NDA-CDS 1 2025

GS

LIVE

PHYSICS

MISCELLANEOUS

CLASS 1

NAVJYOTI SIR

SSBCrack EXAMS

MISCELLANEOUS TOPICS – I

(HEAT TRANSFER)

WHAT WILL WE STUDY ?

- Heat
- Types of Heat Transfer
- Specific Heat
- Terms associated with State Change
- Latent Heat
- Calorimetry

HEAT TRANSFER

- Heat transfer is the movement of heat due to a temperature difference between a system and its surroundings.
- The energy transfer is always from higher temperature to lower temperature.
- The units of heat transfer are the joule (J), calorie (cal), and kilocalorie (kcal).

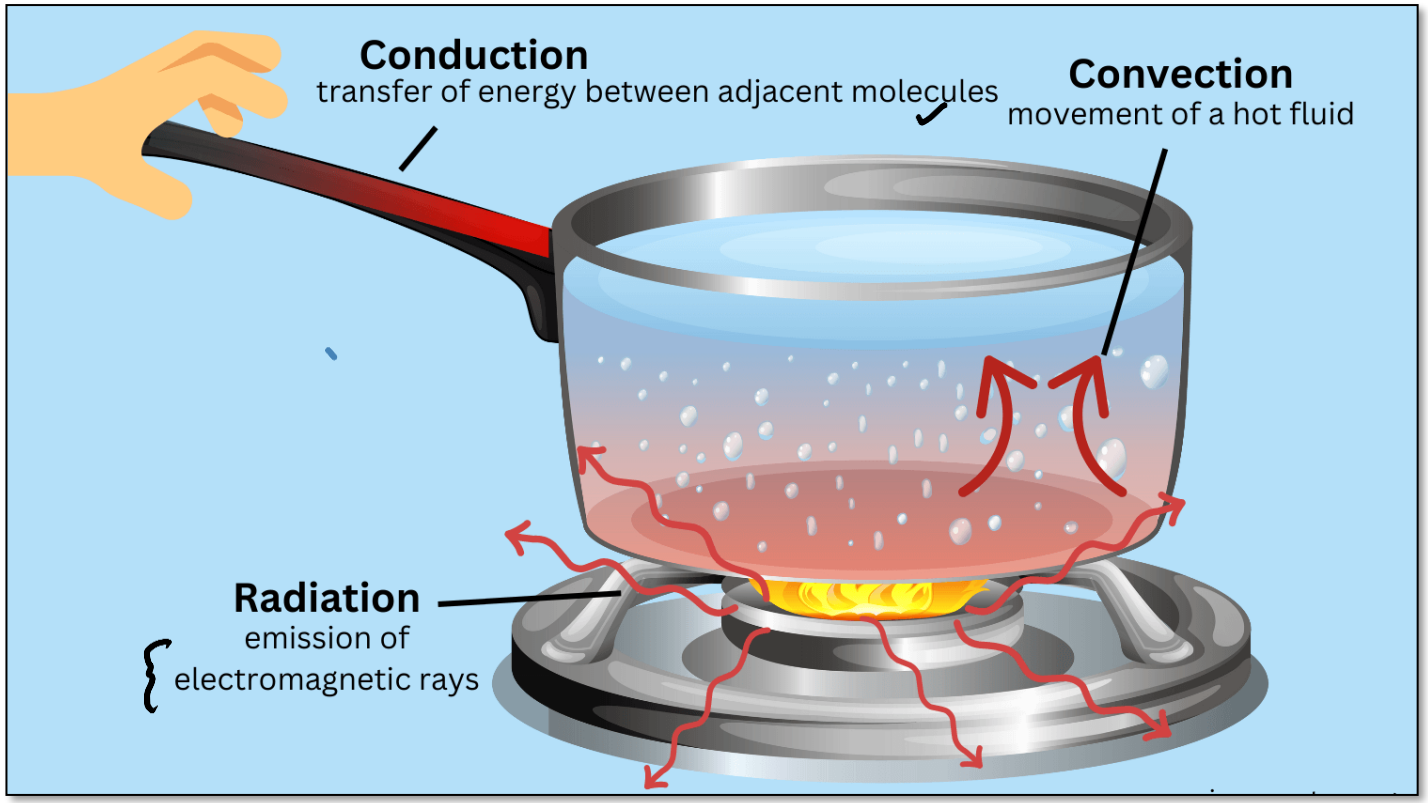
SI / cgs unit (more common)

- The unit for the rate of heat transfer is the kilowatt (KW).

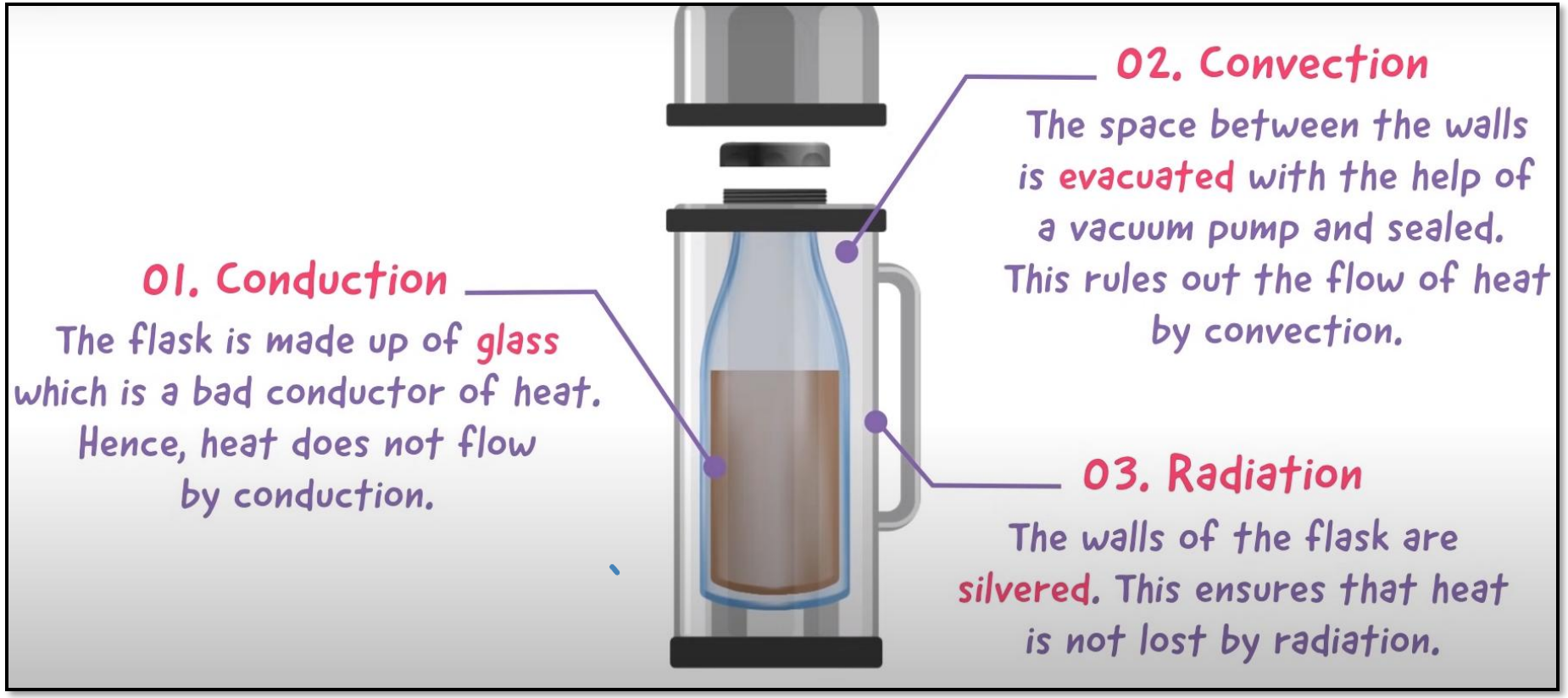
1 cal = 4.18 J

TYPES OF HEAT TRANSFER

- **Conduction** requires contact. → solids
- **Convection** requires fluid flow. → liquids and gases
- **Radiation** does not require any medium.



THERMOS FLASK



SPECIFIC HEAT

- The amount of heat required to raise the temperature of unit mass of the substance through 1°C is called its specific heat. It is denoted by c or s.
- Its SI unit is 'joule/kilogram-°C' (J/kg-°C) or $Jkg^{-1}K^{-1}$

Heat required, $Q = mc\Delta t$

m = mass of the substance,

c = specific heat of the substance

Δt = change in temperature.

Δ - change

$$c = \frac{Q}{m \cdot (\Delta t)}$$

$J\,kg^{-1}\,K^{-1}$ / $cal\,g^{-1}\,°C^{-1}$

- Water has a very high specific heat. It is generally used to cool hot substances.

TERMS RELATED TO CHANGE OF STATE

- **Melting and Melting Point :**

The process of change of state from solid to liquid is called melting. The temperature at which solid starts to liquify is known as the melting point of that solid. The melting point of a substance at atmospheric pressure is called normal melting point.

- **Fusion and Freezing Point :**

The process of change of state from liquid to solid is called fusion. The temperature at which liquid starts to freeze is known as the freezing point of the liquid.

water ⟶ 0°C (273 K)

(Solid and liquid state are at thermal equilibrium)

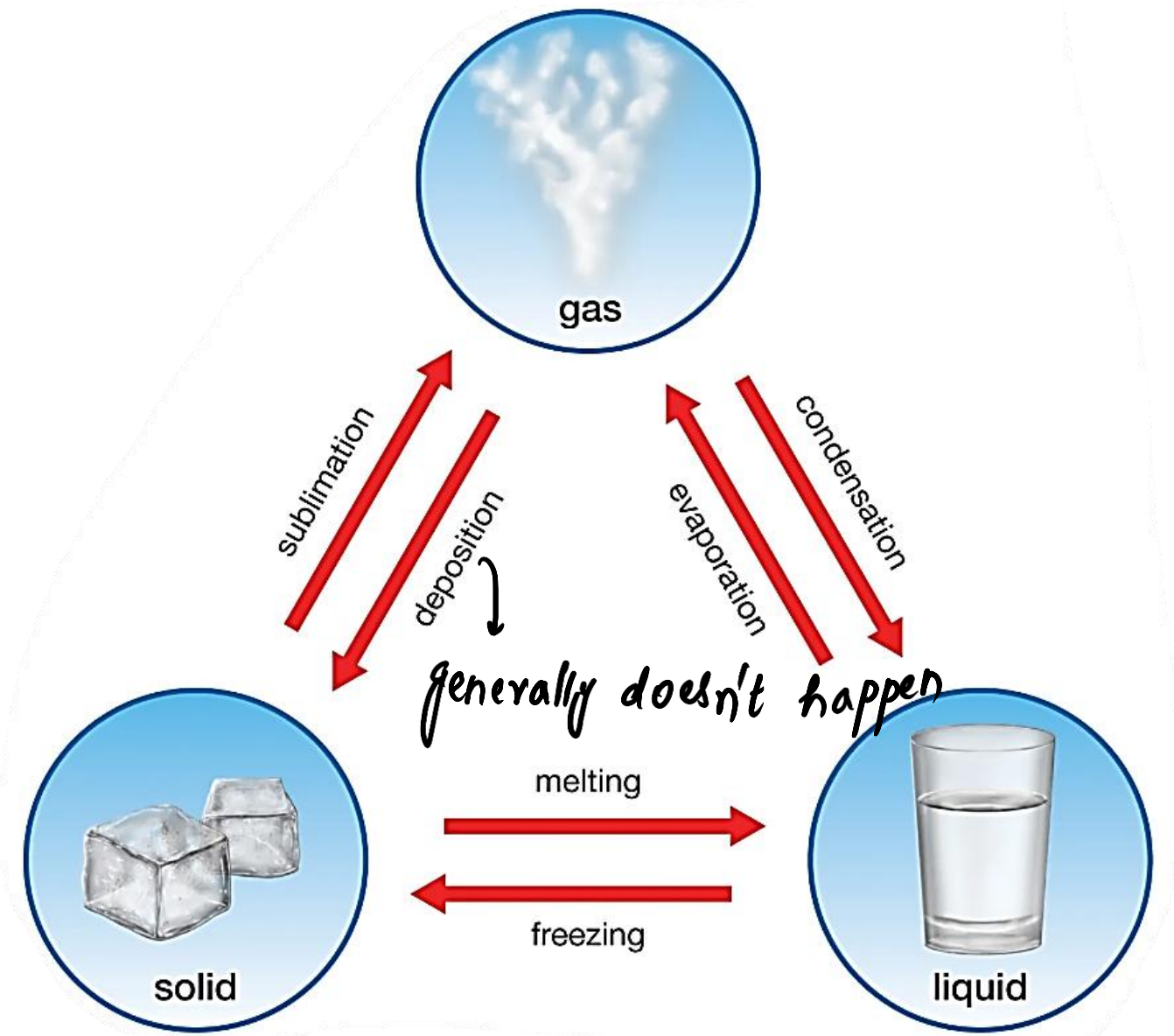
TERMS RELATED TO CHANGE OF STATE

- **Vaporisation :**

- The process of change of state from liquid to vapour (or gas) is called vaporisation. During the change of state (completely), the temperature remains constant which implies both liquid and vapour are at the thermal equilibrium.

- **Sublimation :** The process of change of state directly from solid to vapour (or gas).

↳ Naphthalene balls, Camphor, Ammonium Chloride

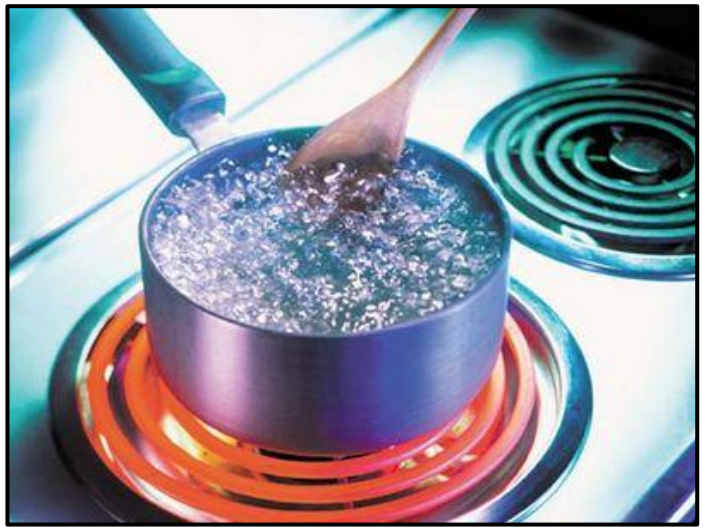


TERMS RELATED TO CHANGE OF STATE

Boiling Point :

At any temperature a liquid partly vaporizes into the space above it until the pressure exerted by the vapour reaches a characteristic value called the vapour pressure of the liquid at that temperature.

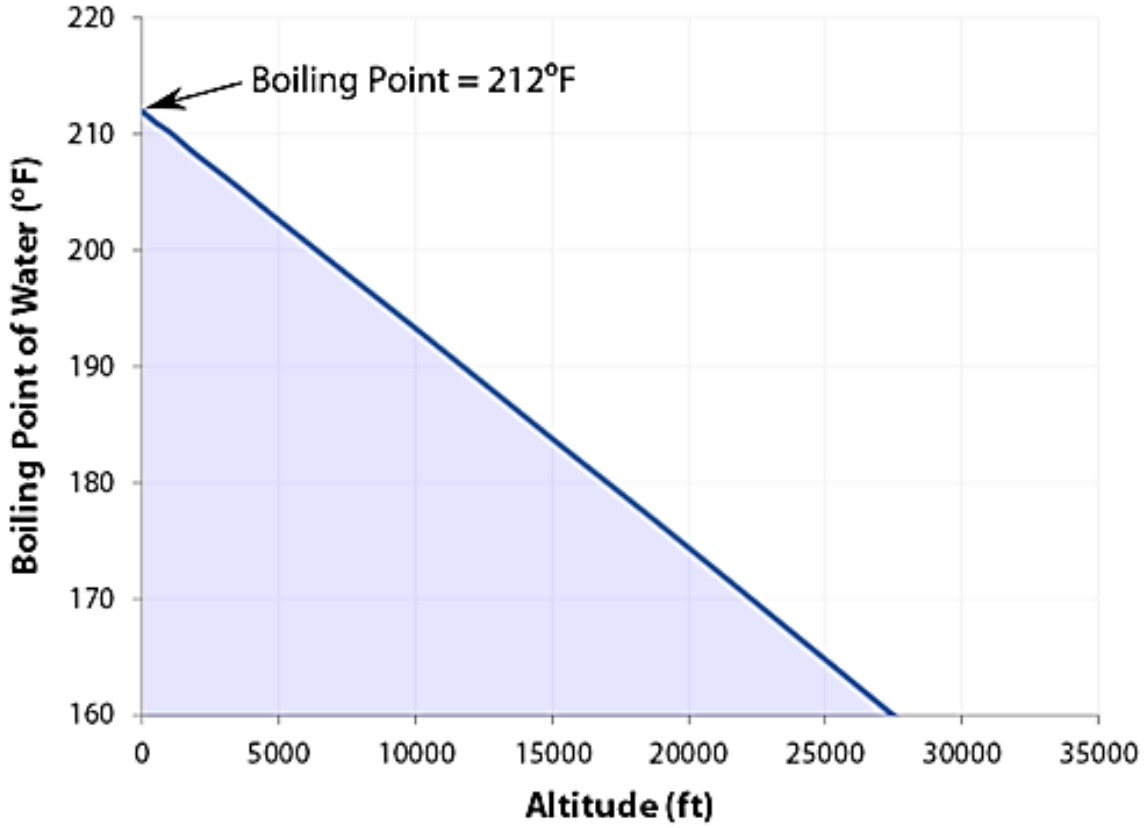
As the temperature is increased, the vapour pressure increases; at the boiling point, bubbles of vapour form within the liquid and rise to the surface. The boiling point of a liquid varies according to the applied pressure; the normal boiling point is the temperature at which the vapour pressure is equal to the standard sea-level atmospheric pressure (760 mm of mercury).



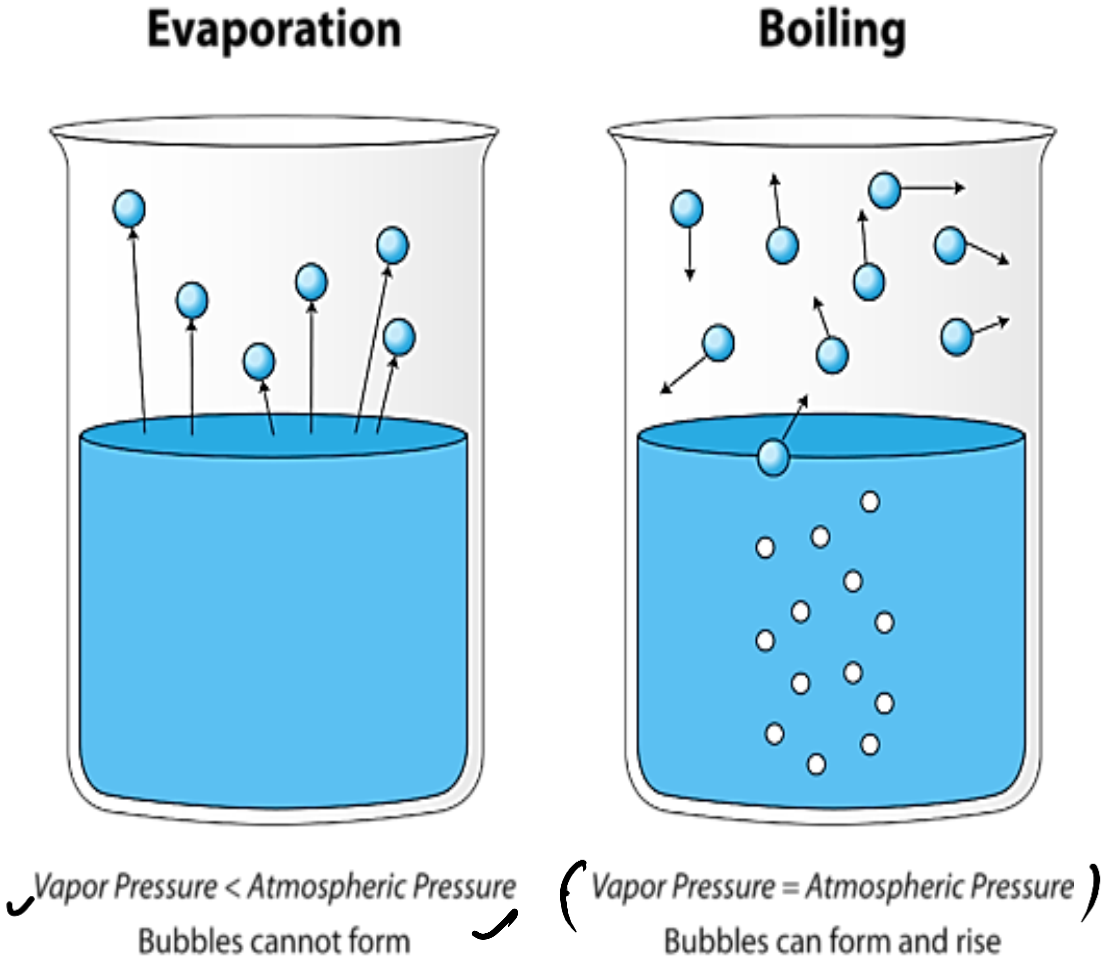
TERMS RELATED TO CHANGE OF STATE

Boiling Point :

At sea level, water boils at 100° C (212° F). At higher altitudes the temperature of the boiling point is lower.



BOILING POINT AND EVAPORATION



In the picture on the left, the liquid is below its boiling point, yet some of the liquid evaporates. On the right, the temperature has been increased until bubbles begin to form in the body of the liquid. When the vapor pressure inside the bubble is equal to the external atmospheric pressure, the bubbles rise to the surface of liquid and burst. The temperature at which this process occurs is the boiling point of the liquid.

LATENT HEAT

- The heat energy absorbed or released at constant temperature per unit mass for change of state is called latent heat.
- Heat energy absorbed or released during change of state is given by

$$Q = mL$$

$$L = \frac{Q}{m}$$

where, m = mass of the substance and L = latent heat.

- Its unit is cal/g or J/kg.

- There are 2 types of Latent Heat : Latent Heat of Fusion and Latent Heat of Vaporisation.

LATENT HEAT OF FUSION

- The amount of heat required to change the state of unit mass of a substance from solid to liquid at its melting point is called latent heat of fusion.
- In case of ice the latent heat of fusion of ice is 80 cal/gm.

LATENT HEAT OF VAPORISATION

- The amount of heat required to change the state of unit mass of a substance from liquid to vapour at its boiling point is called latent heat of vaporisation.
- In case of water the latent heat of vaporisation is 536 cal/gm.

Latent heat of vaporisation > Latent Heat of fusion

Solid $\xrightarrow[\text{Heat}]{\text{Less}}$ Liquid $\xrightarrow[\text{Heat}]{\text{More}}$ Gas

HEAT CAPACITY OR THERMAL CAPACITY

The heat capacity of a body is defined as the amount of heat required to raise its temperature through one degree.

$$\text{Heat capacity} = \text{Mass} \times \text{Specific heat}$$

Unit → $kg\ (J\,kg^{-1}\,K^{-1}) \longrightarrow JK^{-1}$

or, $cal\ {}^{\circ}C^{-1}$.

Specific heat,

$$s = \frac{Q}{m(\Delta T)} \quad (J\,kg^{-1}\,K^{-1})$$

WATER EQUIVALENT

Mass of water which requires the same amount of heat as is required by the given body for the same rise of temperature.

Unit → Mass (kg, g)

(water) H_w = $H_{substance}$ (H_s)

$m_w \times S_w \times (\Delta T) = m_s \times S_s \times (\Delta T)$

$m_w \times S_w = m_s \times S_s$

$$m_w = \frac{m_s \times S_s}{S_w}$$

m → mass

S → specific heat

ΔT → change in temperature

Thermal capacity of substance / specific heat of water

CALORIMETRY

- Branch of heat transfer that deals with the measurement of heat. The heat is usually measured in calories or kilo calories.
- Principle of Calorimetry : When a hot body is mixed with a cold body, then heat lost by hot body is equal to the heat gained by cold body.

  Heat lost = Heat gain , following the law of conservation of energy.

CALORIMETRY

If two substances having masses m_1 and m_2, specific heats c_1 and c_2 kept at temperatures T_1 and T_2 $(T_1 > T_2)$ are mixed, such that temperature of mixture at equilibrium is T_{mix}.

Heat Lost by body 1 = Heat gained by body 2

$(T_2 < T_{mix} < T_1)$

$$m_1 c_1 (T_1 - T_{mix}) = m_2 c_2 (T_{mix} - T_2)$$

$$m_1 c_1 T_1 + m_2 c_2 T_2 = T_{mix} (m_2 c_2 + m_1 c_1)$$

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

NEWTON's LAW OF COOLING

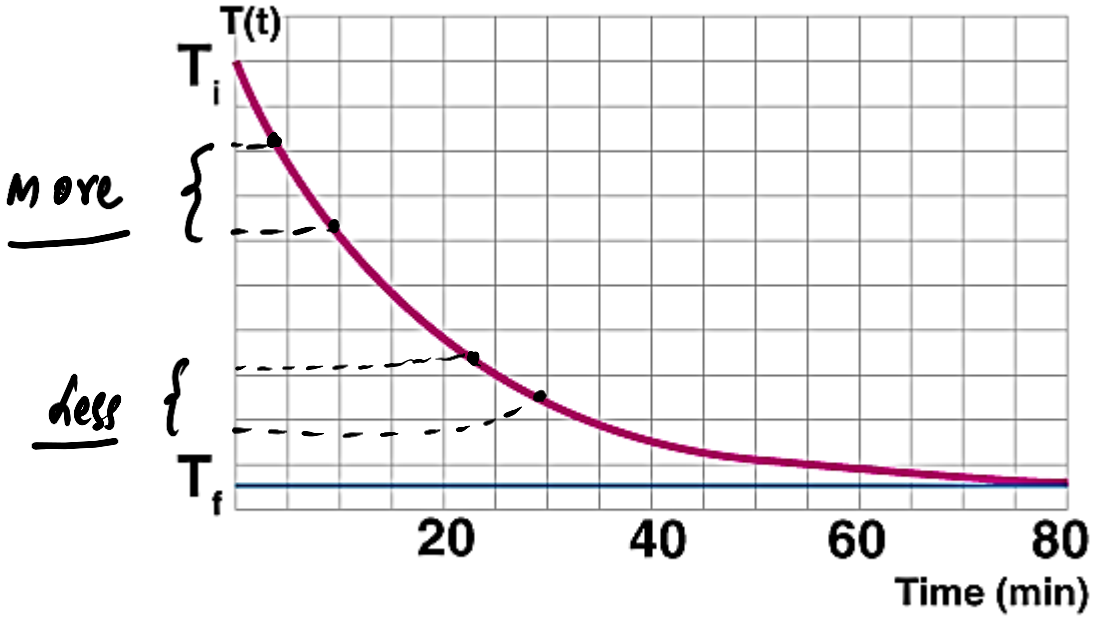
It describes the rate at which an exposed body changes temperature through radiation, which is approximately proportional to the difference between the object's temperature and its surroundings, provided the difference is small.

$$\frac{dT}{dt} \propto T - T_0$$

($\frac{dT}{dt}$ → (change in temperature with time))

$T \longrightarrow$ body's temperature

$T_0 \longrightarrow$ surrounding's temperature



Newton's Law of Cooling – Temperature vs Time

HEAT TRANSFER - MCQs

Thermal capacity of a body depends on the

(a) mass of the body only

(b) mass and shape of the body only

(c) density of the body

(d) mass, shape and temperature of the body

Thermal capacity = mass × specific heat

Thermal capacity — mass

fixed for any substance

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ANSWER : (A)

In which of the following phenomena do heat waves travel along a straight line with the speed of light ?

(a) Thermal conduction

(b) Thermal convection

(c) Thermal radiation

(d) Both, thermal conduction and radiation

EM waves ⇒ Radiation

In which of the following phenomena do heat waves travel along a straight line with the speed of light ?

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ANSWER : (C)

Which of the following statements about specific heat of a body is/are correct ?

1. It depends upon mass and shape of the body
2. It is independent of mass and shape of the body
3. It depends only upon the temperature of the body

Select the correct answer using the code given below :

(a) 1 only

(b) 2 and 3

(c) 1 and 3

(d) 2 only

$$c = \frac{Q}{m(\Delta T)}$$

specific heat is constant for a given substance.

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ANSWER : (D)

Which of the following represents a relation for 'heat lost = heat gained'?

(a) Principle of thermal equilibrium

(b) Principle of colors

(c) Principle of calorimetry

(d) Principle of vaporization

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ANSWER : (C)

Which one among the following statements with reference to the properties of water is ***not*** correct ?

(a) The specific heat of water is abnormally high. ✓

(b) Latent heat of fusion of water is very low. ✗

(c) Density of water is higher than ice. → ice floats on water

(d) Pure water is a non-conductor of electricity. → pure water (distilled water) → does not contain ions

Latent heat of fusion of water is high.

Which one among the following statements with reference to the properties of water is ***not*** correct ?

(a) The specific heat of water is abnormally high.

(b) Latent heat of fusion of water is very low.

(c) Density of water is higher than ice.

(d) Pure water is a non-conductor of electricity.

ANSWER : (B)

On a day when I am in hurry to go to office, I have a fixed quantity of rice which was just cooked and kept in a bowl. In order to cool it quickly, which one of the following is the best option?

(a) Let it be kept on the table in a room where there is no fan, no air conditioner

(b) Let it be kept in a room with AC set at a temperature around 23 °C and a ceiling fan (or table fan) operating at slow speed

(c) Let it be kept in a bowl of water (at room temperature) and operating a ceiling fan (or table fan) at full speed

(d) Let it be kept in a bowl of water at room temperature only

→ evaporation ↑ if wind speed ↑

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ANSWER : (C)

Which one of the following heat transfers is an example of convection ?

(a) Heating of food in a microwave oven

(b) Boiling water in a pot on a gas stove

(c) Feeling the warmth in sun

(d) Heating a brass rod at one end and observing the temperature rise at the other end

microwaves → radiation

convection

Radiation

conduction

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ANSWER : (B)

Which one of the following statements best defines the concept of heat ?

(a) The transformation of energy from one form to another

(b) The conversion of energy into mass and vice-versa due to temperature difference

(c) The transfer of energy due to temperature difference

(d) The change in volume of a substance with temperature

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ANSWER : (C)

Given below are the four cases in which certain heat transfer is taking place :

1. Ice is melting in a glass full of water
2. Water is boiling in an open container
3. A metal rod is heated in a furnace
4. A cup of coffee is allowed to cool on a table

In which of the above cases, the Newton's Law of Cooling is applicable ?

(a) 1 only

(b) 4 only

(c) 1 and 4 only

(d) 1, 2 and 3

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ANSWER : (B)

Which of the following statements about latent heat for a given substance is/are correct ?

1. It is fixed at a given temperature.
2. It depends upon the temperature and volume.
3. It is independent of temperature and volume.
4. It depends on the temperature but independent of volume.

Select the correct answer using the code given below :

(a) 2

(b) 1 and 3

(c) 4 only

(d) 1 and 4

~ ✓ changes with temperature,

~

q does not change with volume,

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ANSWER : (D)

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