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Aye Jaliiii

HEAT AND THERMOMETRY

ouchh

Topics
- Heat

Joule Kelvin

1. Heat And Tempreture

↓ form of energy. (measured in joules)
(non-mechenical way of transfer of energy)

how energy is transfered?
before that:
tempreture: measure of hotness or coldness of ~~every~~ a body
~~molecule~~ OR.
average vibrational kinetic energy of every molecule
tempreture ∝ vibration ∝ kinetic energy.
Heat flows when diffrence in tempreture...
(energy transfers when difference in tempreture
(vibrational energy of molecules))

Thermometry: branch of science that deals with ~~out~~
measurement of heat

$C^{\circ} = K^{\circ} - 273.15$ $\quad K = C + 273.15$

$C^{\circ} = \frac{9}{5}(F-32)$ $\quad K = \frac{9}{5}(F-32) + 273.15$

$F = \left(\frac{5}{9}C\right) + 32$ $\quad F = \left(\frac{5}{9}K - 273.15\right) + 32$

Scales	Ice point (Freezing)	Steam point (boiling)
Celcius	0	100
Kelvin	273.15	373.15
Fahrenheit	32	212

this derivation is excellently explained in padhle video...

for any scale.

$$\frac{\text{Reading} - \text{Icepoint}}{\text{Steam point} - \text{Icepoint}} = \text{constant for any scale}$$

so,

$$\frac{R_c - IP_c}{SP_c - IP_c} = \frac{R_F - IP_F}{SP_F - IP_F} = \frac{R_K - IP_K}{SP_K - IP_K} = \text{constant}$$

(celcius (Frahrenheit) (Kelvin)

deriving the og formulas.

$$\frac{c-0}{100-0} = \frac{\cancel{R}F-32}{212-32} \qquad \frac{c-0}{100-0} = \frac{K-273.15}{373.15-273.1}$$

$$c = (F-32)\frac{100}{180} \qquad \frac{c-0}{100} = \frac{K-273.15}{100}$$

$$c = (F-32)\frac{5}{9} \qquad c = K-273.15$$

Similarly for all...

Q Convert 50°C to Kelvin & Fahrenheit

Q on reaumer scale of tempreture the melting point of ice and the boiling point of water is 0R and 80R respectively. The freezing point and boiling point of mercury on celcius are 39°C a 367°C respectively. Express them in Reomeur scal

2. Thermal Expansion

tendency of a material to change it's dimentions (length, height, area, volume) when it's tempreture is changed.

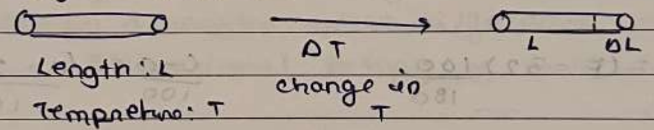
Why does it happen?

- Heating ↑ atomic vibrations
- Average distance between atoms grow
- so material expands.

* Linear Expansion

"increase in the length of a solid material when its tempreture rises"

~~Why it happens:~~



ΔT cause ΔL in L

so $\Delta L \propto \Delta T$ (proportionalities)

$\Delta L \propto L$

$\Delta L \propto \Delta T L$

$$\boxed{\Delta L = \underset{\uparrow}{\alpha} L \Delta T}$$

coefficient of linear thermal expansio

α = increase in length per unit length per unit rise in tempreture.

$(\alpha = \frac{\Delta L}{L \Delta T}$

so unit = $\boxed{\frac{1}{C^\circ}}$

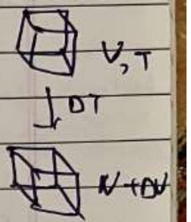
e.g. $\alpha_{steel} = 1.2 \times 10^{-5}\ C^{-1}$

$\alpha_{copper} = 1.7 \times 10^{-5}\ C^{-1}$

* Volume Expansion

"increase in the ~~length~~ volume of a solid material when its tempreture is changed"

so.



Condition: works only till $T < 200\,K$.

$\Delta V \propto \Delta T$

$\Delta V \propto V$

$\Delta V \propto V \Delta T$

$\Delta V = V \gamma \Delta T$ (gemma)

coeffient of volume expansion

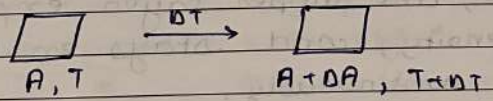
$\boxed{\gamma = \frac{\Delta V}{V \Delta T}}$, unit $\boxed{\frac{1}{c^\circ}}$

γ is not always linearly proportional to ΔT or T
so manier times relations are given.

e.g. $\gamma = T^4 + 2T^2$

* Area Expansion

"increase in the area of the solid material when its tempreture is changed."



so, $\Delta A \propto \Delta T$

$\Delta A \propto A$

$\Delta A \propto A \Delta T$

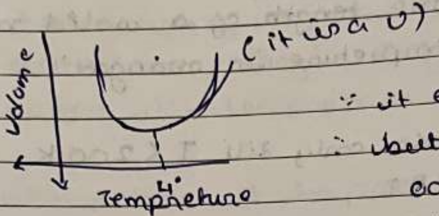
$\boxed{\Delta A = A \beta \Delta T}$ → coefficient of volume expansion (Beta)

* Relation Between α, β, γ ($\gamma = 3\alpha$) ($\beta = 2\alpha$)

$\boxed{\begin{array}{c}\gamma = 3\alpha \\ \beta = 2\alpha\end{array}}$

simple hai bhai, γ is about volume (L^3)
so α is about L, so $\gamma = 3\alpha$
same area $= L^2$, $\beta = 2\alpha$
(you can mathematically prove too)

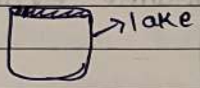
* Anomalous expansion of water



∵ it expands after 4°c
∴ but instead of being
compressed at lower temp
it expands too.

Mast Example.

Imagine a Lake, temp of H_2O → 10°c



1. when it goes to 9°c
the upper layer denses as volume
∴ decreases as ~~mass~~ temp decreases

$$\left(d \propto \frac{1}{V}\right)$$

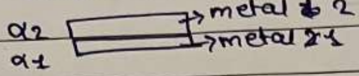
then the secound (which is at surface) cools and moves down and so on...

But at 4°c, when water expands on lower tempretures, the upper layer expands, so lighter density, and stays on top, and cools down continuously,
so you always see the frozen lakes have water beneath and only surface is frozen...

moral: water expands below 4°c too
and expands above 4°c too

* Bimetellic Strip,
when two metal strips of different expansion coefficient are bridged togther.

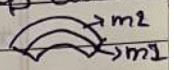
Basic mechanism



$\alpha_2 > \alpha_1$

so metal2 expands more than metal 1

we heated metal 2 expands more and its increase in length (Δl_2) is more but Δl_1 is less, so ends up curled on heating



* Effect on density of liquid.

simply $T \propto V$ and

(density) $\rho \propto \frac{1}{V}$ so high tempretur → low densi

CALORIMETRY:

branch of science that deals with the measurement of heat exchanged during physical changes

* Specific Heat Capacity: (c, cu, S)

J/Kg^{C}

heat amount required to change 1°C (1K temprerture of 1Kg of a material.

c of water: 4.184 $J\,kg^{-1}C^{\circ}$

$$C = \frac{Q}{m\Delta T}$$

Q = heat amount (J) ΔT = change in tempreture (K/C

m = mass (kg)

$$\underset{\text{heat amount}}{Q} = \overset{\text{SHC}}{c}\,\underset{\text{mass}}{m}\,\Delta T$$ → change in tempretune

Q Find the amount of heat required to raise the temp of 10g of water from 10°C to 50°C (c = 4.2 J/g °C)

Q A heater gives heat at the rate of 1000W. It is used to heat 40g of water from 10°c → 50°c find time taken to heat (c = 4.2 J/g°c) power $\boxed{\text{watt}}$

$$P = \text{work done} \, / \, \text{time}$$

Q A complete 1000W heater is used for 5mins to heat some water from 20°C → 50°C. what is the mass. (c=4.2J/g°)

* Principle of Calorimetry

"heat loss by = heat gain by "
hot body(ies) cold body(ies)

based on coversation of energy...

$$Q_{HB} = Q_{CB}$$ $\because \Delta T_{HB} \ != \Delta T_{CB}$

$$C_{HB} m_{HB} \Delta T_{HB} = C_{CB} m_{CB} \Delta T_{CHB}$$

Q 10g of water at 80°C mixed with 50g of copper at 10°C. find final temp of mixture (C_w = 4.2 J/g°C, C_c = 0.41 J/g°C)

$\because \Delta T_{HB}$ = finnal temp − it's og temp

ΔT_{CB} = final temp + it's og temp

answer & confusing

Q In a copper vessel we pour 20g of hot water at 80°C. Now 100g of cold water at 10°C is added, find final temp, if vessel weighs 50g (C_w = 4.2, C_c = 0.4)

* Heat Capacity : (C)

$\boxed{\text{J/K}}$ "amount of heat to raise 1°C (1°K of a body (whole)

$$C = \frac{Q}{\Delta T}$$ → amount of heat / → change in temp

$$C = \underset{\text{SHC}}{c}\, m$$ → mass

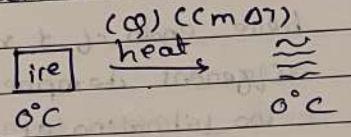
* Change of State

while changing state of a material Heat is required

when state is changed tempreture remains same because, all the heat provided goes into change state. (↑ inter molecular space, ↓ molecular force)

i.e

(Q) (CmΔT)



Solid ↔ liquid ↔ gas

$\boxed{J}$

Latent Heat: amount of heat to change state of a material (no change in ~~water~~ temperture)

(L) $\boxed{J/kg}$

Specific Heat latent: amount of heat to change state of 1kg of material, at constant tempreture

L_{ice} = 336 J/g or 3.34×10^5 J/Kg (from ice → water)

L_{water} = 2267 J/g or 2.26×10^5 J/kg

$L = Q/m$

latent heat ← $Q = \underset{\text{mass}}{m} L$ → specific latent heat

Heat Transfer:

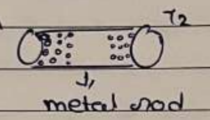
process of transfering heat energy.

↳ conduction (solid)

↳ convection (liquid and gases)

↳ radiation (~~gases~~ light)

* Conduction



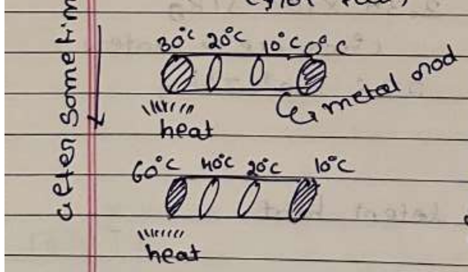
here ends of 1 metal (solid) have different tempretures, (energies) so vibrating at different rates so this vibration spreads to the side that has less temp (vibration)

∵ no flow of matter (molecules), just energy.

∴ heat transfer in solid is due to molecular collisions

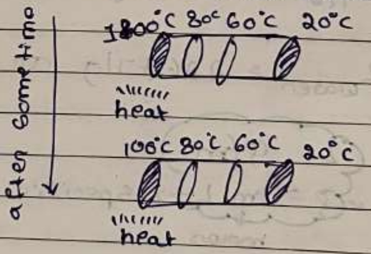
Variable State

(when solid can transfer heat) (not full)



Steady State

(when solid can't transfer heat, because they are full (max molecular vibration))



temp at every intersection remains constant with respect to time

rod ka change hoga because diff of temp

∴ For Steady States

K = thermal conductivity

K unit = J / mK s

= W/mK (J/s = W)

$Q \propto A \rightarrow$ area

$Q \propto 1/L \rightarrow$ length

$Q \propto t \rightarrow$ time

$Q \propto \Delta T$ (temp difference.

$$Q \propto \frac{A \, \Delta T \, t}{L}$$

$$Q = K \frac{A \, \Delta T \, t}{L}$$

↳ thermal conductivity of the substance...

Heat Current : rate of flow of heat

(H) = $H = Q/t$ (replacing $\frac{Q}{t}$ from $Q = K \frac{A \Delta T t}{l}$)

$$H = \frac{K A \, \Delta T}{l}$$

*

HEAT AND THERMOMETRY
-From JA only :)

L1 Heat: form of energy
can be converted from 1 form to another
unit SI: ~~J~~ Joules (J)
CGS: erg
etc: calorie (cal)

temprature: measure of hotness or coldness
"degree of intensity of heat present in a body"
Heat transfer: ·when temp difference
·between body or surrounding

calorie heat required to raise 1°C / 1K temprature of a body with mass 1g.

Kilocalorie heat require to raise 1°C / 1K of 1kg of mass of a body (1kcal = 1000cal)

!? (JA includes wrong definitions of heat / cal / Kcal)

Thermometer device to measure temprature using some measuring scales

L2 Modes of Heat Transfer:

1. Conduction: heat transfer between solids
   (cause molecular vibrations)
   (from higher temp to lower temp)
   without actual molecular movement
   - ✓ heat transfer
   - × molecule transfer
   - require solid medium

2. <u>Convection</u>: heat transfer in fluids (liquids, gases)
- ✓ heat transfer · require medium (fluid)
- ✓ molecular movement

types: natural (sunlight) | forced (external force) (pumping etc)

L3 3. <u>Radiation</u>: heat transfer (emission) through <u>electromagnetic waves</u> without requiring medium

thermal waves
- ✓ heat transfer · ✗ medium required
- ✗ molecular movement

L4 Tempreture Measurement Scales

	* Celcius	* Kelvin	* Fahrient
freezing point	0°C	273.15 K	32°F
boiling point	100°C	373.15 K	212°F
Celcius		C = K - 273.15	C = (F-32) 5/9
Kelvin	K = C + 273.15		K = ((F - 32) 5/9) + 273.15
Fahrenheit	F = (9/5 × C) + 32	F = (9/5 (K - 273.15)) + 32	

Q 50°C to K & F Q -45°C to K & F

Q Temp at which C == F
F == K

Heat Capacity and **Specific Heat Capacity**

Heat Capacity: amount of heat transfered to the body to cause unit (1) tempreture change

Specific Heat Capacity: amount of heat transfered to every Kg (unit mass) of a body to produce of unit tempreture change or H_c

Heat Capacity (rep: C, unit: J/K)

$C = Q/\Delta T \rightarrow$ change in tempreture

$C \downarrow$ heat capacity, $Q \downarrow$ amount of heat

so, $Q = C\Delta T$

Specific heat Capacity (rep: c, unit: J/Kg K)

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

$Q \rightarrow$ amount of heat

$\Delta T \rightarrow$ change in tempreture

$c \downarrow$ specific heat capacity

$m \downarrow$ mass

so, $Q = cm\Delta T$

also $C = cm$ $\rightarrow$ mass

$C \downarrow$ heat capacity, $c \rightarrow$ Specific heat capacity

∵ Heat capacity depends on specific heat capacity and mass

$H_c \propto c$

$H_c \propto m$

∵ Types of Specific Heat Capacity

- Specific Heat at constant volume (C_v)
  amount of heat required to change the tempreture of 1 mole of gas by 1K keeping its volume constant, is called specific heat C_v of the gas at constant volume
- Specific Heat at constant pressure (C_p)
  amount of heat required to change the tempreture of 1 mole of gas by 1K keeping its pressure constant, is called specific heat C_p of the at constant pressure

$$C_p - C_v = \underset{\text{gas constant}}{\underset{\downarrow}{R}}$$

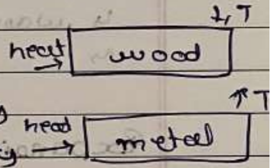
$$\text{pressure} \leftarrow \underset{\substack{\downarrow \\ \text{volume}}}{PV} = \overset{\substack{\text{mole} \\ \uparrow}}{n}\underset{\substack{\downarrow \\ \text{universal gas constant}}}{R_0}T \rightarrow \text{tempreture}$$

(8.314 KJ/Kg mol K)

Coefficient of Thermal Conductivity & It's Thermal Applications

Thermal Conductivity : ability of the material to conduct heat. (~~ability~~ capacity to allow heat current)

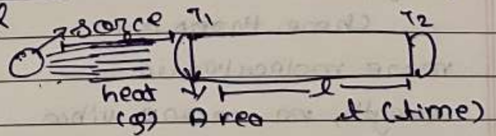
materials properties
- ↳ low thermal conductivity
- ↳ high thermal conductivity



* depends on heat being transfered
1. $Q \propto A$ (cross section area)
   $Q \propto t$ (time)
   $Q \propto \Delta T$ (tempreture difference at both ends)
   $Q \propto \dfrac{1}{l\ (d)}$ (~~distance from the~~ ~~body~~ source ~~to body~~) length of the rod

$$Q \propto \frac{A t \Delta T}{l}$$

$\Delta T = T_2 - T_1$



$$Q = \underset{\substack{\downarrow \\ \text{Coefficient of thermal conductivity}}}{K} \cdot \frac{A t \Delta T}{l}$$

k = unit: W / K m

Tempreture Gradient

the tempreture difference per unit length of the rod is called tempreture gradient.

$$G = \frac{\Delta T}{d} \left(\frac{\text{temp diff}}{\text{distance}}\right) \quad \frac{K}{m}$$

Applications

- ↳ POP at ceiling to reduce heat transfer
  (POP is less thermal conductive)
- ↳ metal handles of wood (↓ TC)
- ↳ vessel of metals (↑ TC)
- ↳ ice kept in wood (↓TC) so no melting (× ↑ T)
- ↳ warm winter clothes
- ↳

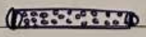
Expansion of Solids, Coefficient of Linear Expansion

when heat provides → ↑ molecular movement
↓
increase in size

(molecular vibrates (moves) equally in all directions, but longer dimension expands more because it has more molecules in its ~~ft~~ direction)

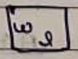
e.g.

strip

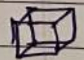


(here there are more molecules in length, so more vibra and movement, so length increases more, than width)

metal sheet



here w, l are equal, but ↓ h so w, l increase causing area expansion



w, l, h are more so all increa so, volum expansion

Linear Expansion

~~Note~~ Moral of the Story:

There is always volume expansion in this 3D world, because molecules vibrates same in every direction.

but, sometimes movement in w, h is ignorable so we named it linear expansion for simplicity

when h is ignorable, we call it area expansion

(refer padhle notes (video)

* Linear Expansion

when length of the object increases due to heat transfer

~~depends on ΔT~~, t,

change in length ΔL depends on,

~~Δ~~ $\Delta L \propto L$ (og length)

$\Delta L \propto \Delta T$ (change in length)

$\Delta L \propto L \Delta T$

$\Delta L = \underset{\downarrow}{K} \Delta T L$

coefficient of linear expansion. (unit: 1/K)

(constant (same) for every material)

$$K = \frac{\Delta L}{L} \times \Delta T$$