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"What one man calls God, another calls the laws of physics."

-Nikola Tesla

TOPIC 11: THERMAL PROPERTIES

THE ABOUT

CHAPTER ANALYSIS

TIME

- 5 **key** concepts
- Not hard to understand but tricky to apply
- Really need to practice to get better at this topic

EXAM

- Highly tested
- Require calculations heavily

WEIGHTAGE

- Medium overall weightage
- Constitute to around **5%** of marks for past 5 year papers

KEY CONCEPT

INTERNAL ENERGY
INTERNAL KINETIC ENERGY
INTERNAL POTENTAL ENERGY

The hot coffee has a **higher temperature**, but **not more internal energy**.

Although the iceberg has less internal energy per mass due to its lower temperature and being in solid state, its enormously **greater mass** gives it a greater total energy than that in the small cup of coffee.

INTERNAL ENERGY OF A SYSTEM

The **internal energy** of a system is the **sum of its internal kinetic energy & internal potential energy.**

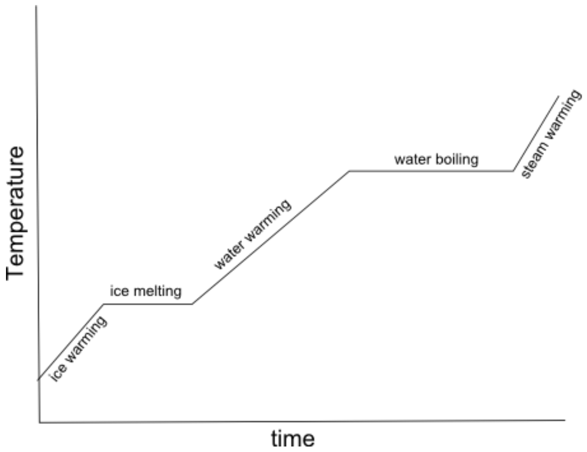
Internal kinetic energy is due to the **motion** of all its particles and depends on **temperature**.

Internal potential energy is due to **intermolecular forces** and depends on their **separation**.

When a body is heated, it either increases its internal kinetic energy (rise in temperature) or increases its internal potential energy (increase separation, change in state).

Heating Graph

Ice warming: internal kinetic energy increases (rise in temperature)
Ice melting: internal potential energy increases (increased separation/change state)
Water warming: internal kinetic energy increases (rise in temperature)
Water boiling: internal potential energy increases (increased separation/change state)
Steam warming: internal kinetic energy increases (rise in temperature)



KEY CONCEPT

THERMAL PROPERTY
HEAT CAPACITY
SPECIFIC HEAT CAPACITY

	Heat Capacity	Specific Heat Capacity
Definition	Amount of thermal energy required to raise the temperature of the body by 1°C or 1K, without any change in state.	Amount of thermal energy required to raise the temperature of a unit mass of a substance by 1°C or 1K, without any change in state.
Equation	$Q = C\Delta\theta$	$Q = mc\Delta\theta$
SI unit	$J\ K^{-1}$ or $J\ (°C)^{-1}$	$J\ kg^{-1}K^{-1}$ or $J\ (kg\ °C)^{-1}$

Heat capacity and specific heat capacity are related as such:

$$C = mc$$

Heat capacity = mass x specific heat capacity

UNDERSTANDING HEAT CAPACITY

When thermal energy is supplied to a body, the body will undergo an increase in internal energy. The internal kinetic energy will increase, hence the **temperature will rise**.

The amount of energy needed to increase the temperature of the **entire body** by 1°C is known as **heat capacity**.

The amount of energy needed to increase the temperature of **1kg of the body** by 1°C is known as **specific heat capacity**.

IMAGINE THIS

You studied too late and you suddenly have a craving for nice shin ramen. You take out the pot and start to boil the water and the water increases from a room temperature of 28°C to 100°C.

The heat supplied to the pot is used to increase the temperature of the water. How much thermal energy, Q, will be needed?

That depends on the specific heat capacity of water & the mass of water.

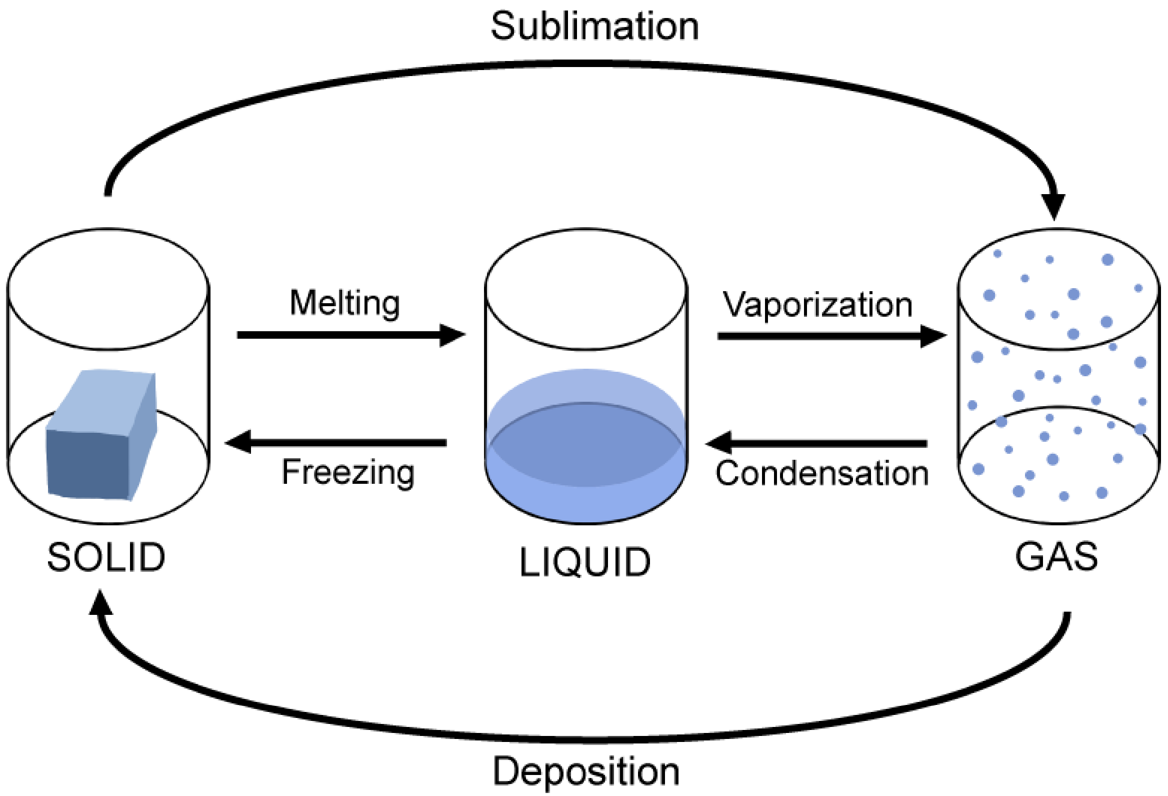
$$Q = mc\Delta\theta$$

Q = Thermal energy
m = mass
c = specific heat capacity
$\Delta\theta$ = change in temperature

KEY CONCEPT

CHANGE IN STATE
LATENT HEAT OF FUSION
LATENT HEAT OF VAPORISATION
EVAPORATION & BOILING

CHANGE IN STATE



MELTING

Energy is absorbed to overcome the attractive forces holding the particles together.

The amount of energy needed to allow a change in state from solid to liquid is known as **latent heat of fusion.**

FREEZING

Energy is released as molecules lose their molecular potential energy and are pulled closer.

The amount of energy released during a change in state from liquid to solid is known as **latent heat of fusion.**

BOILING

Energy is absorbed to overcome the attractive forces & separate the molecules to be far apart.

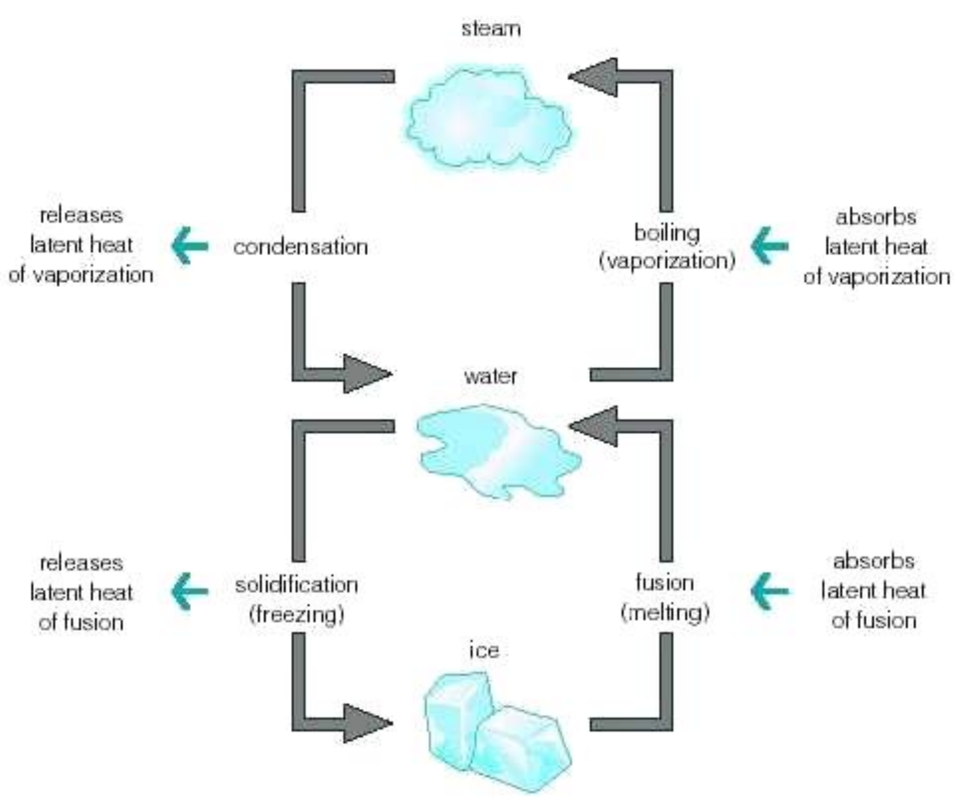
The amount of energy needed to allow a change in state from liquid to gas is known as **latent heat of vaporisation.**

CONDENSATION

Energy is released as molecules lose their molecular potential energy and are pulled closer.

The amount of energy released during a change in state from gas to liquid is known as **latent heat of vaporisation.**

CHANGE IN STATE



The concept is pretty much the same as heat capacity.

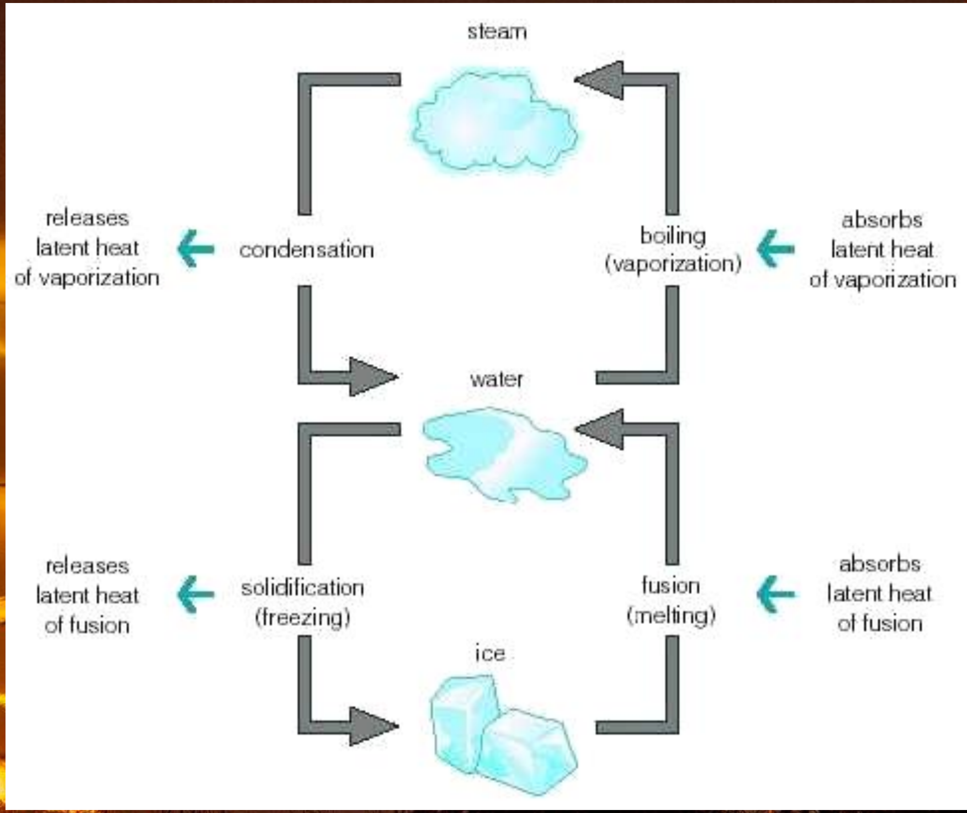
Heat capacity is to **increase temperature**. (change in internal KE)

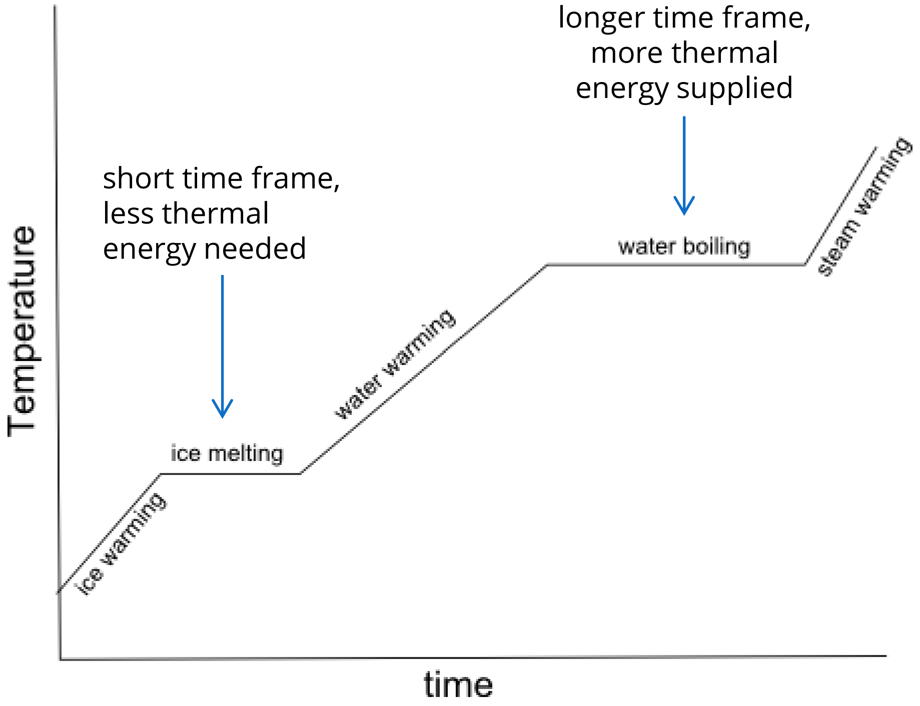
Latent heat is to **change state**. (change in internal PE)

	Latent heat of fusion	**Specific latent heat of fusion**
Definition	Amount of thermal energy needed to change a substance from solid to liquid without any change in temperature.	Amount of thermal energy needed to change **a unit mass** of a substance from solid to liquid without any change in temperature.
Equation		$Q = ml_f$
SI unit	J	J kg^{-1}

	Latent heat of vaporisation	**Specific latent heat of vaporisation**
Definition	Amount of thermal energy needed to change a substance from liquid to gas without any change in temperature.	Amount of thermal energy needed to change **a unit mass** of a substance from liquid to gas without any change in temperature.
Equation		$Q = ml_v$
SI unit	J	J kg^{-1}

CHANGE IN STATE





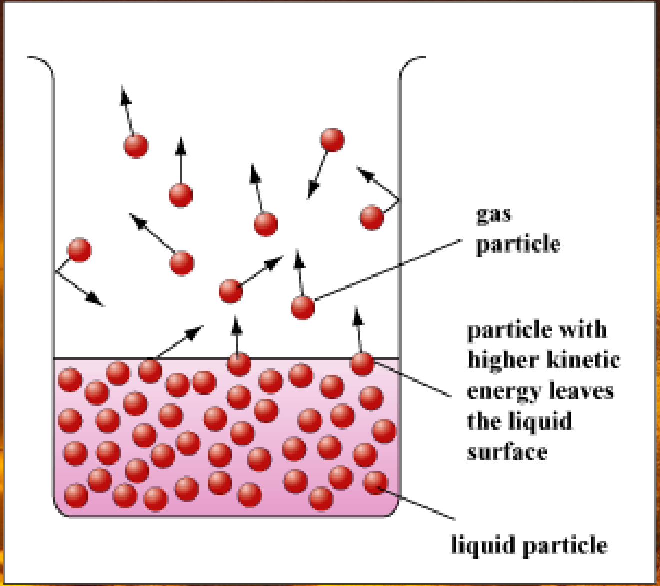
TAKE NOTE!

Latent heat of vaporisation is always **greater than latent heat of fusion.**

The **bond breaking** from **liquid state to gaseous state** requires a large amount of thermal energy as the **intermolecular bonds has to be completely broken** to allow the particles to be far apart.

Furthermore, as **liquid becomes a gas**, **the increase in volume** is more substantial and a huge amount of energy is needed to push the atmospheric pressure away to expand in volume.

EVAPORATION



Why does evaporation occur?

- liquid molecules are in constant random motion and collide with each other continuously

- when the molecules with higher kinetic energy collide with others when it is near the surface of the liquid, it may gain enough energy to overcome the intermolecular forces of the liquid and leave the liquid body

EVAPORATION

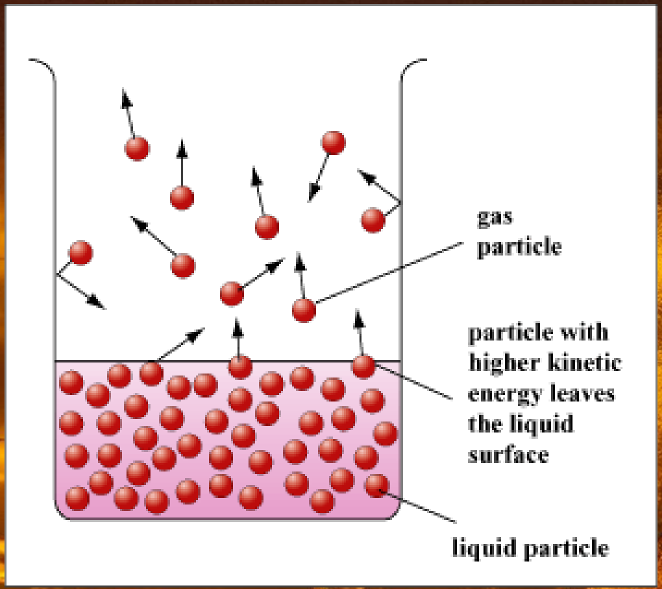
Evaporation is the process by which the **more energetic molecules** at the **surface** of the liquid **overcome the downward attractive intermolecular forces** from other water molecules and **escape** into the surroundings as **gas molecules**.

As the more energetic molecules escape, the **average kinetic energy of the molecules decreases** and the temperature decreases.

Hence, evaporation has a **cooling effect**.

Boiling	Evaporation
Occurs at boiling point	Occurs at any temperature
Occurs throughout the liquid	Occurs at the surface
Bubbles can be seen	No bubbles can be seen
Process is fast	Process is slow
Source of heat required	No direct source of energy needed

EVAPORATION



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FACTORS AFFECTING RATE OF EVAPORATION

Increases when:

- **temperature increases** - higher average kinetic energy of the molecules
- **surface area increases** - liquid molecules are more likely to leave the surface of the liquid
- **humidity decreases** – air is drier, lower likelihood of liquid molecules colliding and rebounding back into liquid
- **wind speed increases** - carries away liquid vapour formed by evaporation and lowers humidity
- **atmospheric pressure decreases** - less air molecules bombard liquid molecules, easier to escape
- **boiling point is low** – liquid is more volatile, easily changes from liquid to gas state

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