Thermal Expansion

= kinetic theory of matter:-

1) All MATTER IS MADE UP OF TINY PARTICLE:-
Everything (solid, liquid, gas) is made up of atoms or molecules.

2) PARTICLES ARE ALWAYS IN MOTION:-
-> In solids:- vibrate in place.
-> In liquids:- slide past each others.
-> In gases:- move freely in all directions.

3) MORE HEAT => FASTER MOVEMENT:-
• When temperature increases, particles move faster.
• When temperature decreases, particles move slower.

4) SPACES BETWEEN PARTICLES VARY:-
-> Solids: very close
-> Liquids: Slightly apart
-> Gases: Far apart.

5) PARTICLES COLLISIONS CAUSE PRESSURE:-
In gase particles hit the wall of the container, it creates pressure.

6) EXPLAIN CHANGES OF STATE:-

→ Melting, boiling, freezing etc. happen due to change in particles energy & movement.

Q1:- Why do our glasses get blury after coming out of an ac (Air conditioned) car?

⇒ When you are inside an AC car, the air is cool & dry & your glasses become cold too.

⇒ But as soon as you step out into the hot & humid air outside, the moisture in the warm air comes into contact with your cold glasses. This cause the water vapour to condense on the lenses, forming tiny droplets, making your glassess blurry & foggy.

IN SHORT :-

Cold Glasses + Warm humid + = Condensation = Foggy lenses.

Same applies for the formation of vapors outside a glass which is cold.

Slo. based Questions:-

Q1:- Explain why glassers get blurry after coming out of an AC room or car?
Q2: Why water vapour forms outside the surface of the bottle or glasses when cold water is pour into glass or bottle?
Q3: Explain why ice floats on water?

thermal expansion:-

[Some slo based important qna]

Q: Why do power line sag between poles?
→ The wires of electricity are made loose because in summer, it expands & in winter it is compressed so to make these wires suitable for summers & winters both we keep them loosen

Q: Why do bridges have gaps?
→ Bridges have gaps (also known as) expansion joints) to accommodate for the expansion & contraction of the bridge materials due to temperature changes. These gaps prevent the bridge from cracking, distorting or even failing as the materials expand in heat & contract in cold.

EXAMPLE OF THERMAL EXPANSION:-

→ Bridges & railway tracks.
→ Bimetellic strips.
→ Murcury Thermometer.
→ Engine parts.
→ Feul Tank Overflow.

SLO BASED:-

Q:- Why there are sac in bridge?
Q:- How the sac helps in flow of current in electric transformation?
Q:- Explain briefly why there are sacs in train tracks?

DEFINATION:-

Thermal expansion is the increase in size [length, area, volume] of a substance when its temperature increase.

> It happens when a substance is heated.
> Its particle gain energy.
> The move faster & vibrate more.
> This increase the space between particles, causing the substance to expand

TYPES OF THERMAL EXPANSION:-

>> LINEAR EXPANSION:-

Increase in length (seen in rods, wires)

>> AREA EXPANSION:-

Increase in surface area.

>> VOLUMETRIC EXPANSION:-

Increase in volume (important in liquids & gases)

Example:-

✓ Railway tracks have small gaps to allow for expansion in summer.

✓ Electric wires sag more in summer due to expansion.

✓ Liquid in a thermometer expands when heated, showing the temperature.

Linear Expansion:-

>> It is the increase in the length of a solid subject when its temperature is heated

>> When a solid is heated, its particles vibrate faster, They move slightly further apart, this cause the length of the object to increase.

Example:-

✓ RAILWAY TRACKS:-

Small gaps are left to allow expansion in summer.

✓ ELECTRIC WIRES:-

They sag more in summer due to expansion.

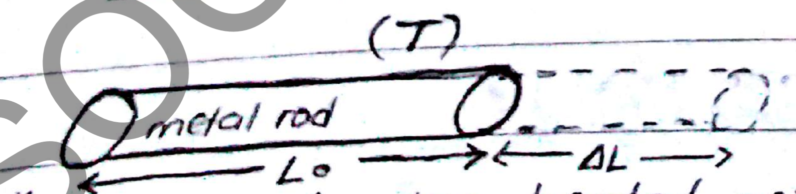
✓ METAL RODS:-

Used in lab experiments to study expansion.

IN SIMPLE WORDS:-

MORE HEAT → MORE PARTICLE MOVEMENT → MORE SPACE BETWEEN → EXPANSION.

derivation:-



* metal rod when heated get elongated*

① Original length (L_0)

② Temperature (T)

③ Nature of material (

$\Delta L \propto \Delta T$ ∴ ΔT = change in temperature

$\Delta L \propto L_o$

By combining eq (1) & (2) then,

$\Rightarrow \Delta L \propto L_o \Delta T$

$\Rightarrow \Delta L = (\text{constant})\, L_o \Delta T$

constant = α

$\Rightarrow \boxed{\Delta L = \alpha L_o \Delta T}$

derivation of formula of linear thermal expansion

$\Rightarrow \Delta L = \alpha L_o \Delta T$

$\Rightarrow \dfrac{\Delta L}{L_o \Delta T} = \alpha$

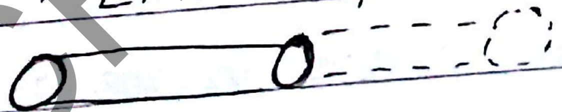
$\Rightarrow \boxed{\alpha = \dfrac{\Delta L}{L_o \Delta T}}$ ✓

∴ $\alpha = K'$

alpha is the constant of proportionality which says that $L_o \Delta T \propto \Delta L$.

THERMAL EXPANSION :-

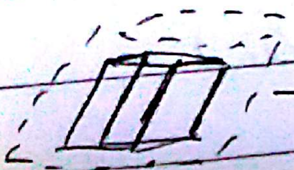
→ Linear expansion:- (one dimensional)



→ Area expansion:-

(Two dimensional)

→ Volumetric expansion:-



→ (Three dimensional)

SLO BASED QNA:-

? How does the type of material affect thermal expansion.

? What is the role of temperature change in thermal expansion?

? How do the original dimensions of an object influence its expansion?

? Why do metals expands more than glasses when heated?

Volumetric Expansions:-

DEFINATION:-

Volumetric thermal expansion is the increase in a materials volume when its temperature rises. As particles move more with heat, they spread out causing expansion.

→ length & volume expansion are scalar quantities because they have only magnitude not direction.

IT DEPENDS ON:-

→ Initial Volume (V_0)

→ Temperature change (ΔT)

→ Materials Nature (β)

DERIVATION:-

(PKMZ <3:)

$\Delta V \propto V_o \longrightarrow (i)$

$\Delta V \propto \Delta T \longrightarrow (ii)$

By combining eq(i) & (ii) then:-

$\Rightarrow \Delta V \propto V_o \Delta T$

$\Rightarrow \Delta V = (\text{constant}) V_o \Delta T$

$\Rightarrow$ constant $= \beta$

∴ Beta will tell if we change temperature of an object to 1K then how much expansion will be in objects volume

$\Rightarrow \Delta V = \beta \Delta T V_o$

$\Rightarrow \boxed{\beta = \frac{\Delta V}{V_o \Delta T}}$ → Derived formula

$\Rightarrow \beta = \frac{\Delta V}{V_o \Delta T} \Rightarrow \beta = \left(\frac{\Delta V}{V_o}\right) \times \frac{1}{\Delta T}$

$\Rightarrow \beta = \left(\frac{\Delta V}{V_o}\right) \times \frac{1}{\Delta T} \Rightarrow \beta = \frac{(\Delta V / V_o)}{\Delta T}$

$\Rightarrow \frac{\text{change in volume / original volume}}{\text{change in temperature}} = \beta$

$\Rightarrow \frac{\text{fractional change in volume}}{\text{change in temperature}} = \beta$

$\Rightarrow \frac{\Delta V / V_o}{\Delta T} \Rightarrow \frac{m^2 / m^2}{K} \Rightarrow \frac{1}{K}$

$\Rightarrow \boxed{\beta = K^{-1}} \longrightarrow$ SI unit!

Key uses :-

- Engineering [expansion joints in bridges]
- Manufacturing [accounting for heat expansion in design]
- Everyday [liquid expanding when heated]

slo based qna :-

(very important)

Q:- Define volumetric expansion & derive its mathematical formula?

Q:- Define beta?

application of consequences of thermal expansion:-

— bimetallic strips:- —

-> Made up of 2 metals with different expansion rates

-> When heated, the strips bends due to unequal expansion.

→ Used in thermostats, electric irons, fire alarms.
→ A bimetallic strip is made by joining two different expansion rates when heated.

= WORKING PRINCIPLE:-

When heated or cooled, one metals expands or constracts more than the other, causing the strip to bend.

= METALS USED:-

→ Usually made of brass (expands more) & iron or steel (expands less)

= THERMAL EXPANSION:

→ The difference in expansion cause the strips to bend toward the metal that expands less.

= REVERSABLE ACTION:-

→ The bending is reversible — when cooled, the strips return to its original space.

Application:

→ Used in thermostats to turn devices on/off with temperature change
→ Found in circuit breakers, irons, clocks, & heat-sensitive switches.

■ ADVANTAGE :- Simple, reliable, no external power need.

HOW IT WORKS IN IRON:-

1. DIFFERENT EXPANSION RATES:

2 metals with different thermal expansion coefficients are bonded together.

2. HEATING:

When heated, one metal expands more than the other.

3. BENDING:

The strip bends due to the difference in expansion, with the metal expanding more on the outside of the curve.

4. MOVEMENT:

This bending movement can be used to activate switches, indicate temperature, or perform other function.

Slo based:-

? Give 3 good example of how thermal expansion is used in everybody applications.

? Explain why gaps are often left between sections of railway track?

Evaporation:-

define it!

It is phenomenon on the surface in which liquid is converted into gaseous state by gaining enough kinetic energy at any temperature.

difference Between evaporation & vaporization:-

→ Evaporation & Evaporization are both processes where a liquid change to a gas, but they differ in how & where this occurs. Evaporation is a surface phenomenon, happening at any temperature below the boiling point, while vaporization is a bulk phenomenon, occuring throughout the liquid, usually at the boiling point.

→ Evaporation is like a queit escape.

→ Evaporization is a full on transformation.

→ Evaporation causes a cooling effect bcuz the energetic molecules leave the surface first.

→ The warmer the liquid, the faster the evaporation.

→ A wider surface speeds up evaporation because more molecules are exposed.

/ /

-> Wind or moving air helps remove vapor, allowing more liquid to evaporate quickly.
-> It is inversly proportional to humidity. This is because when humidity decrease it allows more particles to escape into the gaseous phase.
-> When humidity is high evaporation decrease bcuz it allows less particles to move into the gaseous state.
-> It is endothermic reaction.

factors:-
(easy points)

-> Temperature ∝ Evaporation
-> Surface Area ∝ Evaporation
-> Wind ∝ Evaporation
-> Attraction of particles ∝ 1/Evaporation
-> Pressure ∝ 1/Evaporation
-> Humidity ∝ 1/Evaporation
-> Heat ∝ Evaporation
* Make sure to write the points with heading & detail below in exam *

Example.

-> Drying clothes -> Sweating -> purfume on palm
-> Ink drying.

Slo based QnA [important]

? How evaporation differs from vaporization?
? Is there any role of boiling point in evaporation?
? Write down the factors affecting the rate of evaporation? (most imp)
? Evaporation causes cooling effect. Justify? (from past paper!!)
? What causes liquid molecules to evaporate? (imp)
? Differentiate between boiling & evaporation?

=> refrigator & evaporation:-

-> Refrigerators & cooling device use liquids that absorb heat when they evaporate.
-> This principle helps maintain low temperatures.
-> For examples:- when a liquid like water or alcohol, evaporates, it takes away heat from the surrounding area, creating a cool effect.
-> This is the basic working principle in evaporation by cooler & some fridge.

Main part of refrigerator :-

→ Compressor – Pumps the refrigator through the system.
→ Condensor coil – Release heat from the refrigerant.
→ Expansion valve – Lowers the pressure of the refrigerant
→ Evaporate Coils – Absorb heat from inside the fridge
→ Refrigigerant – The fluid that carries heat away.
→ Thermostat – Controls the temperature.
→ FAN – Spreads cool air inside.

how it cools :-

→ Compressor squeezes the gas (refrigerant) – it gets hots
→ Condenser release the heat outside – gas become liquid
→ Expansion Value cools it down
→ Evaporator absorbs heat from inside the fridge – makes it cold.
→ The gas goes back to the compressor, & the cycle repeats.

Latent heat of fusion:-

Latent heat:-

Energy required to change the state (or phase) of a substance without changing its temperature.

TYPES OF LATENT HEAT:-

• Latent heat of fusion:- Heat required to convert a solid into a liquid (or vice versa) at constant temperature

Example:- Ice melting into water at 0°C.

• Latent heat of vaporization:- Heat required to convert a liquid into gas & vice versa.

Example:- Water boiling at 100 °C

⇒ Formula = $Q = mL$, Q = heat energy, m = mass, L = Latent heat

Latent heat of fusion:

→ The latent heat of fusion is the amount of heat energy required to change a substance from liquid to solid (or vice versa) at constant temperature, without changing its emotion.

Formula:-

$$Q = m \cdot L_f$$

Where:-

- Q = heat energy (in joules, J)
- m = mass of the substance (in kg or g)
- L_f = latent heat of fusion (in J/kg or J/g)

Key Concept:-

- It's called "latent" (hidden) because the temperature doesn't change during the phase change.
- This energy breaks the bonds between solid particles so they can move freely as a liquid.

EXAMPLE:-

1. Melting Ice:-

Melting 1kg of ice at 0°C to needs 334,000J of energy (latent heat of fusion of ice)

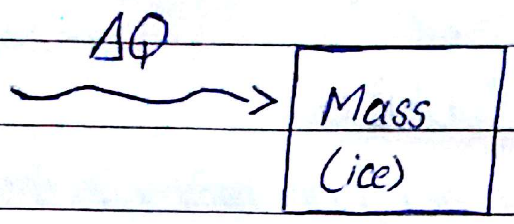
2. Solidifying Wax:-

~~it releases lat~~ As molten wax solidifies, it releases latent heat without changing its temperature.

3. Melting Metal in Casting:-

To melt aluminium, energy is required. It is the process of melting metal & pouring it into a mold to create a specific shape. Once cooled & solidified the metal part is removed & polished. Its widely used to make tools, machine parts & art.

derivation:-



$Q = mL$, whereas
* Q = heat energy *
* m = mass *
* L = latent heat of fusion

$\Delta T = constant$

0°C

$\uparrow \Delta Q \propto m \uparrow$

$\Delta Q = (constant) \times m$

$\Delta Q = L_f m$ => Derived formula.

$L_f = \frac{\Delta Q}{m}$

SLO BASED QNA :-

? What is latent heat of fusion?

? At what temperature does ice melt without changing temperature?

? Is heat absorbed or released while freezing ice?

? Why does temperature not change during melting of ice?

Pressure exerted by gas molecule:-

pressure exerted by gas molecules:-

-> Gas pressure is the force that gas molecule exert on the walls of their container.

CAUSE OF PRESSURE:-

Gas molecules are in contact, constant, random motion. When they collide with the container walls, they transfer momentum

HOW PRESSURE BUILDS:-

Millions of collisions happen every second. These tiny impacts add up, creating a steady force over the surface — which we observe as pressure.

KEY POINTS:-

-> More collisions or faster-moving molecules means higher pressure

-> Directly Proportional:- For a fixed volume gas pressure increases with temperature.

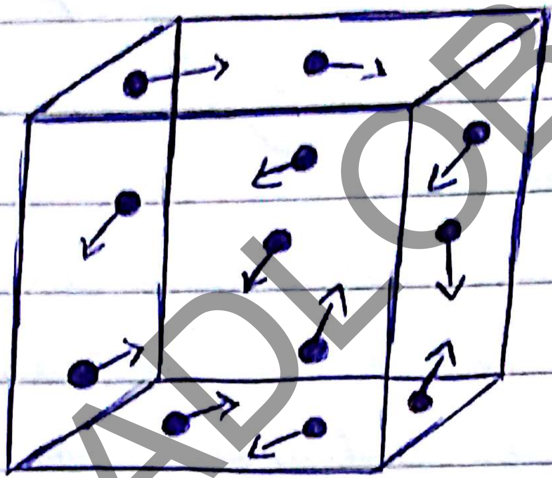
-> FORMULA:- $P1/T1 = P2/T2$ (at constant volume)

-> REASON:- Increased temperature gives gas molecules more kinetic energy, causing more frequent & forceful collisions with container walls.

<<PKMT>>

$P \propto K.E \propto T$

$P \propto T$



$$\text{Pressure} = \frac{\text{Force}}{\text{Pressure}}$$

① TEMPERATURE :-

Temperature $\propto$ K.E of molecule

② PRESSURE :-

$$\text{Pressure} \propto \frac{1}{\text{Volume}\uparrow\downarrow}$$

∴ Pressure is indirectly related with volume

SLO based qna:-

? Define gas pressure & explain how it is produced by gas molecules?

? Describe the relationship between the number of gas molecules & the pressure in a container?

? How does the container with a motion of gas molecules relate to the pressure exerted on container walls?

Superconductivity?

→ Superconductivity is a phenomenon where a material conducts electricity with resistance when cooled below a certain critical temperature.

⇒ key features:-

→ No electrical resistance: Current flows without energy loss.

→ Perfect Diamagnetism: Superconductivity expel magnetic fields (Meissner effect)

→ It also has a specific critical temperature.

→ Used in MRI, maglev trains & particles.

END!