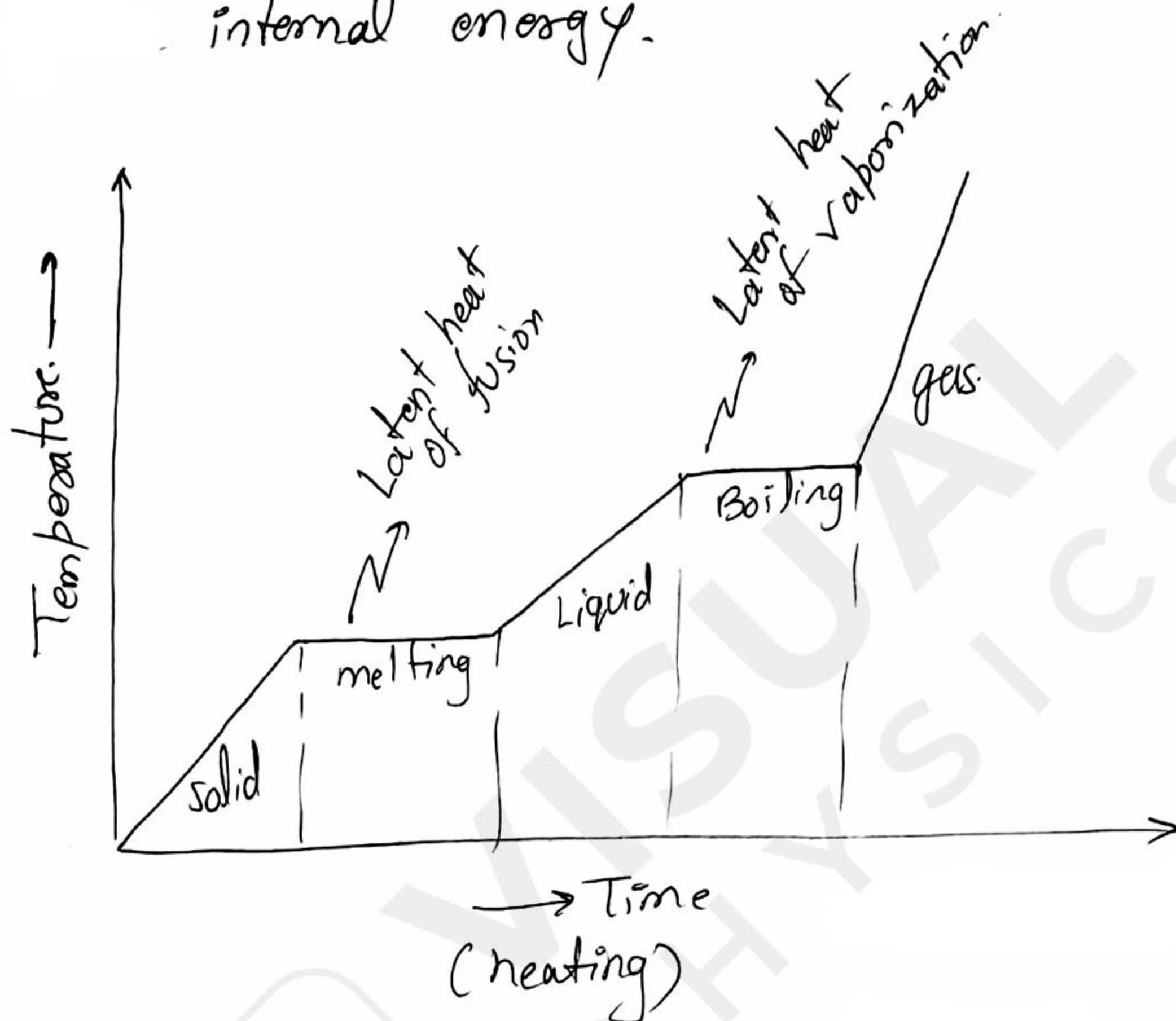
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→ final Temperature $\Rightarrow T_L \leq T_f \leq T_H \rightarrow$ higher temperature
lower temp $\swarrow$ final temp $\nwarrow$

→ 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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