# THERMAL PROPERTIES OF MATTER

## CHANGE OF STATE

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#### Phase change and latent heat

Based on temperature and pressure, matter can exist in different states—solid, liquid, or gaseous. These distinct states are commonly referred to as phases of matter. The energy of molecules in a substance can be altered by providing heat, leading to changes in phase. To illustrate this concept, we'll explore the three phases of $H_2O$ molecules: ice, water, and steam.

Imagine a container containing 1 kg of ice at a temperature of -25°C. The following graph illustrates the alterations in the state of ice over time as additional heat is introduced.

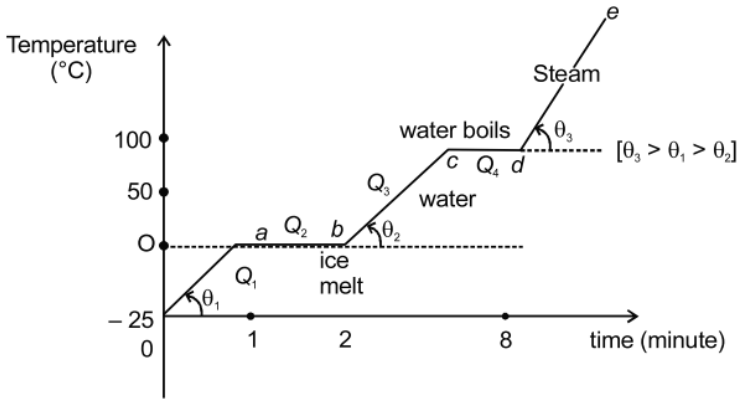


**Fig.:** Graph of temperature vs water for a specimen of water initially in the solid phase (ice)

The heat energy supplied to the system is as follows:

- $Q_1 = 12.5$ kcal (ice)
- $Q_2 = 80$ kcal (melting point of ice)
- $Q_3 = 100$ kcal (phase change from ice to water)
- $Q_4 = 540$ kcal (water)
- $Q_5$ Represents the phase change from water to steam.

The corresponding phases for each segment are as follows:

- Segment $OA$ represents the phase of ice $(a)$.
- Segment $AB$ represents the melting point of ice.

- Segment $BC$ represents the phase change from ice to water ($b$).
- Segment $CD$ represents the phase change from water to steam ($c$).
- Segment $DE$ represents the phase of steam ($e$).

**(i)** Initially, the ice is at a temperature of (-25°C) with a specific heat of 0.5 kcal/kg°C. This means that for every kilocalorie of heat supplied, the temperature of the ice increases by 2°C. When the temperature reaches 0°C, the steady temperature rise stops, and the ice begins to melt. The point $a$ on the curve corresponds to the melting point of ice.

**(ii)** At this point, the temperature remains constant at 0°C while an additional 80 kcal of heat is added. This heat is needed to melt 1 kg of ice at 0°C into water at 0°C. This phase change is indicated by the horizontal line $ab$, signifying the transition from a solid to a liquid without a change in temperature. The heat supplied is utilized to increase the energy of the molecules, allowing them to break free from their bonds in the solid structure and transform into a liquid.

**(iii)** Once all the ice has turned into water, the temperature rises again as further heat is supplied. The specific heat of water is 1 kcal/kg°C, resulting in a temperature rise of 1°C per kilocalorie of heat supplied. This rate of change is lower than that of ice, and thus, the slope of the graph $bc$ is smaller than that of $oa$ . The point $c$, corresponding to 100°C, represents the boiling point of water.

**(iv)** Upon reaching 100°C, the temperature remains constant despite additional heating until a total of 540 kcal is added. This amount of heat is required to vaporize 1 kg of water at 100°C into steam at 100°C. The horizontal portion $cd$ of the graph signifies a phase change from a liquid to a vapor state without a change in temperature. Once again, the supplied heat is used to break the water molecules into free molecules in the gaseous or steam phase.

**(v)** When all the water has transformed into steam, the temperature increases once again. The specific heat of steam is 0.48 kcal/kg°C, resulting in a temperature increase of 2.1°C per kilocalorie of heat supplied. This portion of the graph has a steeper slope compared to those corresponding to ice or water, reflecting the change in the state of steam.