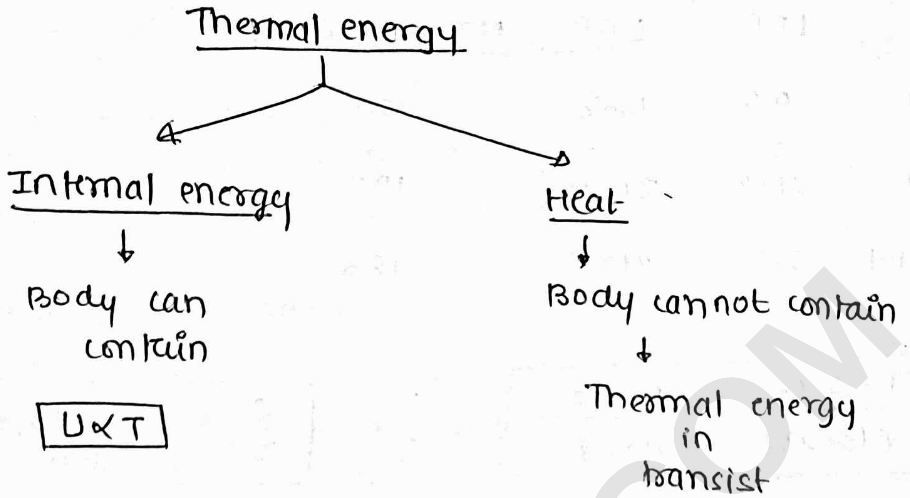
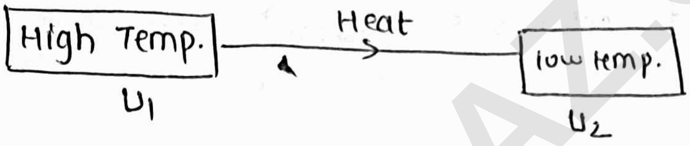
13/1/20 L-1

THERMAL PROPERTIES OF MATTER

* **Temperature** :- it is measurement of hotness & coldness of an object



Natural flow of Heat



$U_1 > U_2$

16/1/20 L-2

** ~~Tem~~ THERMOMETERY :-

→ it is branch of science which deals with temp. scales.

* in this linear variation in some physical properties with Ies in ~~set~~ temp is noticed, it is the basic principle of thermometery.

* These properties are cld Thermometric properties.

① length of liquid in capillary] ⇒ liquid thermometery.

② Pressure of gas at const. vol.

③ vol. of Gas at const. Pressure } ⇒ Gas Thermometery.

④ Resistance of a platinum wire] ⇒ Resistance Thermometery

Temp scales

LFP → Lower fixed point
TFP → Upper fixed point.

$$\boxed{\frac{T-LFP}{UFP-LFP} = const.} \quad \text{OR} \quad \boxed{\frac{T-LFP}{\text{No. of Divisions}} = const.}$$

Scales	LFP	UFP	No. of divisions
celcius	0°c	100°c	100
Kelvin	273K	373 K	100
farenhiet	32°F	212°F	180

$$\boxed{\frac{C-0}{100-0} = \frac{K-273}{373-273} = \frac{F-32}{212-32}} \Longrightarrow \boxed{\frac{C}{100} = \frac{K-273}{100} = \frac{F-32}{180}}$$

Ques. ✓ common reading of celsius & F scale?

$$\Rightarrow \frac{C}{100} = \frac{C-32}{180}$$

$$\Rightarrow \boxed{C = -40°c}$$

Ques. ✓ for a scale LFP = 0°
UFP = 80°
then 40° on this scale is equivalent to T°c = ?

$$\frac{C}{100} = \frac{40-0}{80-0} \qquad \underline{C = 50°c}$$

Ques. ✓ ✗

	LFP	UFP
x	0°	90°
y	-20°	70°
z	30	120

Arrange 50x, 50y, 50z in desing order.

Sol. i)

$$\frac{T_1}{100} = \frac{50-0}{90-0} \qquad \frac{T_2}{100} = \frac{50+20}{90} \qquad \frac{T_3}{100} = \frac{50-30}{90}$$

$$T_1 = \frac{500}{9}°c \qquad T_2 = \frac{700}{9}°c \qquad T_3 = \frac{200}{9}°c$$

$$\boxed{T_3 < T_2 < T_1}$$

THERMAL EXPASION

* when a matter is heated without change in its state it expands.

* Rise in Temp.
↓
Amplitude of vibrations ↑es
↓
energy of atoms increase
↓
collisions ↑es
↓
Average dist. b/w atoms ↑es
↓
Thermal expansion

* Temperature rise
↓
every linear dimensions will be ↑esed

* $\boxed{\alpha = \frac{dL/dT}{L_0}} = \frac{dL/L_0}{dT}$

$\alpha \Rightarrow$ per°c / per K

① Linear Expansion

→ Along the length

⇒ $\boxed{L = L_0(1+\alpha\Delta T)}$

L_0 = length at 0°c
$\Delta T = T \Rightarrow T-0$
L = length at temp. T

- Applicable for solids.

② Area expansion

$\boxed{A = A_0(1+\beta\Delta T)}$ → only for solids

③ volume expasion

$\boxed{V = V_0(1+\gamma\Delta T)}$ → ~~only~~ for All

* for solids:- $\boxed{\beta = 2\alpha}$ $\boxed{\gamma = 3\alpha}$ $\boxed{\alpha : \beta : \gamma = 1 : 2 : 3}$

Isotropic

*

$\boxed{L = L_0(1+\alpha\Delta T)}$

solids

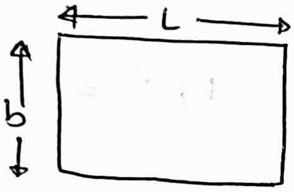
~~$\beta = \gamma_1+\gamma_2$~~

$\boxed{\beta = \alpha_1+\alpha_2}$ $\boxed{\gamma = \alpha_1+\alpha_2+\alpha_3}$

$\alpha_1 = \alpha_2 \Rightarrow$ Isotropic

$\alpha_1 \neq \alpha_2 \Rightarrow$ Anisotropic

Anisotropic expansion



$A_0 = L_0 b_0$

$$A = Lb = [L_0(1+\alpha_1\Delta T)][b_0(1+\alpha_2\Delta T)]$$

$$= L_0 b_0[1+\alpha_2\Delta T + \alpha_1\Delta T + \cancelto{0}{\alpha_1\alpha_2(\Delta T)^2}]$$

$$\boxed{A = A_0(1+(\alpha_1+\alpha_2)\Delta T)}$$

Expansion in liquid :-

* As liquid does not have any shape of their own so they expand in terms of volumetric expansion only

vol. of liquid ↑ $V_{L0} = V_{c0} \Rightarrow$ At 0°C ↖ vol. of ~~liq~~ container

* Temp rise ⇒ same

$\boxed{V_L = V_{L0}(1+\gamma_L\Delta T)}$

$\boxed{V_c = V_{c0}(1+\gamma_s\Delta T)}$

$\Delta V = V_L - V_c$

$\boxed{\Delta V = V_0(\gamma_L - \gamma_s)\Delta T}$

$\boxed{\Delta V = V_0\gamma_{app.}\Delta T}$

* coeff. of Apparent Expansion of liquid :-

$$\boxed{\gamma_{app} = \gamma_L - \gamma_s}$$

$$\boxed{\gamma_{app} = \gamma_L - 3\alpha_s}$$

- * $\gamma_L > \gamma_s \Rightarrow$ liquid overflow / level rise.
- * $\gamma_L < \gamma_s \Rightarrow$ level of liquid ↓es.
- * $\gamma_L = \gamma_s \Rightarrow$ level unchanged.

Que:- A liquid is heated in copper vessel, then App. expansion coeff. is c when liquid is heated in silver vessel, the App. expansion coeff is S. if coeff. of volume expansion for Cu is γ_c then find coeff of linear expansion for silver.

Sol.

$$c = \gamma_L - \gamma_c \rightarrow \gamma_L = c + \gamma_c$$

$$S = \gamma_L - \gamma_s$$

$$\rightarrow S = \gamma_L - 3\alpha_s$$

$$\rightarrow S = c + \gamma_c - 3\alpha_s$$

$$\boxed{\alpha_s = \frac{c + \gamma_c - S}{3}}$$

Que. Glass flask of volume = 1000 cm³ at 0°c filled completely with Mercurgy at same temp. when Heated to 100°c then 15.2 cm³ of Hg overflow $\gamma_{Hg} = 1.82 \times 10^{-4}/°c$ $\alpha_{glass} = ?$

Sol.

$$\gamma_a \Delta V = V_0 \gamma_{app} \Delta T \qquad V = V_0 (1 + \gamma \Delta T)$$

$$\frac{15.2}{1000} = (1.82 \times 10^{-4} - 3\alpha_g) \times 100 \qquad \frac{\Delta V}{V_0} =$$

$$1.52 \times 10^{-4} = 1.82 \times 10^{-4} - 3\alpha_g$$

$$3\alpha_g = 0.3 \times 10^{-4}$$

$$\boxed{\alpha_g = 10^{-5}/°c}$$

$$\Delta V = V_0 \gamma_{app} \Delta T$$

$$\frac{1000 - 15}{1000} = 1.82 \times 10^{-4} - 3\alpha_s \times 100$$

$$\frac{985}{1000} = 1.82 \times 10^{-4} - 3\alpha_s$$

$$9.85 \times 10^{-3} = 0.182 - 3\alpha_s.$$

$$3\alpha_s =$$

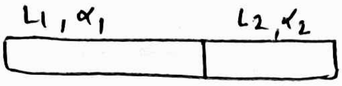
$$\frac{15.2}{100000} = 1.82 \times 10^{-4} - 3\alpha_s$$

$$3\alpha_s = 1.82 \times 10^{-4} - 1.5 \times 10^{-4}$$

$$3\alpha_s = 0.3 \times 10^{-4}$$

$$\boxed{\alpha_s = 10^{-5}}$$

Ques.



composite rod.

⊛ Total expansion = ?

$$\Delta L = \Delta L_1 + \Delta L_2$$

$$\boxed{\Delta L = \Delta T(L_1\alpha_1 + L_2\alpha_2)}$$

⊛ $\alpha_{combination}$ = ?

$$L_1' = L_1(1+\alpha_1\Delta T)$$
$$L_2' = L_2(1+\alpha_2\Delta T)$$

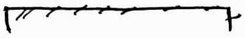
$$\boxed{L' = L(1+\alpha_{comb.}\Delta T)}$$

$$L_1' + L_2' = L_1 + L_1\alpha_1\Delta T + L_2 + L_2\alpha_2\Delta T$$

$$L_1' + L_2' = (L_1+L_2) + (L_1\alpha_1 + L_2\alpha_2)\Delta T$$

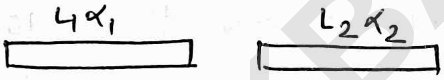
$$L(1+\alpha_{com.}\Delta T) = (L_1+L_2)\left\{1 + \left(\frac{L_1\alpha_1 + L_2\alpha_2}{L_1+L_2}\right)\Delta T\right\}$$

⊛



$$\boxed{\alpha_{comb.} = \frac{L_1\alpha_1 + L_2\alpha_2}{L_1+L_2}}$$

⊛



- Difference in length is independent of Temp. change

OR

Diff. in length is same at every temp.

→ $L_2 - L_1 = L_2' - L_1'$

$$= L_2(1+\alpha_2\Delta T) - L_1(1+\alpha_1\Delta T)$$

$$= (L_2 - L_1) + (\underset{\Downarrow\atop 0}{L_2\alpha_2 - L_1\alpha_1})\Delta T$$

$$\boxed{L_1\alpha_1 = L_2\alpha_2}$$ Ans.

$$\boxed{L \propto \frac{1}{\alpha}}$$

⊛ Time period of simple Pendulum

↳ Temp = Δθ

$$\boxed{T = 2\pi\sqrt{\frac{l}{g}}}$$

$$\boxed{\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta l}{l} = \frac{1}{2}\alpha\Delta\theta}$$

→ change in time period ⇒ $\boxed{\Delta T = \frac{1}{2}T\alpha\Delta\theta}$

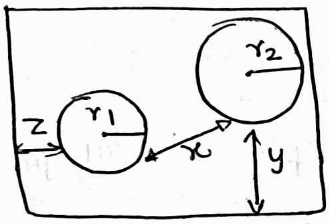
→ fractional change ⇒ $\boxed{\frac{\Delta T}{T} = \frac{\alpha\Delta\theta}{2}}$

% change = $\frac{\Delta T}{T}\times 100\% = (50\alpha\Delta\theta)\%$

$\Delta T = +ve$ ⇒ T↑ = clock = slower → slow in summer

$\Delta T = -ve$ ⇒ T↓ clock = faster → fast in winter

⊛ Expansion of a cavity :-

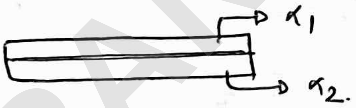


As temp. ↑es.

⇓

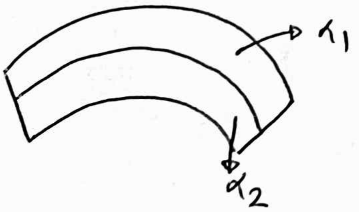
x, y, z, r_1, r_2 ⇒ ↑es.

⊛ Bimetallic strip

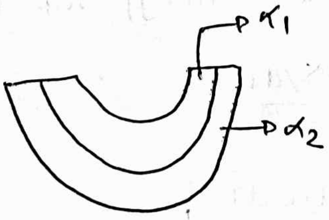


जिसका α ज्यादा वो बाहर रहेगा

$\alpha_1 > \alpha_2$



$\alpha_2 > \alpha_1$



जिसका 'α' more

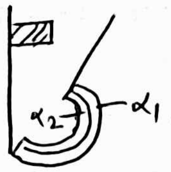
⇓

expansion more

- circuit में

α_2 more
~~out~~ inner.

- Fire Alaram



α_1, more
outer

17/01/20

L-2

TL-82

HEAT AND CALORIMETERY :-

① Specific Heat :- It is the energy required to raise the temp. ~~of~~ of 1gm substance by 1°c. ~~is~~

$$\therefore \quad s = \frac{dQ/dt}{m}$$

$$\Rightarrow dQ = smdt$$

$$\Rightarrow \boxed{\Delta Q = sm\Delta T}$$ unit → Joule / Kg °c OR cal/gm°c

* $\boxed{s_{water} = 1\ cal/g°c}$ $\boxed{s_{ice} = 0.5\ cal/g°c}$ $\boxed{s_{steam} = 0.5\ cal/g°c}$

* AKA Gram specific Heat.

* Depends on Nature of substance.

② Molar specific Heat :- energy req. to raise temp. of 1 mol subs. by 1°c

$$\therefore \Rightarrow c = \frac{dQ/dT}{\mu}$$

$$\Rightarrow \boxed{dQ = \mu c dT}$$

$$\Rightarrow \boxed{\Delta Q = \mu c \Delta T}$$

$$\mu = \frac{M}{M_w}.$$

$$c = \frac{dQ/dT}{M/M_w}.$$

$$c = \frac{dQ}{dT} \times \frac{M_w}{M}$$

$$s = \frac{dQ/dT}{m}$$

$$s = \frac{dQ}{dTm}$$

~~$\boxed{c = s \times M_w}$~~

~~dQ~~ = $\boxed{c = s \times M_w}$

③ **Heat capacity:-** OR **Thermal capacity:-** Energy req. to raise temp of complete Mass of subst. by 1°C.

* $\boxed{\text{Heat capacity} = ms}$ $\boxed{S = Ms}$

depends on Nature of substance.
&
its Mass.

④ **Molar Heat capacity:- (C)** energy req. to raise temp of. Given mol. of subs. by 1°C.

* $\boxed{C = \mu c}$

⑤ **Water equivalent of a body:-**

→ It is the mass of water having same Heat capacity as the body. is cla water equivalent of the body.

- it is used in Ques. to define Heast capacity of the body.

$$\boxed{\text{Heat capacity} = (\text{Mass of water})(\underbrace{S_{water}}_{1\ cal/g°c})}$$

⑥ **Latent Heat (L):-**

when the state of matter changes it takes place at const. temp.

$$\boxed{\underset{(ice)}{\text{solid}} \xrightarrow{L_f} \underset{(water)}{\text{liquid}} \xrightarrow{L_v} \underset{(steam)}{\text{vapour}}}$$

Heat absorbed = latent Heat

$S \longrightarrow L \Rightarrow$ const. Temp = M.P

$L \longrightarrow V \Rightarrow$ const. Temp = B.P

$$\underset{(gas)}{\text{vapour}} \xrightarrow{L_v} \underset{(water)}{\text{liquid}} \xrightarrow{L_f} \underset{(ice)}{\text{solid}}$$

Heat rejected

L_f = ice to water (0°c)
= 80 Kcal/~~g~~ kg
= 80 cal/g

L_v = water to steam
= 536 ≈ 540 Kcal/kg
= 540 cal/g.

* **Latent Heat of Fusion** (Lf) :- energy requ. (in Kcal) to ~~rais~~ change the state of 1 kg solid to liquid at its M.P.

* **Latent Heat of vapourisatⁿ** (Lv) :- energy req. (in kcal) to change the state of 1 kg mass of liquid to vapour at its B.P.

Types of Questions

① $\Delta Q = ms\Delta T$

$\Delta Q = mL_v \text{ or } L_f$

$\Rightarrow Q = ms\Delta T \longrightarrow$ Temp. change but not state

$\Delta T = +ve \quad Q \rightarrow$ absorbed

$\Delta T = -ve \quad Q \rightarrow$ rejected

$\Rightarrow Q = mL_v / Q = mL_f \longrightarrow$ state changes but not temp.

$\left.\begin{matrix} S \rightarrow L \\ L \rightarrow V \end{matrix}\right\}$ $Q =$ absorbed

$V \rightarrow L \rightarrow S \Rightarrow Q =$ rejected

② **Mechnical Equivalent of Heat** $\boxed{J = 4.2}$

$\boxed{1 \text{ cal} = 4.2 J}$

$\boxed{1 J \rightarrow \frac{1}{4.2} \text{cal}}$

Given

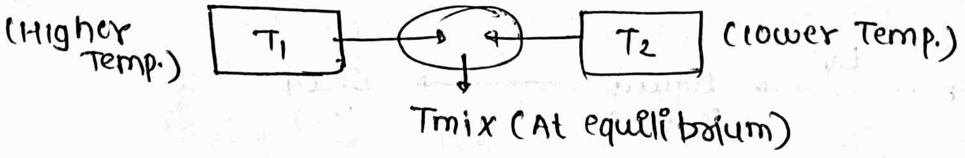
E = in Joules

E → in cal

E′ = in cal $= \frac{E}{J}$

E′ = in Joule $= E \times J$

③ **Law of Eq. Mixtures** (calorimetory):-



* $\boxed{T_2 \leq T_{min} \leq T_1}$

* $\boxed{\text{Heat lost by body at High temp.} = \text{Heat absorbed by body at low temp}}$

$$\boxed{m_1 s_1 (T_1 - T_{mix}) = m_2 s_2 (T_{mix} - T_2)}$$

i) ✓ $$\boxed{T_{mix} = \frac{m_1 s_1 T_1 + m_2 s_2 T_2}{m_1 s_1 + m_2 s_2}}$$

ii) if masses are equal.

$$\boxed{T_{mix} = \frac{s_1 T_1 + s_2 T_2}{s_1 + s_2}}$$

iii) if same subst.

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

~~iv)~~ if same subs. & equal masses

$$\boxed{T_{mix} = \frac{T_1 + T_2}{2}}$$

Que. A Bullet of mass 63 gm is moving with spd. 200 m/s it strikes an ice block if $\frac{2}{3}$rd of K.E of bullet is used to melt the ice find mass of ice melt.

sol. $$\text{K.E} = \frac{1}{2} m v^2 = \frac{1}{2}\, 63 \times 10^{-4} \times 4 \times 10^4 = K$$

$\frac{1}{2} \times \frac{62}{1000} \times 2 \times 1$

cal में ⇒ $$\boxed{\frac{K}{J} = mL}$$

$$\frac{\cancel{\frac{1}{2}}\; \overset{21}{63} \times 10^{-3} \times 4 \times 10^4}{4.2} \times \frac{\cancel{2}}{\cancel{3}} = m \times 80$$

$$m = \frac{200}{80}\ \text{gm}$$

⇒

Ques. A Block of Mass 20kg is released from rest, from a Height of 10m It strikes a water surface at bottom most point, if 75% of its energy is used to raise the temp. of 1kg water then find rise in temp. of water.

Sol.

$$\frac{3}{4}\frac{mgh}{4.2} = 1 \times 10^3 \times \Delta T$$

$$\Delta T =$$

Ques. 10gm ice at $-20^\circ c$ is converted to water at $10^\circ c$. Required Heat ?

Sol.

$$-20^\circ C \text{ ice} \xrightarrow{Q_1} 0^\circ \text{ ice} \xrightarrow{Q_2} 0^\circ \text{ water} \xrightarrow{Q_3} 10^\circ C \text{ water}$$

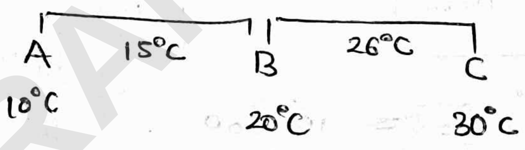
$$Q_1 = ms\Delta T$$
$$= 10 \times \frac{1}{2} \times 20 = 100$$

$$Q_2 = mL_f$$
$$= 10 \times 80 = 800$$

$$Q_3 = ms\Delta T$$
$$= 10 \times 1 \times 10 = 100$$

$$\boxed{Q_{net} = 1000 \text{ cal}}$$

Ques



equal mass

Tmix for A+C =?

$$15 = \frac{S_A(10) + S_B(20)}{S_A + S_B}$$

$$15S_A + 15S_B = 10S_A + 20S_B$$

$$5S_A = 5S_B$$

$$S_A = S_B.$$

$$26 = \frac{S_B(20) + S_C(30)}{S_B + S_C}$$

$$26S_B + 26S_C = S_B(20) + 30S_C$$

$$6S_B = 4S_C$$

$$6S_A = 4S_C$$

$$T_{mix} = \frac{4S_A(10) + S_C\,\frac{6}{4}S_A \times 30}{S_A + \frac{6}{4}S_A} = S_A(10)$$

$$\frac{40S_A + 180S_A}{10S_A} = \frac{220S_A}{10S_A} = 22^\circ$$

Que. 1 Kg ice at $-20°C$ is mixed with 1 Kg steam at $200°C$ find mix content & Temp at equilibrium.

sol.

1 Kg ice at $-20°C$

$\downarrow$ $Q_1 = ms\Delta T = 1 \times 0.5 \times 20 = 10$ Kcal

1 Kg ice at $0°C$

$\downarrow$ $Q_2 = 1 \times 80 = 80$ Kcal

1 Kg water at $0°C$

$\downarrow$ $Q_3 = 1 \times 1 \times 100 = 100$ Kcal

1 Kg water at $100°C$

Energy req. = 190 Kcal

1 Kg steam at $200°C$

$\downarrow$ $1 \times 0.5 \times 200 = 50$ Kcal

1 Kg steam at $100°C$

$\downarrow$ $1 \times 540 = 540$ Kcal

1 Kg water at $100°C$

Energy avail. = 590 Kcal

540
190

Finally $140 = m(540)$

$\boxed{m} = \frac{140}{540} = \frac{7}{27}$ Kg

mass of steam condensed

140
190
400

steam $= 1 - \frac{7}{27} = \frac{21}{27}$ Kg

water $= 1 + \frac{7}{27} = \frac{34}{27}$ Kg

$\boxed{T_{mix} = 100°C}$

Que. 5 Kg ~~ice~~ steam at $100°C$ is mixed with 10 Kg of ice at $0°C$ find equil. Temp & mixt. content.

$Q_1 = 10 \times 80 = 800$ Kcal

$Q_2 = 10 \times 1 \times 100 = 1000$ Kcal

$= 1800$ Kcal

$Q = mL$

$= 5 \times 540$

$\Rightarrow 2700$ Kcal

$Q =$

$Q_1 = 10 \times 80 = 800$ Kcal

$Q_3 = 0$

$10 \times 1 \times 100 = 1000$

1800 Kcal

5×540

$Q =$ mL

5×540

$= 2700$ Kcal

2700

900

$\frac{400}{540}$

$\frac{30}{18}$

$\frac{15}{3}$

$Q = mL$

$900 = m(540)$

$\boxed{1.6 \text{ Kg steam}}$

$\boxed{\text{water } 11.6 \text{ Kg}}$

$Q_{Left} = 900$

$Q = mL$

$\frac{900}{540} = m$

$m \simeq 1.6$

PHASE DIAGRAM

* **Phase** :- ophase of subs. is defined as the form which is Homogenous physically distinct + mechanically separable from other form of subs.

* **Phase diagram**

It is graph b/w pressure & temp. in which pressure along y-dirc^n, Temp. x-dirc^n

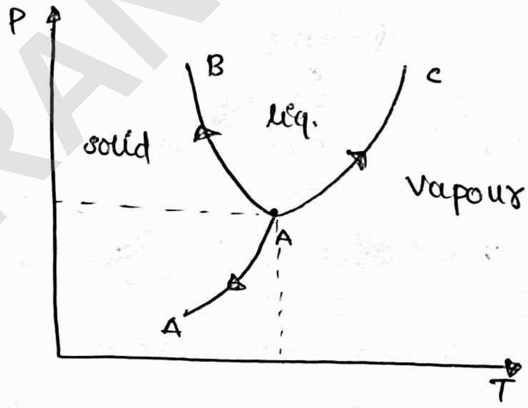
* **phase diagram of water** :-

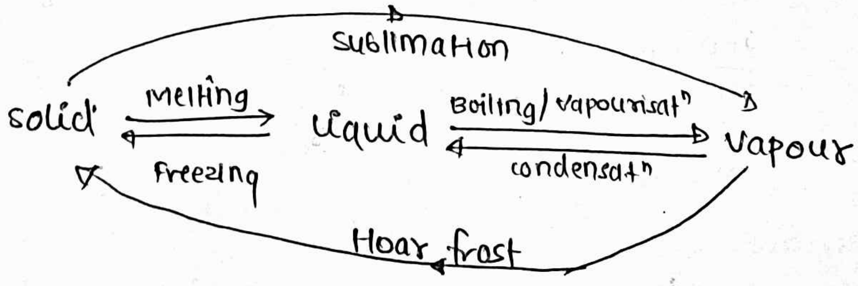
in this graph it is given that all 3 phases of water can be ~~with~~ in equil. with each other

- This graph consist of 3 diff curves which can intersect at point A it is dq triple point of water

i.e at this point when press. is = 6.0×10^{-3} atm
Temp = 273.16 K

All there phases of water can stay in equilibrium.





AB = Fusion curve OR ice-line

AC = Vapourisation-curve OR steam line

AD = sublimation curve or Hoar frost line.

* Along curve AB ice & water remain in equilibrium it is k/a Fusion curve or ice-line

* This curve shows melting point of ice ↓es with ↑es in pressure.

* Along curve AC ~~liquid~~ water & steam will be in equilibrium this graph is k/a vapourisat^n curve or steam line

this curve shows boiling of water ↑es with ↑es in pressure.

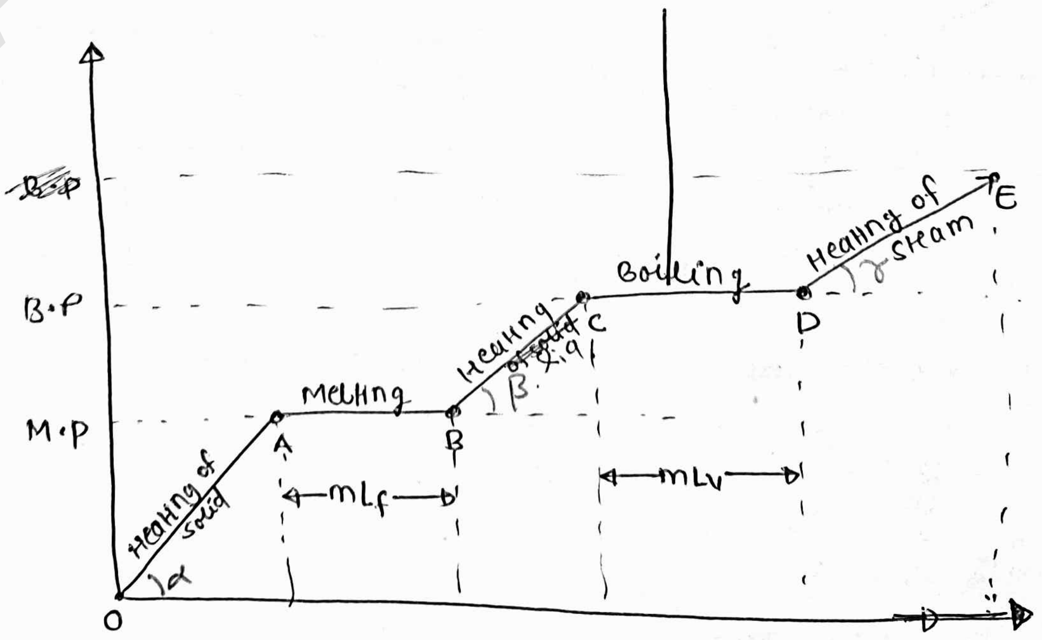
* Along curve AD ice-water vapour equil. remain is there. curve is k/a "sublimation curve" / Hoar frost line.

* Heating curve

→ Graph b/w temp. & time

→ when a given mass 'm' of a solid, Heat is supplied at constant rate i.e $\boxed{\frac{dQ}{dt} = \text{const.}}$

then graph b/w T & t is k/a "Heating curve of solid".



length of AB ∝ L_f

length of CD ∝ L_v

$\boxed{\text{length of CD} > \text{length of AB}}$

गलती :- This Graph is not for water (in General)

$$\boxed{\alpha > \beta > \gamma}$$

$$dQ = ms\,dT$$

$$\frac{dQ}{dt} = ms\left(\frac{dT}{dt}\right)$$

$$\boxed{\left(\frac{dT}{dt}\right) \propto \frac{1}{ms}}$$

$$\downarrow$$

$$\boxed{\text{slope} \propto \frac{1}{ms}}$$

$$\boxed{s_{solid} < s_{liq} < s_{steam}}$$

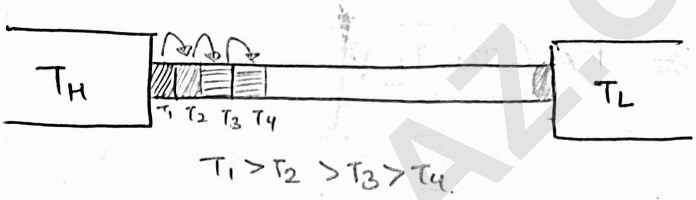
RADIATION AND HEAT TRANSFER

* Mode of Heat transfer

① conduction :-

* It is process of Heat transfer in which medium is required preferably solid.
but Heat is not transferred due to actual motion of medium particle.

* in process of conduction Heat is transferred from Hot end to cold end of a solid part.
via diff. cross section.



Amount of Heat given

$Q \propto A$

$Q \propto \frac{1}{L}$

$Q \propto t$

$Q \propto (T_H - T_L) = \Delta T$
Temp. diff.

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

$$Q = K\left[\frac{A(\Delta T)t}{L}\right]$$

$$\boxed{\frac{dQ}{dt} = \frac{KA(\Delta T)}{L} = i_{th}}$$

$$\boxed{\text{Thermal resistance} = R_{th} = \frac{L}{KA}}$$

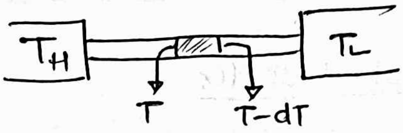
K = thermal conductivity
↳ depends on material

$\boxed{\text{Dimension} = M^1L^1T^{-3}K^{-1}}$

Steady state :- when temp. of All cross section ~~[illegible]~~ is ~~[illegible]~~ constant but not same
then thermal current will be equal for each cross sec.

$$\boxed{\frac{dQ}{dt} = \star}$$

* Temperature Gradient $\left[\frac{dT}{dx}\right]$



$\Delta T = (T-dT)-(T) = -dT$

$\Delta x = x+dx-x = dx$

$\frac{dT}{dx}$ = variation of temp w.r.t dist.

from High end → -ve
from low end → +ve

$$\frac{dQ}{dt} = -KA\left(\frac{dT}{dx}\right) = -KA\left(\frac{d(T_f-T_i)}{dx}\right)$$

$$\boxed{\frac{Q}{t} = KA\left(\frac{T_H-T_L}{L}\right)}$$

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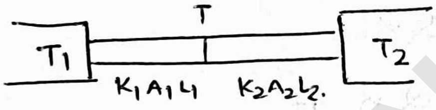
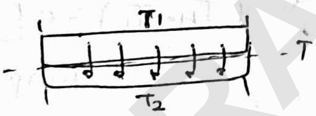
* combination

$$\boxed{R = \frac{L}{KA}}$$

① series



OR



* equivalent thermal conductivity

$R = R_1+R_2$

$$\frac{L_1+L_2}{KA} = \frac{L_1}{K_1A} + \frac{L_2}{K_2A}$$

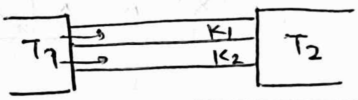
$$\boxed{K = \frac{L_1+L_2}{\frac{L_1}{K_1}+\frac{L_2}{K_2}} = \frac{\Sigma(L)}{\Sigma\left(\frac{L}{K}\right)}}$$

length = equal (identical rod)

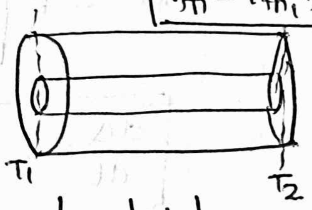
$$\boxed{K = \frac{2K_1K_2}{K_1+K_2}}$$

② Parallel

ΔT = same



$$\boxed{i_{th} = i_{th_1}+i_{th_2}}$$



*

$\frac{1}{R} = \frac{1}{R_1}+\frac{1}{R_2}$

* $\frac{K(A_1+A_2)}{L} = \frac{K_1A_1}{L} + \frac{K_2A_2}{L}$

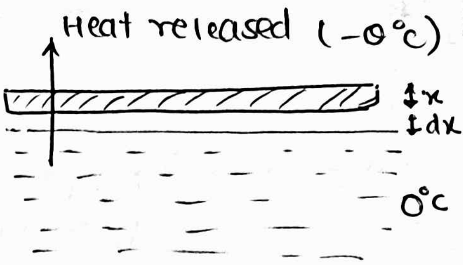
* $K = \frac{K_1A_1+K_2A_2}{A_1+A_2} = \frac{\Sigma(KA)}{\Sigma(A)}$

* Identical rods

$$\boxed{K = \frac{K_1+K_2}{2}}$$

★ Growth of ice on lake surface:-

* To freeze the water, Temp. must be below (0°c) [of the atmosphere surroundings)



* Heat released by the thickness of ice.

$$dQ = \frac{KA(0-(-\theta))\,dt}{x} \quad -①$$

* To freeze the extra thickness 'dx'

$$dQ = mL_F \rightarrow dQ = \rho A(dx)L_f \quad -②$$

$$\frac{KA\theta}{x}\,dt = (\rho A L_f)\,dx$$

$$dt = \frac{\rho A L_F (x \cdot dx)}{KA\theta}$$

0 to x

$$\boxed{t = \frac{\rho L_F}{2K\theta}(x^2)}$$

x_1 to x_2

$$\boxed{t = \frac{\rho L_F}{2K\theta}(x_2^2 - x_1^2)}$$

Ques. Al. cube of side 20cm. one face is maintained at 100°c & opp. face at 0°c $K_{Al} = 210$ N/m°c. Find heat flow in 10se.

Sol.

$$dQ = \frac{KA(T_H-T_L)\,t}{L}$$

$$= \frac{210 \times 20 \times 20 \times 10^{-4} \times 100 \times 10}{20 \times 10^{-2}}$$

$$= 42000\,J.$$

$$dQ = \frac{KA(T_H-T)t}{l}$$

$$= \frac{210 \times 20 \times 20 \times 10^{-4}}{20 \times 10^{-2}} \times 100$$

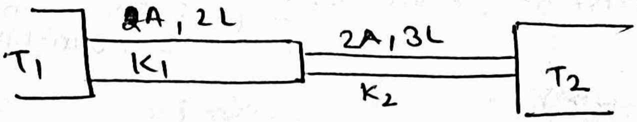
42×10^2

4200 J

~~42k~~

42 kJ

Ques.



Sol. $R = R_1 + R_2$

$$\frac{5L}{K(A)} = \frac{2L}{K_1(2A)} + \frac{3L}{K_2(2A)}$$

$$\frac{5}{K} = \frac{2}{K_1} + \frac{3}{K_2}$$

$$\frac{5}{K} = \frac{2K_2 + 3K_1}{K_1K_2}$$

$$\boxed{K = \frac{5K_1K_2}{3K_1 + 2K_2}}$$

$\frac{1}{K} =$

$\underline{5L}$

$R = R_1 + R_2$

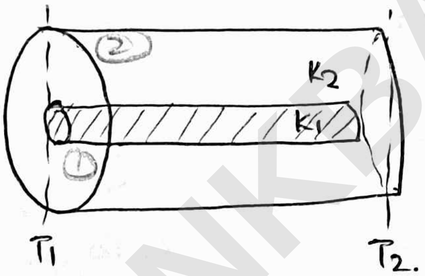
$$\frac{5L}{K(A)} = \frac{2L}{K_1(2A)} + \frac{3L}{K_2(2A)}$$

$$\frac{5}{K} = \frac{2}{K_1} + \frac{3}{2K_2}$$

$$\frac{5}{K} = \frac{2K_2 + 3K_1}{2K_1K_2}$$

$$\boxed{K = \frac{5K_1K_2}{3K_1 + 2K_2}}$$

Ques.



inner Radius = R
outer Radius = 2R

Sol. $A_1 = \pi R^2$ $A_2 = 3\pi R^2$

$A_2 = 3\pi R^2$

$\frac{1}{R} = \frac{1}{R_1}$

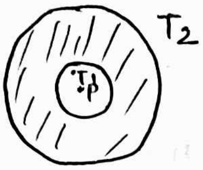
$$K = \frac{K_1 \pi R^2 + K_2 3\pi R^2}{4\pi R^2}$$

$$\frac{LA}{L} = K = \frac{K_1\pi R^2 + K_2 3\pi R^2}{4} \Rightarrow \frac{K_1 + 3K_2}{4}$$

$$= \frac{K_1 + 3K_2}{4}$$

Ques. concentric shell of radii r_1 + r_2 are given space b/w them is filled with a material of thermal conductivity K temp. of inner surface is T_1 + of outer surface is T_2 is maintened by keeping a thermal Heater of const. Power P. calculate P.

$r_1 < r_2$



Sol.

$$\frac{dQ}{dt} = \frac{KA}{L}(T_H - T_L)$$

$$\boxed{P = \frac{\cancel{KA}}{\cancel{L}} \frac{\Delta T}{R_{th}}}$$

$$\boxed{\frac{dQ}{dt} = \frac{KA}{L}(T_H - T_L)}$$

$$R_{th} = \int dR_{th}$$

$$dR = \frac{dx}{K(4\pi x^2)}$$

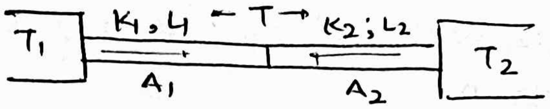
$$= \int_{r_1}^{r_2} \frac{1}{4\pi K} \cdot \frac{dx}{x^2} = \frac{1}{4\pi K}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

$$= \frac{1}{4\pi K}\left[\frac{r_2 - r_1}{r_1 r_2}\right]$$

$$\boxed{P = \frac{(T_1 - T_2)}{r_2 - r_1} 4\pi K(r_1 r_2)}$$

$$\boxed{P \propto \frac{r_1 r_2}{r_2 - r_1}}$$

★ Temperature of the Junction:-



(✱) Assume that 'T' is highest

→ outgoing thermal current = 0

(✱) At a time only for ~~the~~ one Junction

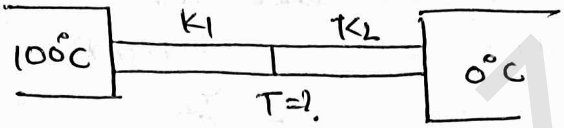
$$i_{th} = \frac{KA(\Delta T)}{L} = \frac{dQ}{dt}$$

equat^n

$$\boxed{\frac{K_1A_1}{L_1}(T-T_1) + \frac{K_2A_2}{L_2}(T-T_2)=0}$$

Ques:-

identical rods
(A, L = same)



i) $\frac{K_1}{K_2} = \frac{2}{3}$

ii) $\frac{K_1}{K_2} = 1$

Sol. i)

$$K_1(T-100) + K_2(T-0) = 0$$

$$2(T-100) + 3(T-0) = 0$$

$$2T-200 + 3T = 0$$

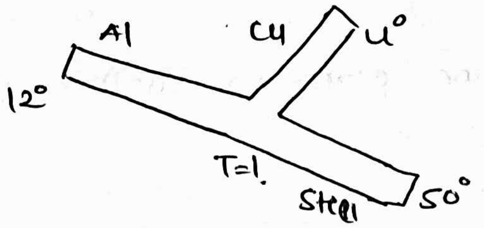
$$\boxed{T = 40°C}$$

ii)

$$T-100 + T = 0$$

$$\boxed{T = 50°C}$$

Ques:-



$K_{Al} = 400\ W/m°C$

$K_{Cu} = 200\ W/m°C$

$K_{Steel} = 50\ W/m°C$

Sol.

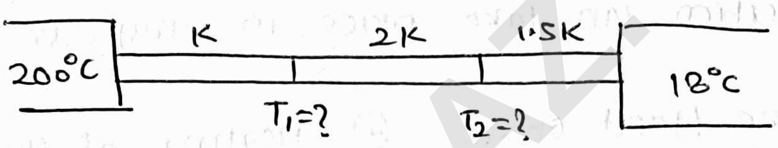
$$400(T-12) + 50(T-50) + 200(T-4) = 0$$

$$400T - 4800 + 50T - 2500 + 200T - 800 = 0$$

$$650T = 8100$$

$$T = \frac{810}{65}$$

Ques.



Identical rods

Sol.

$$K(T_1-200) + 2K(T_1-T_2) = 0$$

$$4K(T_2-T_1) + 3K(T_2-18) = 0$$

$$T_1 - 200 + 2T_1 - 2T_2 = 0$$

$$\boxed{3T_1 - 2T_2 = 200}$$

$$4T_2 - 4T_1 + 3T_2 - 54 = 0$$

$$\boxed{7T_2 - 4T_1 = 54}$$

$$12T_1 - 8T_2 = 800$$

$$21T_2 - 12T_1 = 162$$

$$13T_1 = 962$$

$$\boxed{T_1 = 74}$$

$$\boxed{T_2 = 11}$$

CONVECTION

- ⊛ when Heat is transfer, from one place to another by actual movem. of Heat subst.
- ⊛ medium is essential
- ⊛ Nearly 90% of Heat transferred on earth is due to convection.
- ⊛ when movement of medium particles is due to diff. in densities then it is cla "Natural convection"
- ⊛ when subst. is moved by a force from Heater, blower, pump etc. then it is cla forced convection.
- ⊛ Natural convection take place from bottom to top. due to gravity while forced convection can take place in any dirᶜⁿ.

eq:-
① sea Breeze / Land breeze
② Monsoon
③ ventilation of room
④ Heating of fluid
⑤ Temp. regulation of a Human body by blood flow.

RADIATION

- ⊛ Heat transfer is due to radiation does not req. any medium.
- ⊛ it can take place in vaccum.
- ⊛ eq:- ~~[illegible]~~ sun light reaching earth after travelling through vaccum.
- ⊛ Thermal radiation (Infra red) are EMW. so it can with spd. of Light.
- ⊛ radiation take place in solid, liquid & gases but convection is used for liquids mainly. but used for gas also.

⊛ काम की बात

Focus on units of quantities involved

Intensity ⇒ Energy per unit area per unit time

$$I = \frac{E}{At} \rightarrow J/m^2s$$
$$\rightarrow watt/m^2$$

⇓

$$\boxed{\epsilon = \frac{Q}{At}}$$

$$Q = \epsilon At$$

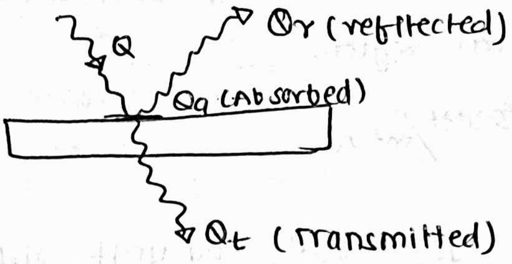
$$\boxed{Power = \epsilon A}$$

* Energy → Q
↓
Intensity
↓
emissive } ⇒ E
↓
Radiation intensity

$$\frac{dQ}{dt} = \text{Rate of Heat Flow} = R_H = \text{Rate of Heat loss}$$

$$\frac{dT}{dt} = \text{Rate of Temp. change} = R_F = \text{Rate of Fall in temp.}$$

*



(*) $Q = Q_a + Q_r + Q_t$

$$\frac{Q_a}{Q} + \frac{Q_r}{Q} + \frac{Q_t}{Q} = 1$$

$$\boxed{a + r + t = 1}$$

$a = \frac{Q_a}{Q}$ → absorptive power

$r = \frac{Q_r}{Q}$ → Reflective power

$t = \frac{Q_t}{Q}$ → Transmitive Power

For a surface

- $a = 1 \Rightarrow r = 0 = t$

* Perfect absorber

(ideal Black body

- $r = 1 \Rightarrow a = 0 = t$

* Perfect Reflector

$t = 1 \Rightarrow a = 0 = r$

* Perfect transparent.

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L-3

TL-85

(*) Absorptive Power :- it is the amount of thermal radiation absorbed to the incident thermal radiation
(a)

→ $a = \frac{Q_a}{Q}$ - * unitless dimensionless physical quantity

(*) spectral absorptive power :- it the absorptive power for a wavelength

- $a_\lambda = \frac{Q_{a_\lambda}}{Q_\lambda}$ → Defined for unit spectral region

- $a = \int_0^\infty a_\lambda \cdot d\lambda$ unit /m (or) /nm.

$$\boxed{a_\lambda = \frac{da}{d\lambda}}$$

* Emissive Power :- it is intensity

:- Amount of radiation (thermal) emitted by a black body per unit area per sec. at a particular temp.

* unit :- $J/m^2 s$ or $\frac{watt}{m^2}$

* Spectral emissive Power :- $e_{(\lambda)}$ radiation emitted by unit area in 1 sec. in unit spectral region.

* unit :- $Watt/m^2 A^\circ$

* Emissivity :- Radiation energy given out by unit surface area per sec. corresponding to ~~chang~~ unit difference in temp. w.r.t surroundings.

* unit :- watt/ $m^2 K$

* Relative emissivity :- (e_r) $e_r = \frac{Q_{GB}}{Q_{IBB}} = \frac{E_{GB}}{E_{IBB}}$.

GB = Grey body or General body

it is ratio of amount of radiation emitted by a grey body to the amt. of radiation emitted by a ideal black body at same temp.

* $\boxed{\text{IDEAL BLACK BODY}}$

⊛ Need not be black in color eg:- sun

⊛ it is a surface which has $\boxed{a_\lambda = 1}$ i.e $\boxed{a = 1}$

$\downarrow$ Perfect absorber

⊛ In General Rough, black surface is B.B.

★ Prevost theory of Heat Exchange :-

Acc. to it at every possible temp. (more than 0K) the heat exchange b/w body + surrounding is continous + this exchange carry on for ∞ time.

cases

⊛ $\boxed{T_B > T_{surroundings}}$

⇒ $\boxed{\text{Rate of emission of radiation by the body} > \text{Rate of absorption by the body}}$

* T_B will $\downarrow$es ⇒ cooling effect

⊛ $\boxed{T_B < T_S}$

⇒ $\boxed{\text{Rate of emission} < \text{Rate of absorption}}$

⇒ T_B $\uparrow$es = Heating of effect

⊛ $\boxed{T_B = T_S}$

→ $\boxed{\text{Rate of emission} = \text{Rate of absorption}}$

→ $T_B = \star$

★ Kirchoff's law

⊛ Good absorbers are good emitters.

⊛ Good absorbers at low temp. are good emitters at $\uparrow$gh temp.

⊛ At particular temp., for all bodies the ratio of their spectral emissive power to their spectral absorptive power is const.
& is equal to emissive power of ideal black body at same temp.

$$\boxed{\frac{a_\lambda}{e_\lambda} = \star}$$

$$\boxed{\underset{\text{at high temp.}}{e_\lambda} \propto \underset{\text{at low temp.}}{a_\lambda}}$$

i) $\boxed{\left[\frac{e_\lambda}{a_\lambda}\right]_1 = \left[\frac{e_\lambda}{a_\lambda}\right]_2}$

ii) $\boxed{\left[\frac{e_\lambda}{a_\lambda}\right]_{GB} = \left[\frac{e_\lambda}{a_\lambda}\right]_{IBB} = (e_\lambda)_{IBB}}$

$(a_\lambda = 1)$

Ex:- in Deserts, Days are hot but nights are cold.

Ex:- ① Metal utensils ⇒ has shiny surface

↓ (Rough, Black color)/(starch) → Heat absorb करेगा।

$\underbrace{\text{(Rough, Black color)/(starch)}}_{\text{behave as BB}}$

↓ To cool down in dark room

↓ BB shine

② Black utensils

← Heat

scratch → shine ××

STEFAN'S LAW [STEFAN-BOLTZMANN'S LAW]

the Amount of radiation emitted per unit area per sec. by IBB is directly proportional to its 4th power of its absolute temp.

i.e $E \propto T^4$ ↓ intensity

$\boxed{E = \sigma T^4}$

σ = stephan's const. = 5.67×10^{-8} watt/$m^2 K^4$

T = Temp in kelvin

* when IBB is kept in surround of Temp T_s.

↳ Net emission by IBB $\boxed{E = \sigma(T^4 - T_s^4)}$

$\boxed{Q = \sigma A (T^4 - T_s^4) t}$

$E = \frac{Q}{At} = \sigma T^4$

$\boxed{Q = \sigma A T^4 t}$

$$\boxed{Q_{GB} = e_r\, Q_{IBB} = e_r\, \sigma A (T^4 - T_s^4)\, t}$$

* **Rate of Heat loss (R_H)**

$$\boxed{\frac{dQ}{dt} = \sigma A (T^4 - T_s^4)}$$

* Rate of fall in temp.

or

Rate of cooling

$$\boxed{R_F = \frac{dT}{dt} = \frac{\sigma A}{msJ}(T^4 - T_s^4)}$$

$$\frac{dQ}{dt} = ms\frac{dT}{dt}$$

$$\frac{dT}{dt} = \frac{dQ}{dt\,(ms)}$$

$R_H \propto A$ (if T & T_s same) of diff case

$R_H \propto \frac{A}{ms}$ (")

$\propto \frac{A}{\rho V s}$.

Q. Temp. of an IBB is 227°C it is kept in surroundings of temp. $T_s = 120°C$ then Amount of radiation $= Q$. If temp of IBB is increased to 327°C & kept again same surroundings. the amt. of radiation emitted =?

$$\begin{array}{r} 327 \\ 273 \\ \hline 600 \end{array} \qquad \begin{array}{r} 120 \\ 273 \\ \hline 493 \end{array} \qquad \begin{array}{r} 227 \\ 273 \\ \hline 00 \end{array}$$

Sol. $E \propto (T^4 - T_s^4)$

$500^4 -$

$$\frac{Q}{n} = \frac{(500)^4 - (493)^4}{(600)^4 - (493)^4}$$

$Q\,(600)^4 - Q(493)^4 = [illegible]$

$n(493)^4$

Ques. Temp. of IBB is ↑sed by 50% of its initial value then find the % ↑es in radiation emitted per unit area per sec.

Sol.

$$\boxed{E \propto T^4}$$

$$\Rightarrow \frac{E_2}{E_1} = \left(\frac{T_2}{T_1}\right)^4$$

$$\Rightarrow \frac{E_2}{E_1} = \left(\frac{1.5T}{T}\right)^4$$

$$\Rightarrow \frac{E_2}{E_1} = \frac{81}{16}$$

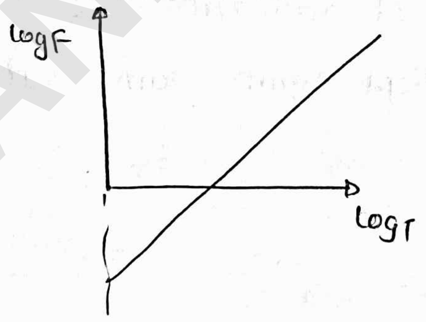
$$\frac{E_2 - E_1}{E_1} \times 100 = \left(\frac{81-16}{16}\right) \times 100$$

$$\approx 400\%$$

Ques. For eq: $E = \sigma T^4$ plot the Graph b/w $\log_{10} E$ & $\log_{10} T$

Sol.

$$\underbrace{\log E}_{y} = \log \sigma + 4 \underbrace{\log T^4}_{x}$$



$x + \frac{50}{100}$

$100 + 50$

$\boxed{E \propto T^4}$

$\frac{E_1}{E_2} = \frac{T^4}{T}$

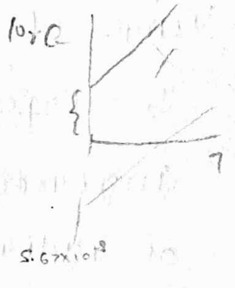
$\Rightarrow \frac{(100)^4}{100+50}$

$\left(\frac{100}{150}\right)^4$

$\Rightarrow \left(\frac{2}{3}\right)^4$

$\Rightarrow \frac{81}{16} - 16 \times 100$

$\log E = \log \sigma + 4 \log T$



$\sigma = 5.67 \times 10^{-8}$

$\log \sigma = -8$

☆. NEWTON'S LAW OF COOLING :-

* Excess temp. $\boxed{\Delta T = T - T_s}$ $\boxed{T = T_s + \Delta T}$

* NLC is applicable ~~for~~ only when ΔT is not more than 35°C

* temp ⇒ °C.

* Acc. to NLC Rate of cooling is directly proportional to excess temp of the body over given surrounding i.e

$$\boxed{\frac{dT}{dt} \propto (T - T_s)}$$

As per stefan - Boltzmann's law.

$$\boxed{\frac{dT}{dt} = \frac{\sigma A}{msJ}(T^4 - T_s^4)}$$

$$\Rightarrow \frac{dT}{dt} = \frac{\sigma A}{msJ}(4 \Delta T \, T_s^3)$$

$$\Rightarrow \boxed{\frac{dT}{dt} = \left(\frac{4\sigma A T_s^3}{msJ}\right)\Delta T}$$

$$\boxed{\frac{dT}{dt} \propto \Delta T}$$

$$\boxed{K = \frac{4\sigma A T_s^3}{msJ}}$$

→ depends on
- Temp. of surrounding
- A, m, s of the body.

For Ques.

Temp. of a body falls from T_1 to T_2 in T time

T_s = Given.

$$\boxed{\frac{T_1 - T_2}{t} = K\left(\frac{T_1 + T_2}{2} - T_s\right)}$$

$$T_1 \xrightarrow{t} T_2$$

* Rate of change in Temp = $\boxed{\frac{dT}{dt} = -K(T-T_s)}$

$$\Rightarrow \int_{T_0}^{T} \frac{dT}{T-T_s} = \int_{t=0}^{t} -K\,dt$$

$$\Rightarrow \left[\ln(T-T_s)\right]_{T_0}^{T} = -Kt$$

$$\Rightarrow \ln\left[\frac{T-T_s}{T_0-T_s}\right] = -Kt$$

$$\Rightarrow \frac{T-T_s}{T_0-T_s} = e^{-Kt}$$

$$\boxed{T = T_s + (T_0-T_s)e^{-Kt}}$$

29/01

L-4

TL-86

Ques:- Temp. of a body kept in surrounding of temp. 30°c falls from 50°c to 45°c in 5 min. Find temp. of body at end of next 5 min.

sol.

$$\frac{5}{5} = K\left[\frac{50+45}{2} - 30\right]$$

$$\frac{45-T}{5} = K\left[\frac{45+T}{2} - 30\right]$$

$$\frac{5}{45-T} = \frac{50+45-60}{45+T-60}$$

$$\frac{\cancel{5}}{45-T} = \frac{\cancel{35}7}{T-15}$$

$$T-15 = 315 - 7T$$

$$\frac{T_1-T_2}{t} = K\left(\frac{T_1+T_2}{T_2} - T_s\right)$$

$$\frac{5}{\cancel{300}} = K\left(\frac{95}{\cancel{2}} - 30\right]$$

$$\frac{1}{60} = K\left[5\right)$$

$$K = \frac{1}{60\times11}$$

$$\frac{45-4}{3\cancel{60}} = \frac{1}{64\times15}\left[\frac{45+4}{2} - 30\right]$$

$$135-34 = \frac{41+4-60}{2}$$

$$170 - 64 = 245$$

$$7\mathrm{M} =$$

Q. excess temp. of a body becomes Half of its previous value in 10min Initial temp. of the body = 50°c $T_s = 30°c$ Find temp. of body in next 10 min.

Sol.

$$\overset{°C}{50} \xrightarrow{10min} T_1 \xrightarrow{10min} T_2$$

40°c.

$\Delta T = T - T_s$

$\Delta T = 50 - 30 = 20°C$

$\Delta T' = \frac{\Delta T}{2} = 10°C$ $\quad \frac{\Delta T}{} = \Delta T$

$T_B' - T_s = 10$ $\quad \frac{50 - T}{100} = \Delta T$

$T_B' = 40°$ $\quad \frac{50 - T}{20} = \frac{\Delta T}{2}$

$\frac{10 - T}{10} = \frac{1}{2}\left(\frac{50 - T}{20}\right)$

$(T, 10)$

①

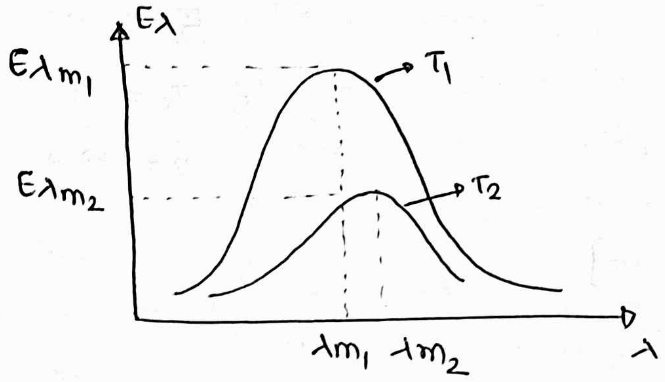
$$\frac{50 - 40}{t_1} = K\left[\frac{50 + 40}{2} - 30\right]$$

$$\frac{40 - T_2}{t_2} = K\left[\frac{40 + T_2}{2} - 30\right].$$

* SPECTRAL ENERGY DISTRIBUTION CURVES :-

* Given by Planck

* Explainatⁿ by Maxwell



λm = wavelength asso. with maximum emission

* If temp. ↓es
$T_2 < T_1$

* $\lambda m_2 > \lambda m_1$

* Peak value of Graph ↓es
$E_{\lambda m_2} > E_{\lambda m_2}$

⊛ Wien's Displacement law :-

⇨ Acc. to it, when temp of BB is ↑esed, then wavelength corresp. to Maximum emission ↓es.

$$\boxed{\lambda_m T = b}$$

$$\boxed{\lambda_m T = \star}$$

~~E ∝~~ $\boxed{\lambda_m \propto \frac{1}{T}}$

T = in Kelvin

b = wien's constant
$= 2.87 \times 10^{-3}$ mK
$= 3 \times 10^{6}$ nmK

⊛ Wien's 5th Power law:-

→ Acc. to it, Amount of radiation associated with λm is directly Proportional to 5th Power of Absolute temp. of IBB.

→ i.e $\boxed{\text{Peak of Graph} \propto T^5}$

– $\boxed{E_{\lambda m} \propto T^5}$

⊛ Stefan's law :-

Acc. stefan's law ; the total aml. of radiation per unit Area per sec.

$$\boxed{E = \int_0^\infty E_\lambda \cdot d\lambda = \text{Area of the graph} \propto T^4}$$

Note:- wien's law is used to determine the temp. of star.

Red → 3×10^3 K

Orange → 4×10^3 K

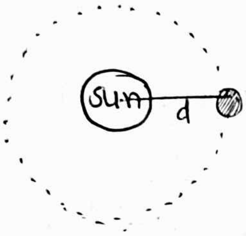
Yellow → 5×10^3 K

white → 10 to 20×10^3 K
(our sun).

Blue → $20 - 30 \times 10^3$ K.

SOLAR CONSTANT

→ it is the amt. of solar radiant energy received per unit area / sec. by a black surface held at right Angles to the sun rays. & Place at Mean distance of earth. In absence of atmosphere.



$\boxed{R_{sun} = R}$

$\boxed{E = \sigma T^4}$

* Power emitted $P_{sun} = (\sigma T^4)(4\pi R^2)$

* Power received by earth per unit Area

$$\boxed{S = \frac{(\sigma T^4)(4\pi R^2)}{(4\pi d^2)}}$$

$S = 1340$ watt/m2.

* Temp. of sun

$$\boxed{T = \left(\frac{Sd^2}{\sigma R^2}\right)^{1/4} = 5800K}$$

$$S = \frac{(\sigma T^4)(4\pi R_s^2)}{4\pi d^2} \times \pi R_e^2$$

☆ IMP POINTS

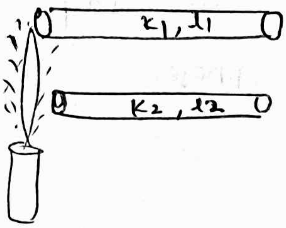
* Range of liquid (Mercury) thermometers ⟹ $-50°C$ to $350°C$

(Alcohol) " ⟹ $-80°C$ to $350°C$

* Error in scale due to expansion or contraction

at θ	at $\theta' > \theta$	at $\theta < \theta'$
TV = SR	TV' > SR	TV < SR

*



coated with wax.

length of rod upto which wax is melted is

$$\boxed{\frac{l_1}{l_2} = \sqrt{\frac{K_1}{K_2}}}$$

* Heat transfer via convection ; temp gradient exists in vertical dirⁿ

* Prism to see spectrum of radiation

→ KCl prism

→ Rock salt Prism

→ Flourspar prism.