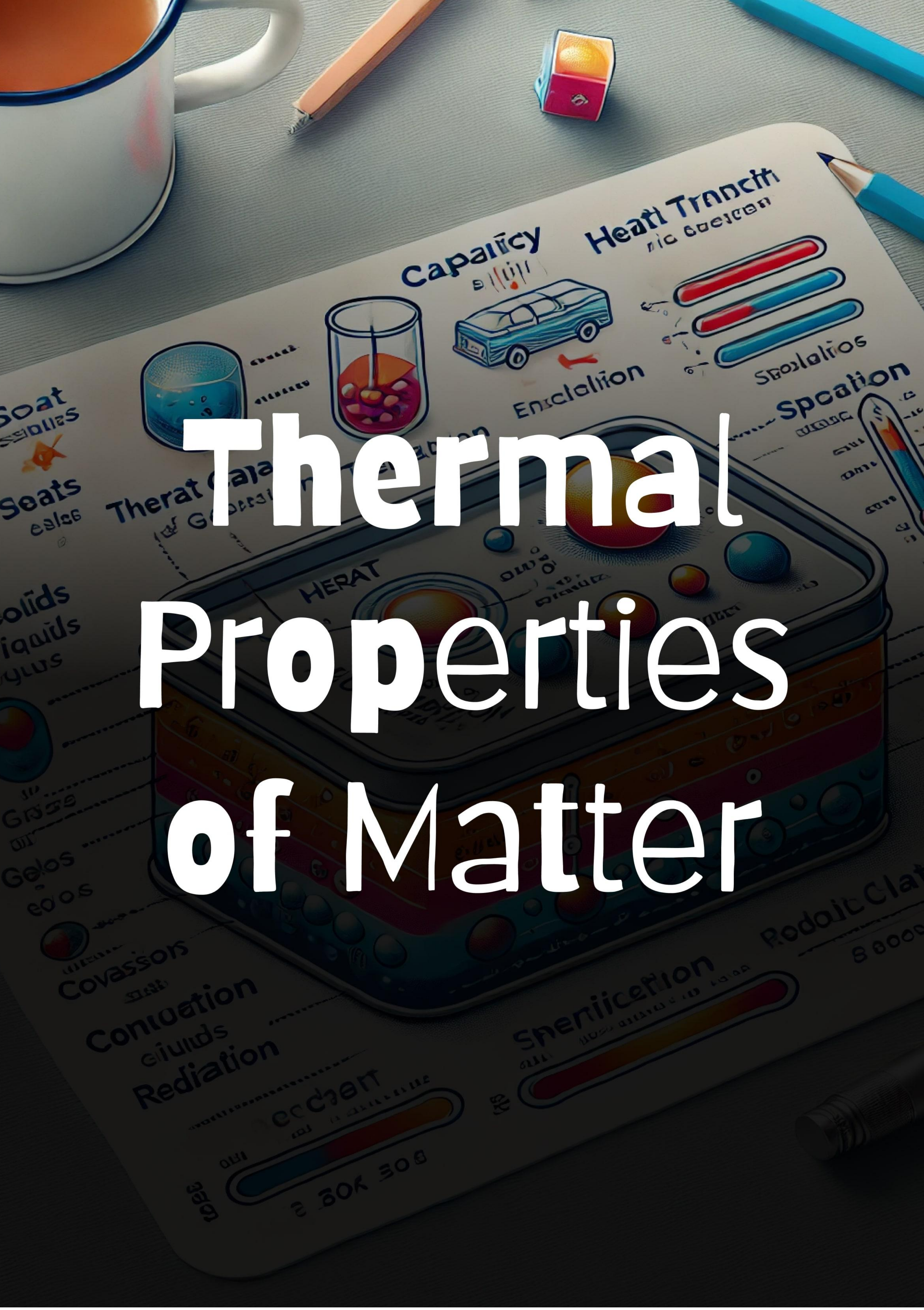


Thermal Properties of Matter

L-1

THERMAL PROPERTIES OF MATTER

Heat → cause change in thermodynamic stage
↳ Heat is a Transit form of energy

A body can store heat (false).
↳ Temperature will increase.

Vibration of atom induces temperature

Vibration ↑ temp^n ↑
↳ ↓ ↳ ↓

True > If heat is removed from body, then temp^n will decrease

Heat 1 cal = 4.2 J
↳ Energy which flow from one body to other due to temp^n difference
↳ It can't store by body

Ramlal scale = x MR = 4 MR

BP of H_2O → 100°C = 373 K = 212°F

Melting point Ice → 0°C = 273 K = 32°F

Rankine & Reaumer practical scale of Measure.

$$\frac{C-0}{100-0} = \frac{F-32}{212-32} = \frac{K-273}{373-273} = \text{const}^n$$

↳ all represents same temp^n but not same value

Rel^n b/w K & C :-

$$\frac{C-0}{100-0} = \frac{K-273}{373-273}$$

$$C = K - 273$$

$$\Delta C = \Delta K$$

Change in °C = change in K

C & F

$$\frac{C}{5} = \frac{F-32}{9}$$

$$9C = 5F - 160$$

$$9\Delta C = 5\Delta F$$

$$\Delta F = \frac{9}{5}\Delta C$$

$$\Delta F = 1.8\Delta C$$

Page No
Date

(1) If $temp^r$ of object raised by 27°C. Then raise $temp^r$ in Kelvin?
✓(a) 300K
(b) 27K
(c) 273K
(d) 246K

(2) If $temp^r$ of an object is 27°C, then its $temp^r$ in Kelvin?
(a) 27K
(b) 273K
✓(c) 300K
(d) 246K

(3) $Temp^r$ diff. = 5°C
✓(a) 9°
(b) 41°
(c) 2.8°
(d) 15°

$\Delta f = \frac{9}{5}(\Delta C) = \frac{9}{5} \cdot 5 = 9°$

(4) $\frac{C}{100} = \frac{f-32}{180} \Rightarrow \frac{C}{5} = \frac{C-32}{9}$

$\Rightarrow 9C = 5C - 160$

$\Rightarrow 9C - 5C = -160$

$\Rightarrow C = -\frac{160}{4} = -40°C$

> At −40°C reading of Celsius & farenheit scales are same.

> 0°C is equivalent to 273.15K.

(5) $C = 40°C$

$\frac{40}{5} = \frac{f-32}{9}$

$\Rightarrow f - 32 = \frac{360}{5} = 72$

$\Rightarrow f = 32 + 72$

$= 104$

(6) LFP = 20°MR

BFP = 150°MR

$$\Rightarrow \frac{x - 20}{150 - 20} = \frac{60° - 0}{100 - 0}$$

$$\Rightarrow x - 20 = \frac{60 \times 130}{100}$$

$$\Rightarrow x = 78 + 20 = 98°C$$

(7) A faulty thermometer has its fixed points marked at 60° & 96°. What is the correct temperature on the centigrade scale when this thermometer reads 85°?

(a) 83°C
(b) 93°C
(c) 90°C
(d) 69°C ✓

$$\frac{85 - 60}{96 - 60} = \frac{C}{100}$$

$$\Rightarrow \frac{25}{36} = \frac{C}{100}$$

$$\Rightarrow C = \frac{25 \times 100}{36} = \frac{625}{9} = 69.4$$

(8) On a new scale of temperature (which is linear) and called the W scale, the freezing and boiling pts of water are 39°W and 239°W respectively. What will be the temperature on the new scale corresponding to a temperature of 39°C on the celsius scale?

(a) 78°W
(b) 117°W ✓
(c) 200°W
(d) 139°W

$$\frac{W - 39}{239 - 39} = \frac{39}{100}$$

$$W = 39 \times 2 + 39$$

$$= 117°W$$

(9) A Centigrade & a fahrenheit thermometer are dipped in boiling water. The H_2O temperature is lowered until the fahrenheit thermometer registers 140°F. What is the fall in temperature as registered by the centigrade thermometer.

(a) 40° ✓
(b) 80°
(c) 50°

(d) 90°

100°C / 212°F $\Delta f = 212 - 140$ $\Delta f = 72$

$\Delta f = \frac{9}{5}\Delta C$

$\Delta C = \frac{5}{9}\Delta f = \frac{5}{9} \times 72 = 40$

Construction of thermometer:-

Length thermometer → Based on the expansion of length due to raise in tempr

Length of rod at 0° C → L_0

Length of rod at 100°C → L_{100}

at t°C = ?

Change in tempr = 100

change in length = $(L_{100} - L_0)$ when tempr changes from 0°C - 100°C

" " per unit change in tempr = $\frac{L_{100} - L_0}{100}$

" " in t° change in tempr = $\frac{L_{100} - L_0}{100} = \frac{L_t - L_0}{t}$

Pressure thermometer → $\frac{P_t - P_0}{t} = \frac{P_{100} - P_0}{100}$

Volume thermometer → $\frac{V_t - V_0}{t} = \frac{V_{100} - V_0}{100}$

Resistance thermometer → $\frac{R_t - R_0}{t} = \frac{R_{100} - R_0}{100}$

(10) Resistance at 25° C is 50Ω and at 100°C is 80Ω, then find resistance at 60°C.

Per unit tempr = $\frac{30\Omega}{75} = \frac{R - 50}{35}$

$\Rightarrow R = 14 + 50 = 64\Omega$

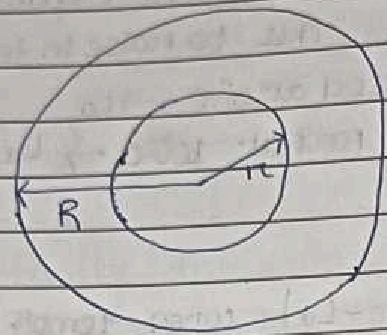
-2 (Zoom)

Date

Thermal expansion:-

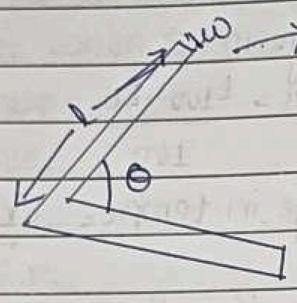
Temp^{r} ↑ Inter molecular dist. ↑ Inter molecular force ↓

(11) Angular disc, when temp^{r} increase then



R↑, r↑

Expansion = Magnification

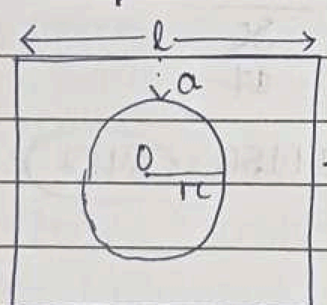


→ when temp^{r} increase when l↑, w↑, θ → same

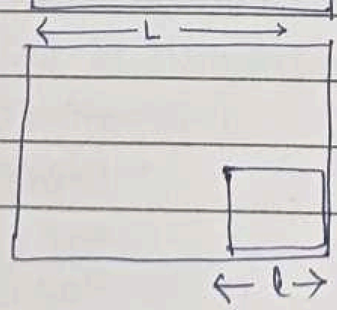
When Isotropical material is heated then all linear increases but not angular its just a photographic enlargement (zoom)

Solid → Linear expansion
→ Areal expansion or superficial expansion
→ Volume expansion.

Liquid and gas → only volume expansion.

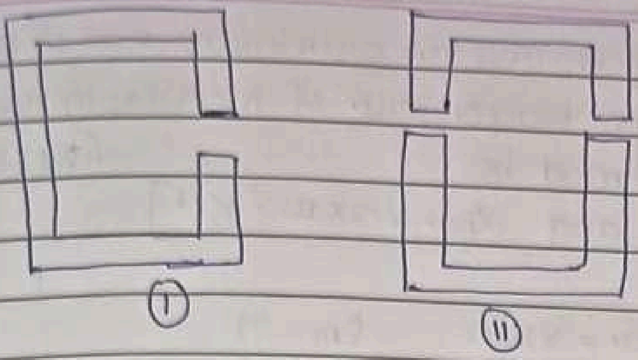


→ l↑, r↑, a↑



Temp^{r} ↓, l↓, L↓

Page No.
Date



(Temp↑)

In fig(1) Increase & fig(2) decrease.

Thermal expansion :- Linear expansion.

(Change in length) $\Delta l \propto l_0$
$\Delta l \propto \Delta T$

[unit of α = K^{-1}]

α = Co-efficient of linear expansion. → depends on nature of Solid / crystal.

$\Delta l = \alpha l_0 \Delta T$

$\Delta l = \alpha l_0 \Delta T$

$l_f - l_0 = \alpha l_0 \Delta T$

$\boxed{l_f = l_0 (1 + \alpha \Delta T)}$

→ $\alpha = \frac{\Delta l}{l_0 \Delta T}$ = fractional change in length per unit raise in tempr.

$\frac{\Delta l}{l_0}$ = fractional change in length.

$100 \times \frac{\Delta l}{l_0}$ = % change in length.

feel (12) A metallic bar is heated from 0°C to 100°C. The Co-efficient of linear expansion is 10^{-5} K^{-1}. what will be the percentage increase in length.

Change Tempr is always same

(a) 0.01%
(b) 0.1% ✓
(c) 1%
(d) 10%

$\Delta T = 100°C = 100K$

$\alpha = 10^{-5}$ K^{-1}

$\boxed{\Delta l = l_0 \Delta T \alpha}$ → (MR Ratta.)

$\frac{\Delta l}{l_0} \times 100 = \Delta T \cdot \alpha \times 100$

$= 100 \times 10^{-5} \times 100 = 0.1\%$

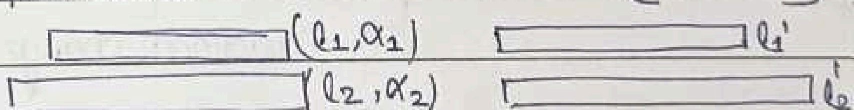
(13) 2 rods of length l_1 & l_2 are made of materials whose co-efficient of linear expansion are α_1 & α_2. If the difference b/w 2 lengths is independent of temperature [NEET-2016]

(1) $\frac{l_1}{l_2} = \frac{\alpha_1}{\alpha_2}$

(2) $\frac{l_1}{l_2} = \frac{\alpha_2}{\alpha_1}$ ✓

(3) $l_2^2 \alpha_1 = l_1^2 \alpha_2$

(4) $\frac{\alpha_1^2}{l_1} = \frac{\alpha_2^2}{l_2}$



$l_2 - l_1 = l_2' - l_1'$

$\Rightarrow (l_2 - l_2') = (l_1 - l_1')$

$= \Delta l_2 = \Delta l_1$

$\Rightarrow l_2 \Delta T \alpha_2 = l_1 \Delta T \alpha_1$

$\Rightarrow \frac{l_2}{l_1} = \frac{\alpha_1}{\alpha_2}$

(14) A copper rod of 88cm and an aluminium rod of unknown length have their difference in length independent of increase in temperature. The length of aluminium rod is: (NEET - 2019)
[$\alpha_{Cu} = 1.7 \times 10^{-5} K^{-1}$ and $\alpha_{Al} = 2.2 \times 10^{-5} K^{-1}$]

(a) 6.8 cm
(b) 113.9 cm
(c) 88cm
✓(d) 68cm

$l_{Cu} = 88cm$ $l_{Al} = ??$

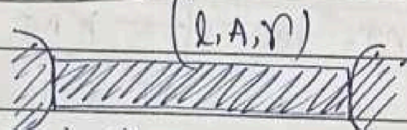
$l_c \alpha_c = l_{Al} \alpha_{Al}$

$88 \times 1.7 \times 10^{-5} = l \times 2.2 \times 10^{-5}$

$l = \frac{88 \times 1.7}{2.2} = 68\ cm$

(15) A metal of length l & cross section area A is fixed b/w rigid supports at negligible tension. If this is cooled, the tension in the wire will be.
(a) Proportional to l.
(b) Inversely proportional to l.
✓(c) Independent of l.
(d) Independent of A

Thermal Stress:-



Hook यहा ने होगा

$\frac{f}{A} = Y \frac{\Delta l}{l}$

$\frac{\Delta l}{l} = \frac{f}{AY}$ — (1)

↳ fractional change in length

Temp↑, $\frac{\Delta l}{l} = \alpha \Delta T$ — (II)

$\frac{f}{AY} = \alpha \Delta T$

$\boxed{\frac{f}{A} = Y\alpha \Delta T}$

Thermal stress

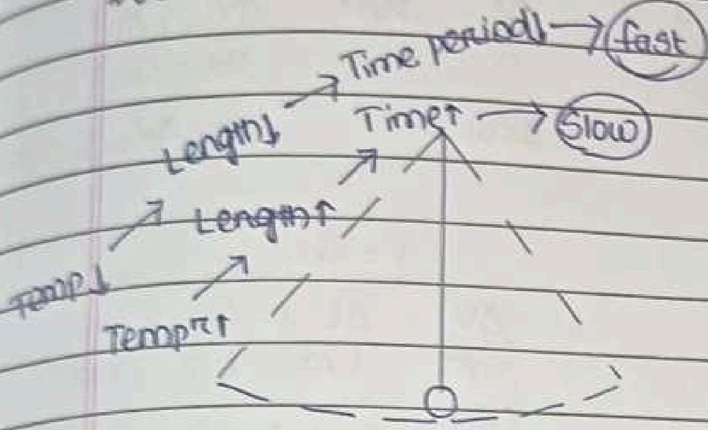
(16) A Rod is fixed b/w 2 points at 50°C. The co-efficient of linear expansion of material of rod is $2 \times 10^{-5}/°C$ and young's modulus is $1.5 \times 10^{11} N/m^2$. What is the stress developed in the rod if temp of rod becomes 70°C?

(a) 3×10^{4} N/m^2
(b) 6×10^{7} N/m^2 ✓
(c) 9×10^{12} N/m^2
(d) 11×10^{11} N/m^2

$T_i = 50°C$ $\quad T_f = 70°C$
$\alpha = 2\times10^{-5}$
$Y = 1.5\times10^{11}$

$$\frac{F}{A} = Y\alpha\Delta T$$
$$= 1.5\times10^{11}\times2\times10^{-5}\times20$$
$$= 60\times10^{6}$$
$$= 6\times10^{7}\ \text{N/m}^2$$

PENDULUM :-



Time period of oscillation

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

$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta l}{l}$ → fractional change in the

expansion $\frac{\Delta l}{l} = \alpha\Delta\theta$

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

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

$= \frac{1}{2}\alpha\Delta\theta$ (86400 sec)

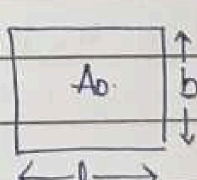
(17) The temp^r of pendulum the time period of which is t is raised by ΔT. The change in its time period is
(a) $\frac{1}{2}\alpha t\Delta T$
(b) $2\alpha t\Delta T$
(c) $\frac{1}{2}\alpha\Delta T$
(d) $2\alpha\Delta T$

Change in Time Period $= \frac{1}{2}\alpha(\Delta T)t$

Areal expansion:-

$\Delta A \propto A_0$
$\Delta A \propto \Delta T$

$\Delta A = \beta A_0\Delta T$



$B = \frac{\Delta A}{A_0\Delta T}$ → K^{-1}

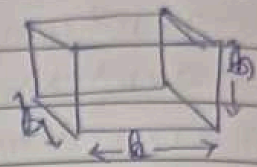
$\frac{\Delta A}{A_0} = B\Delta T$

$\frac{\Delta A}{A_0}\times100 = B\Delta T\times100$

$A_f - A_0 = BA_0\Delta T$
$A_f = A_0(1 + B\Delta T)$

B = sufficient of areal expansion.

Volume expansion:- (liquid, gas & solid)



(Change in volume) $\Delta V \propto V_0$

$\Delta V \propto \Delta T$

γ = Co-efficient of volume expansion.

$\Delta V = \gamma V_0 \Delta T$

$V_f - V_0 = \gamma V_0 \Delta T$

$$\boxed{V_f = V_0(1+\gamma\Delta T)}$$

$\beta = \frac{\Delta A}{A_0 \Delta T}$ $\quad \gamma = \frac{\Delta V}{V_0 \Delta T}$

$\frac{\Delta A}{A_0} = \beta\Delta T$ $\quad \frac{\Delta V}{V_0} = \gamma\Delta T$

100 $\quad 100\frac{\Delta V}{V_0} = 100\gamma\Delta T$

L-3

$$\left[\frac{\Delta A}{A\Delta T} = \frac{\Delta l}{l\Delta T} + \frac{\Delta b}{b\Delta T}\right]$$

$[\beta = \alpha_x + \alpha_y]$

$V = lbh$

$$\frac{\Delta V}{V\Delta T} = \frac{\Delta l}{l\Delta T} + \frac{\Delta b}{b\Delta T} + \frac{\Delta h}{h\Delta T}$$

$$\boxed{\gamma = \alpha_x + \alpha_y + \alpha_z}$$

Relation betn α, β & γ:-

$$\boxed{\frac{\alpha}{1} = \frac{\beta}{2} = \frac{\gamma}{3}}$$ MR*

(18) The volume of a solid decreases by 0.6% when it is cooled through 50°C Its coeffecient of linear expansion is

(a) $4\times10^{-6}\,K^{-1}$

(b) $5\times10^{-5}\,K^{-1}$

(c) $6\times10^{-4}\,K^{-1}$

✓(d) $4\times10^{-5}\,K^{-1}$

$\frac{\Delta V}{V}\times 100 = 0.6$

$\gamma = 3\alpha = \frac{\Delta V}{V\Delta T}$

$\alpha = \frac{\Delta V}{V\Delta T\times 3}$

$= \frac{0.6\ 2\times 2}{100\times 3\times 50\times 2}$

$= 4\times10^{-5}$

Page No.
Date

(18) A pendulum clock keeps correct time at 20°C. The correction to be made during summer per day where the average tempr is 40°C. (= 10^{-5}/°C) will be:

(a) 5.64 sec
(b) 6.64 sec
(c) 7.64 sec
✓(d) 8.64 sec

$\Delta T = 20K$

$T = 2\pi\sqrt{l/g}$

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

$T \alpha \sqrt{l}$

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

$= \frac{1}{2} 10^{-5} \times 86400 \times 20$

$= \underline{8.64 sec}$

$\frac{\Delta T}{T} = \frac{1}{2}\left(\frac{\Delta l}{l}\right) = \frac{1}{2}\alpha\Delta\theta$

(19) If the coefficient of cubical expansion is x times of the co-efficient of superficial expansion, then value of x is - AIIMS

(a) 3
(b) 2.5
✓(c) 1.5
(d) 2

$\frac{\beta}{2} = \frac{\gamma}{3}$

$\gamma = \frac{3}{2}\beta$

$\Rightarrow x = \underline{1.5}$

(20) Relation b/w Bulk Modulus of elasticity and thermal co-efficient of volume expansion.

$B = \gamma$

Volumetric Stress $\Rightarrow \Delta P = B\frac{\Delta V}{V}$ (Magnitude)

$\frac{\Delta V}{V\Delta T} = \gamma$ — (ii)

$\boxed{\frac{\Delta P}{B} = \gamma\Delta T}$ This is required relation.

(21) A pendulum clock is 5s fast at a tempr of 15°C and 10s slow at a temp. at 30°C. At what temp. does it give the correct time?

✗(a) 10°C
✓(b) 20°C
✗(c) 15°C
✗(d) 25°C

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

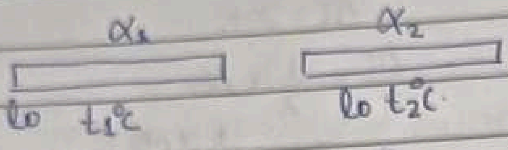
$\frac{-5 = \frac{1}{2}\alpha(T-15)}{10 = \frac{1}{2}\alpha(T-30)} = -\frac{1}{2} = \frac{T-15}{T-30}$

$\Rightarrow 2T + T = 30 + 30$

$\Rightarrow 3T = 60$

$T = 20°C$

(21) If 2 metal rods of co-efficient of linear expansion α_1 & α_2 have same length at t_1°C & t_2°C respectively then the common temperature at which they have again the same length is (t)



l_f (t) $\quad$ l_f (t)

$(l_f - l_0)$ 1th $\quad$ $(l_f - l_0)$ 2nd

$l_0 \alpha_1 (t - t_1) = \alpha_2 l_0 (t - t_2)$

$\alpha_1 t - \alpha_1 t_1 = \alpha_2 t - \alpha_2 t_2$

$\alpha_1 t - \alpha_2 t = \alpha_1 t_1 - \alpha_2 t_2$

$t(\alpha_1 - \alpha_2) = \alpha_1 t_1 - \alpha_2 t_2$

$$\boxed{t = \frac{\alpha_1 t_1 - \alpha_2 t_2}{\alpha_1 - \alpha_2}}$$

↳ This is the temp^{r}.

* Volume of liquid (must) increase by increasing temp^{r} → T/F → water → Analomous behaviour.

for liquid / solid / gas

$\Delta V \propto V_0$

$\Delta V \propto \Delta T \quad \Delta V = \gamma V_0 \Delta T$

(22) Variation of density with temperature for normal liquid.

$m = \rho V$ (m → const.)

$\frac{\Delta m}{m} = \frac{\Delta \rho}{\rho} + \frac{\Delta V}{V}$

$\frac{\Delta V}{V} = -\frac{\Delta \rho}{\rho}$

divided by ΔT both side

$\frac{\Delta V}{V \Delta T} = \frac{-\Delta \rho}{\rho \Delta T}$

$\gamma = \frac{-\Delta \rho}{\rho \Delta T}$

$-\gamma = \frac{\Delta \rho}{\rho \Delta T}$

$\Delta \rho = -\gamma \rho \Delta T$

$\rho_f - \rho = -\gamma \rho \Delta T$

$$\boxed{\rho_f = \rho(1 - \gamma \Delta T)}$$

(23) The value of coefficient of volume expansion of glycerin is 5×10^{-4} K^{-1}. The fractional change in the ~~velocity~~ density of glycerin for a rise of 40°C in its temp. is

(a) 0.010

(b) 0.015

✓(c) 0.020

(d) 0.025

$\gamma = 5 \times 10^{-4}$ K^{-1}

$\frac{\Delta \rho}{\rho} = \frac{\Delta V}{V} = \gamma \Delta T$

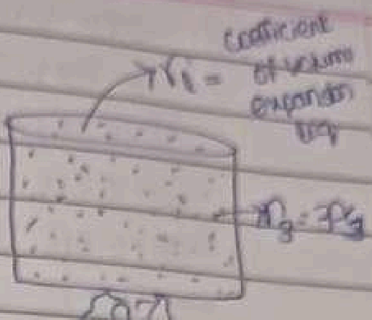
$= 5 \times 10^{-4} \times 40$

$= 200 \times 10^{-4}$

$= 0.02$

app. coefficient of volume expansion of liquid $\gamma_l' = \gamma_l + \gamma_s$ ×

$$\boxed{\gamma_l' = \gamma_l - \gamma_s}$$
$$= \gamma_l - 3\alpha_s$$



If $\gamma_l = \gamma_s$
$\gamma_l' = 0$
Tempr increased, Liquid level remains same

Tempr, $\gamma_l > \gamma_s$, liquid over-flow

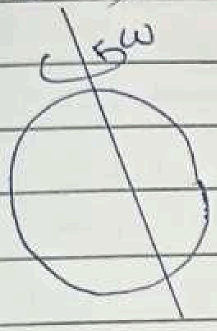
If $\gamma_l < \gamma_s$, $\gamma_l' = -ve$, Tempr ↑, liquid level fall.

(24) The co-efficient of apparent expansion of a liquid in a copper vessel is C & in a silver vessel S. The coeffecient of volume expansion of copper is γ_c what is the coefficient of linear expansion of silver.

(a) $(C + \gamma_c + S)/3$
(b) $(C - \gamma_c + S)/3$
✓(c) $(C + \gamma_c - S)/3$
(d) $(C - \gamma_c - S)/3$

$$\boxed{\gamma_l' = C = \gamma_l - \gamma_c} \quad \text{— (I)}$$
$$\gamma_l' = S = \gamma_l - \gamma_s \quad \text{— (II)}$$
(I) = (II)
$$\gamma_l = \gamma_l$$
$$C + \gamma_c = S + \gamma_s$$
$$C + \gamma_c - S = 3\alpha_s \Rightarrow \alpha_s = \frac{(C + \gamma_c - S)}{3}$$

effect on ω due to raise of tempr.



Tempr ↑ →
R↑, MOI ↑
$\tau = 0$
$L = \uparrow I \, \omega\downarrow = \text{const}$

(25) The density of water at 20°C is 998 Kg/m³ & 40°C 992 Kg/m³. The coefficient of volume expansion of water is [NEET KAR. 2013]

(a) $10^{-4}/°C$
✓(b) $3 \times 10^{-4}/°C$
(c) $2 \times 10^{-4}/°C$
(d) $6 \times 10^{-4}/°C$

$$\Delta \rho = \rho(1 - \gamma \Delta T)$$
$$= 992 - 998 = 998(1 - \gamma \times 20)$$
$$\rho_f = \rho_i(1 - \gamma \Delta T)$$
$$= \frac{\Delta \rho}{\rho \Delta T} = \gamma$$
$$\gamma = \frac{6}{998 \times 20}$$

Date

(28) The value of coefficient of volume expansion of glycerine is $5\times10^{-4}K^{-1}$ The fractional change in the density of glycerine for a rise of 40°C in its tempr is

(a) 0.010

(b) 0.015

(c) 0.020

(d) 0.025

$\frac{\Delta \rho}{\rho} = \gamma \Delta T$

$= 5\times10^{-4}\times40$

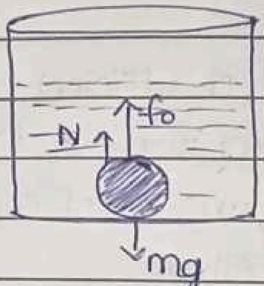
$= 20\times10^{-4}$

Effect of tempr in buyancy:-

$f_B = \rho_l V_S g$

Temp. ↑

May increase or decrease



$\gamma_l > \gamma_S \rightarrow f_B = ??$ Increased App. weight = decreased

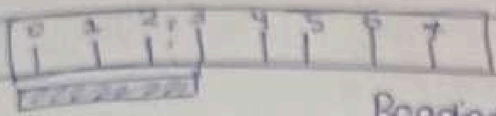
$\gamma_l < \gamma_S \rightarrow f_B = ??$ Decreasing. App. weight = Increased.

Apparent weight $= mg - f_B$

Const.

Expansion scale:-

T°C (true reading



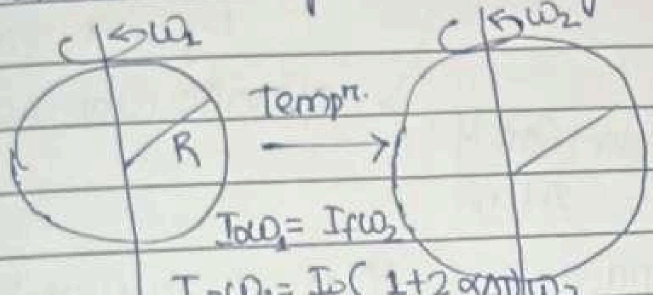
Reading taken at higher temp^n (Apparent reading)

| True reading = (App. reading at higher temp^n) + Δl |

= (App. reading) l_0 + $\alpha l_0 \Delta T$

Both are same

(27) A sphere of coefficient of linear expansion α, mass m and radius r is spinning about an axis through its diameter with an angular velocity ω, If the temp. of the sphere increases by Δt then its new angular velocity is ω_2.



$R = R_0(1+\alpha\Delta T)$

$I = \frac{2}{5}MR^2$ = Const^n

$I_1\omega_1 = I_2\omega_2$

$\frac{\Delta I}{I} = 2\left(\frac{\Delta R}{R}\right) \Rightarrow \frac{\Delta I}{I_0} = 2\alpha\Delta T$

$I_f = I_0(1+2\alpha\Delta T)$

$I_0\omega_1 = I_f\omega_2$

$I_0\omega_1 = I_0(1+2\alpha\Delta T)\omega_2$

$\omega_2 = \frac{\omega_1}{(1+2\alpha\Delta T)}$

(28) A scale which is calibrated at 10°C measures the length of a stick to be 60 cm, at temp^n 30°C. If thermal co-efficient of linear expansion of the scale is 2×10^{-5}/°C, the correct length of the stick in cm is.

(a) 60.015
(b) 60.024 ✓
(c) 60.400
(d) 60.600

$\Delta T = 20$

$\alpha = 2\times10^{-5}$/°C

True reading $= l_0 + \Delta l = l_0 + \alpha l_0 \Delta T$

$= 60 + 2\times10^{-5}\cdot 60 \times 20$

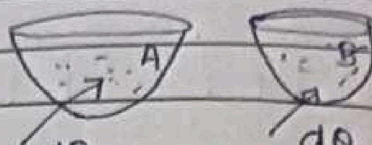
$= 60 + \frac{24}{1000}$

$= 60 + 0.024$

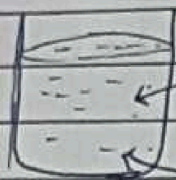
$= 60.024$

Amount of liquid also same

(29) The rate of heat supply is same to both the liquid
After some time $T_A > T_B$
then there spc. heat will be



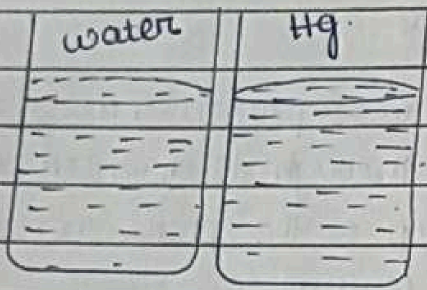
(a) $S_A = S_B$
(b) $S_A > S_B$
(c) $S_A < S_B$
(d) Can't say



ΔQ (heat given) $\propto \Delta T$
$\Delta Q \propto$ mass (amount)

$$\boxed{\Delta Q = Sm\Delta T}$$

→ Property of liquid



m = Same
ΔT = Same

$$\boxed{S = \frac{\Delta Q}{m\Delta T}}$$

Heat given per unit mass to raise the tempr by unit °C/K
→ Speacific heat Capacity

$dQ_1 = dQ_2$

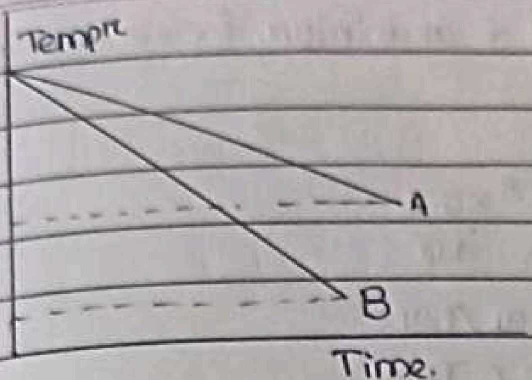
$$\boxed{S \propto \frac{\Delta Q}{\Delta T m}}$$

S (Specific heat capacity) = Heat required to raise the tempr by unit of unit mass

$S = \frac{dQ}{m\Delta T}$
→ unit J/Kg K $\left(\frac{Cal}{gm°C}\right)$

$S = 1 cal/gm°C = 1 cal/gm K = 4.2 J/10^{-3} Kg K$
$= 4200$ J/Kg K
(for water)

$S_{ice}/S_{steam} = 0.5 cal/gm K$
$= 2100$ J/Kg K



$\underline{S_B < S_A}$

water
(1L) (2L) (3L)

Heat capacity:-

Specific heat capacity - S. S S
heat capacity - C 2C 3C

$dQ \propto \Delta T$

$\boxed{dQ = C\Delta T}$ —

$C = \frac{dQ}{\Delta T}$ - heat required to raise the tempr by unit of given mass

$S = \frac{dQ}{(m\Delta T)}$ $\boxed{C = mS}$

$\frac{C}{S} = m \Rightarrow \boxed{C = mS}$

The quantities of heat required to raise the temperature of two solid copper sphere of radii r_1 & r_2 ($r_1 = 1.5r_2$) through 1K are in the ration (NEET = 2020)

(a) $\frac{27}{8}$

(b) $\frac{9}{4}$

(c) $\frac{3}{2}$

(d) $\frac{5}{3}$

$dQ = ms\Delta T$

$dQ \propto$ mass

$$\frac{dQ_1}{dQ_2} = \frac{m_1}{m_2} = \frac{\rho \times \frac{4}{3}\pi r_1^3}{\rho \times \frac{4}{3}\pi \left(\frac{2}{3}r_1\right)^3}$$

$$= \frac{27}{8}$$

Date

(31) Thermal capacity of 40g of aluminium ($s = 0.2$ cal/gK) is

(a) 168 J/K

(b) 672 J/K

(c) 840 J/K

(d) 33.6 J/K

$C = ms$

$= \frac{40 \times 10^{-3} \times 0.2}{10}$

$= 8$ cal/Kal

$= 33.6$ J/Kal

Molar heat capacity :-

Amount of heat capacity require to raise the temp^n of 1 mole substance by 1°C

$$C_0 = \frac{\Delta\theta}{\Delta t n} = \frac{J}{Kg\,mol}$$

$$C_0 = \frac{\Delta Q}{\Delta T n} = J/Kg\,mol$$

$$dQ = ms\Delta T$$

Heat given to the substance Then temp^r must increase. (False)

Ice → water (0°C)

water → steam (100°C)

Latent heat :- The amount of heat required to change the unit mass of a substance completely from one state to another at constant temp^r is called latent heat of the substance.

$\Delta Q \propto m$

$\Delta Q = Lm$

↳ Latent heat capacity.

$L = \left(\frac{\Delta Q}{m}\right)$ = heat given to convert phase of a unit mass

$$dQ = mL$$

↳ heat

Page No.
Date

m gram Ice at $-10°C$ → (heat) → m gram Ice at $0°C$ → (heat, Phase) → m gram water at $0°$ → (heat) → water tempⁿ increases upto $100°C$ → (heat) → Phase change: Steam at $100°C$ → (heat) → Steam at $>100°C$

(32) Amount of heat required to convert 20gm Ice from $-20°C$ to steam at $100°C$.

$m = 20gm$ at $t = -20°C$ → Ice at $0°C$

$dQ_1 = ms\Delta\theta$
$= 20 \times \frac{1}{2} \times 20$
$= 200\,cal$

Ice at $0°C$ → (heat, dQ_2) → water at $0°C$

$dQ_2 = ml$
$= 20 \cdot 80$
$= 1600\,cal$

water at $0°C$ → (heat, dQ_3) → water at $100°C$

$dQ_3 = ms\Delta T$
$= 20 \times 1 \times 100$
$= 2000\,cal$

water at $100°C$ → (dQ_4) → Steam at $100°C$

$dQ_4 = ml = 20 \times 540$
$= 10800\,cal.$

$Q = 14600\,cal$

(33) 10 gm ice is at $-50°C$ the heat required to convert (5gm Ice + 5gm water) at $0°C$

Solⁿ

10gm Ice at $-50°C$
↓ $dQ = ms\Delta\theta$
$= 10 \times \frac{1}{2} \times 50 = 250$

Ice at $0°C$
↓
5gm water at $0°C$

$dQ_2 = ml$
$= 5 \cdot 80$
$= 400\,cal$

Total $Q = 650$

(34) find heat required to convert 20 gm Ice of $-30°C$ to (5gm Ice + 15 gm water) at $10°C$.

L-5

Rate of heat loss & Rate of Boiling

Heat gain
Heat loss

$\Delta Q = ms\Delta\theta$

$\frac{dQ}{dt} = ms \frac{dT}{dt}$ → Rate of cooling / heat loss

→ Rate heat loss/gain

(35) A refrigerator convert 100gm of water at $10°C$ at $0°C$ in 1 hr. find heat removed per min.

| 10°C water | → | 0°C water | → | 0°C Ice |

$dQ_1 = ms\Delta\theta$

$= 100 \times 1 \times 10 = 1000$ Cal.

$dQ_2 = mL$

$= 100 \times 80$

$= 8000$ cal

Total Q = 9000 Cal

60 min → 9000 cal

1 min → $\frac{9000}{60}$ = 150 cal/min

L = 80 cal/gm water → Ice

L = 540 cal/gm water → Steam

(36) Which is more dangerous
(1) Burn by 100°C water
✓(2) Burn by 100°C steam
(3) Same by both

→ Reason: water at 100°C

$dQ = ms\Delta T$

$= m \times 1 (100 - 99)$

$= m$

Steam at 100°C → Convert in water

heat loss = mL = 540m

Temp^r of Ice = −ve or 0°C

Temp^r of water: $0° \le T \le 100°C$

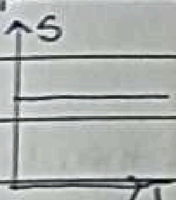
water at 100.00001°C ✗

for steam: $100° \le T_{steam}$

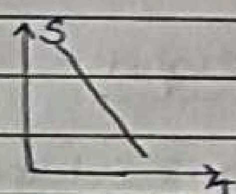
for Ice: $0 \ge T_{ice}$

(37) Graph for specific heat?

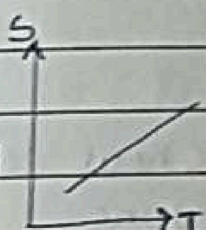
(a)



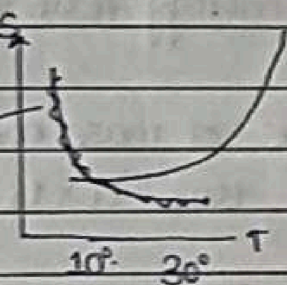
(b)



(c)



✓(d)

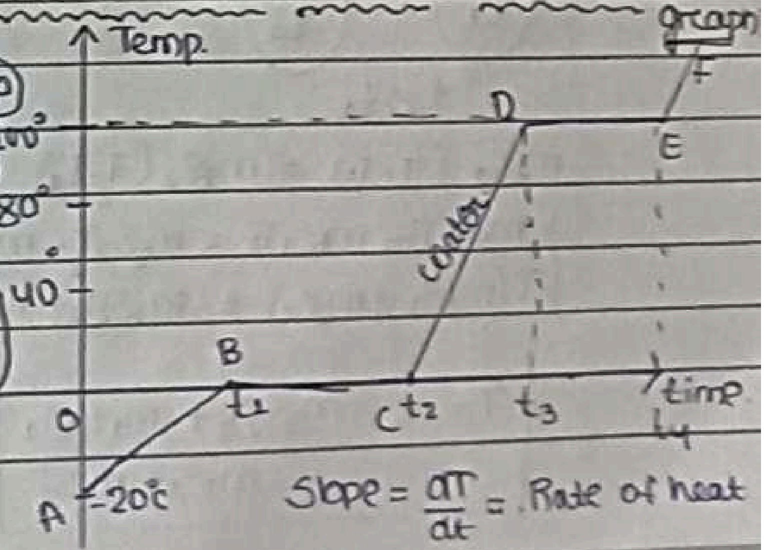


Constant heat supply to the ice at −20°C then draw Temp-time graph

m gram ice at −20°C → Ice at 0°C → H_2O at 0°C → H_2O at 100°C → Steam at 100°C

$\frac{dQ}{dT}$ = const.

Slope (m)
(a) $m_{AB} = m_{CD}$
(b) $m_{AB} > m_{CD}$
(c) $m_{AB} < m_{CD}$

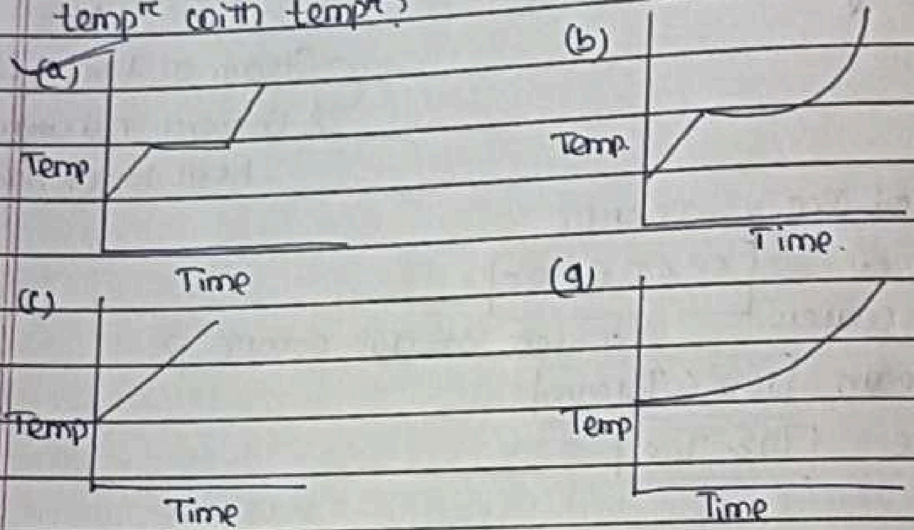


Slope = $\frac{dT}{dt}$ = Rate of heat

$\frac{dT}{dt} \propto \frac{1}{\text{Specific heat}(S)}$

Date

(38) Liquid oxygen at 50K is heated to 300K at constant pressure of 1 atm. The rate of heating is constant. Which one of the following graphs represents the variation of temp^{r} with temp^{r}?



Mixture of 2 liquids:-

> when we mix 2 substance of same phase then only temp^{r} will change of both the substance.

Heat → energy flows due to temp^{r} diff.

(39) Two liquids of mass m_1 & m_2 of specific heat capacity S_1 & S_2 at temp. t_1 & t_2. find temp. of mixture.

$(m_1, S_1, t_1) + (m_2, S_2, t_2) \rightarrow (m_1+m_2, T)$

$t_2 > t_1$.

Law of Calorimetry
~~Law of~~ Based on energy conservation
Heat gain = Heat loss
(which at lower tempr) = (which is at higher temp)

$m_1S_1(T-T_1) = m_2S_2(T_2-T)$

$\Rightarrow m_1S_1T - m_1S_1T_1 = m_2S_2T_2 - m_2S_2T$

$\Rightarrow T(m_1S_1 + m_2S_2) = m_2S_2T_2 + m_1S_1T_1$

$$\boxed{T = \frac{m_2S_2T_2 + m_1S_1T_1}{m_1S_1 + m_2S_2}}$$

Page No.
Date

$\begin{pmatrix} m_1 \\ S_1 \\ T_1 \end{pmatrix} + \begin{pmatrix} m_2 \\ S_2 \\ T_2 \end{pmatrix} = \begin{pmatrix} m_1+m_2 \\ T \end{pmatrix}$

$$T = \frac{m_2S_2T_2 + m_1S_1T_1}{m_1S_1 + m_2S_2}$$

→ Liquid of same nature (same specific heat)

$$T = \frac{m_2T_2 + m_1T_1}{m_2+m_1}$$

→ Same nature of liquid, same mass

$$T = \frac{T_1+T_2}{2}$$

(40) 20 gm H_2O at 30°C is mixed with 40 gm H_2O at 10°C then find temp^{r} of mixture?

$$T = \frac{20\cdot30 + 40\cdot10}{40+20}$$

$$= \frac{600+400}{60} = \frac{1000}{6} = 16.6°C.$$

(41) 2 liquid of same mass at 20°C & 60°C mixed then temp. of mixture is 30°C. then find ratio of their specific heat.

Sol^{n}

$$T = 30° = \frac{m\cdot S_1\cdot 20° + m S_2 60°}{m S_1 + m S_2}$$

$$20S_1 + 60S_2 = 30S_1 + 30S_2$$

$$\Rightarrow 30S_2 = 10S_1$$

$$\Rightarrow \frac{S_1}{S_2} = \frac{30}{10} = \frac{3}{1}$$

3:1

(Solution)

(42) 2 identical bodies are made of a material for which the heat capacity increases with temp. One of these is at 100°C while the other one is at 0°C. If the 2 bodies are bought into contact, then, assuming no heat loss, the final common temp is (NEET-II-2016)

(a) 50°C
(b) > 50°C ✓
(c) < 50°C but > 0°C
(d) 0°C

0°C —— 100°C

m, S_1 Temp = ?? m, S_2

$T_m = \frac{S_1 \cdot 0 + S_2 100}{S_1 + S_2}$

Let $S_2 = 2S_1$

$= \frac{2S_1 100}{3S_1} = \frac{100 \times 2}{3}$

$= 66.6$

(43) 40 gm H_2O at 10°C is mixed with 10 gm Ice at 0°C then find temp. of mixture)

10 gm Ice at 0°	40 gm H_2O at 10°C
$dQ = mL = 800$ cal	$dQ = mS\Delta T = 40 \cdot 1 \cdot 10 = 400$ cal
water at 0°	40 gm H_2O at 0°

$T_{mix} = 0$

5 gm ice

water = 45 gm

$dQ = 400$

$mL = 400$

$m' = \frac{400}{80} = 5$ gm

(44) 80 gm H_2O at 20°C is mixed with 15 gm Ice at 0°C then temp. of mixture and mass of ice & H_2O in mixture

15 gm ice at 0°C

$dQ = 15 \times 80$

$= 1200$ cal

heat required to melt ice at 0°C is 1200 cal

dQ = Heat given by water when temp. fall to 0°C

$dQ = 80 \times 1 (20-0)$

$= 1600$ Cal.

Same tem
Same ph
human

water at 0°C = 95 gm

$400 = 95 \times 1(T-0)$

$T = \frac{400}{95} = 4.2°C$

Mixture of Ice & water:-

Mgm ice at 0°c ⟶ Mixed ⟵ wgm water at T°c

(heat required to convert ice to water) at 0°c	heat given by water to decrease temp from T°c to 0°c of water
$(dQ)_{required} = mL$	$= ms\Delta T$
	$= w \times 1(T-0)$
	$= wQ$
Case-1 $mL = wT$ (पानी + पानी) $T_{mix} = 0°c$	$= dQ$ supply.
Case-2 $mL > wT$ (complete ice won't melt)	

$m'L = wT$

Case-3 $mL < wt$

(complete ice will melt)

$T_{mix} = \frac{wT - mL}{m+w}$

(45) If 10g of ice at 0°c is mixed with 10g of water at 40°c the final mass of water in mixture is.

(a) 10g
(b) 15g ✓
(c) 18g
(d) 20g

$dQ = mL = 10(80) = 800 cal$

$dQ = ms\Delta T = 10 \times 1(40) = 400 cal$

only 5g ice will melt.

Amt of H_2O = 15g

(46) 1 kg of Ice at 0°c is mixed with 1 kg of H_2O at 10°c. The resulting temp. will be-

(a) B/w 0°c & 10°c
(b) 0°c ✓
(c) < 0°c
(d) > 0°c

1 kg water at 0°c

$= mL = 1000(80) = 80000 cal$

$\Delta Q = ms\Delta T = 1000 \cdot 1 \cdot 10 = 10000$

70000 cal.

सारा ice melt nhi hoga
requirement 0°c hoga

Date

(47) 5 g of H_2O at 30°c and 5g of Ice at −20°c are mixed together in a Calorimeter. Neglect the H_2O equivalent of the calorimeter. The final temp. of the mixture is
(S of ice = 0.5 cal g^{-1} °c^{-1})

(a) 0°c ✓
(b) −20°c
(c) −10°c
(d) +1.2°c

5 gm H_2O at 30°c
↓ $dQ = ms\Delta T$ =
5 gm H_2O at 0°c
= 5.1.30
= 150 cal

5g Ice −20°c
↓ $dQ = ms\Delta T$
5g Ice 0°c
$= 5 \cdot \frac{1}{2} \cdot (20)$ [10]
= 50 cal
↓ $dQ = mL = 5.80$ = 400
5g H_2O at 0°c
T = 450 cal

(48) 1 gm of Ice is mixed with 1 gm of steam. After thermal equilibrium the temp. of the mixture is

(a) 0°c
(b) 100°c ✓
(c) 55°c
(d) 80°c

1 gm Ice at 0°c
→ water at 100°c
$dQ_1 = mL = 1 \times 80$ cal
$dQ_2 = 1 \times 1 (100)$
= 100 cal
T = 180 cal

1 gm of steam at 100°c
↓
1 gm water at 100°
~~ΔQ = mL~~
= 1 (540)
= 540 cal
− 180 cal
(460 cal)

mg Ice at 0°c → wg steam at 100°c
mixed

$m_{ice} : m_{steam} = 3:1$
T_{mix} = 100°c

~~$dQ = m \times 80 + m \times 100$~~
= 180m
→ required to convert water at 100°c

$dQ_{supply} = \omega \cdot 540$

$(dQ_{supply}) = (dQ)_{Ice\ required}$
$\omega 540 = 180m$

$\frac{\omega}{m} = \frac{1}{3}$

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Page No.
Date

M gm Ice at 0°C

Melt to H_2O at 0°C

$dQ_{req.} = mL$

$= m \times 80$

$= 80m$

$T_{mix} = 0$

If supply = required

$80m = \frac{640\omega}{8}$

$m_{ice} : m_{steam} = 8:1$

ω gm steam 100°C

$dQ_1 = \omega L = 540\omega$

ω gm H_2O at 100°C

$dQ_2 = ms\Delta T = \omega 100$

ω gm H_2O at 0°C

$dQ = 640\omega$

Mice : Msteam

1 : 2
1 : 1
2 : 1
3 : 1

$T_{mix} = 100°C$

4 : 1
5 : 1
6 : 1
7 : 1

T_{mix} b/w 0° – 100°C

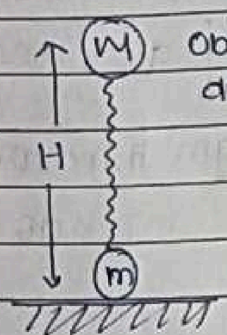
8 : 1
9 : 1
10 : 1

$T_{mix} = 0°$

Lec-06

Loss = Initial − final
Change = final − Initial

(49) M gm object is released from height H then find raise in temperature, if loss in potential energy completely transfer to heat energy.

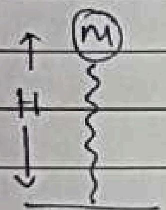


object drop → Loss in PE = dQ

$mgH = ms\Delta T$

$\boxed{\Delta T = \frac{gH}{S}}$ Ans.

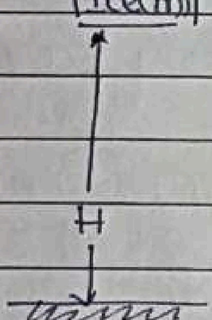
(50) M gm object is released from height H then find, rise in temperature. if 60% of loss in potential energy, transfer to heat energy.



$(mgH)\frac{60}{100} = ms\Delta T$

$\boxed{\Delta T = \frac{3gH}{5S}}$

(51) Conversion of mechanical energy into heat.
A block of ice of mass m drop from height H, and its potential energy converted into heat, then find mass of ice that will melt, temperature of ice 0°C



t = 0°C

Sol^n $mgH = m'L$

$\boxed{m' = \frac{mgH}{L}}$

(52) (m) $\xrightarrow{\text{Object}}$ V_i - - - - - - - - - - (m) → V_f

If ($V_f > V_i$) loss in KE is converted into heat then find raise in temp^r of that object

Page No.
Date

Soln $(\Delta KE)_{loss} = dQ$

$\frac{1}{2} m(V_i^2 - V_f^2) = ms\Delta T$

$\boxed{\Delta T = \frac{V_i^2 - V_f^2}{2s}}$

KOIN BANEGA DR. D'.........

(53) If heat capacity of object C= 30cal/°c then amount of heat required increase its temp. from 50°c - 80°c

(a) Incomplete question

✓(b) 900 cal

(c) 3700 cal.

$dQ = C\Delta T$

$= 30 \times 30 = 900$ cal.

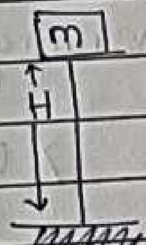
(54) A piece of ice falls from a height h so that it melts completely only one- quarter of heat produced is absorbed by the ice & all energy of ice gets converted into heat during its fall. The value of h is (Latent heat of ice is 3.4×10^5 J/kg) & g= 10N/kg) [NEET-1-2016]

(a) 136 km

(b) 68 km

(c) 34 km

(d) 544 km.



$\frac{1}{4}(mgH) = mL$

$H = \frac{4L}{g} = \frac{4(3.4 \times 10^5)}{10}$

$= 13.6 \times 10^4$

$= 136$ km

(55) 10 gm H_2O at 80°c mixed with a liquid of 20gm at 40°c having Specific heat capacity ½ cal/g then find temp^re of the mixture

$T_{mix} = \frac{m_1S_1T_1 + m_2S_2T_2}{m_1S_1 + m_2S_2}$

$= \frac{10(1)80°C + 20(1/2)40}{10 \cdot 1 + 20 \cdot 1/2} = \frac{800 + 400}{20}$

$= \frac{1200}{20}$

$= 60°c$

Date

(56) Steam at 100°C is passed into ~~A piece of ice balls from a height~~ 20g of H_2O at 10°C. When H_2O acquires a temp. of 80°C, the mass of water present will be (Take specific heat of water = 1 cal g^{-1}°C^{-1} and latent heat of steam = 540 cal g^{-1}) (2014)

(a) 24g
(b) 31.5g
(c) 42.5g
✓(d) 22.5g

[m gm of steam at 100°]
↓ $dQ = mL$
$= 540m$ cal
[water at 100°C]
↓ $dQ = ms\Delta\theta$ $= m \cdot 20$ cal
[water at 80°]
$dQ = 560m$ cal

H_2O at 10°
$dQ = ms\Delta T$
$= 20 \cdot 1\,(70)$
$= 1400$ cal

$560m = 1400$ cal
$\Rightarrow m = \frac{1400}{560} = 2.5$ g

Total $H_2O = 22.5$g

(57) An electric heater rated as 2kW (→2000W) is used to heat 200kg of H_2O from 10°C to 70°C. Assuming no heat losses, the time taken is-

$S = \frac{1 \times 4.2\,J}{10^{-3}\,kg\,°C}$ = 4200 J/kg°C

(a) 25.2s
(b) 6×10^3 s
✓(c) 25.2×10^3 s
(d) 25.2×10^6 s

$P = \frac{E}{t} \Rightarrow E = Pt = ms\Delta\theta$

$\Rightarrow 2000\,t = 200 \times 4200 \times 60$

$t = 25200$

$= 25.2 \times 10^3$ sec

(58) Velocity of 10kg object reduced from 4m/s to 2m/s & 60% loss kinetic energy converted into heat then find rise in temp. of object if specific heat of object is 0.4 cal/gm°C

$(KE)\frac{60}{100} = ms\Delta T$

$= 10 \times 1680 \times \Delta T$

$\frac{60}{100} \cdot \frac{1}{2} m(16-4) = 0.4 \cdot \Delta T$

$S = 0.4$ cal/gm°C
$= \frac{0.4 \times 4.2\,J}{10^{-3}\,kg\,°C}$
$= 1680$

$\Delta T = \frac{12 \times 30}{40} = 9°C$

$\Delta T = \frac{12 \times 30}{1680 \times 10 \times 2} = \frac{6}{2800} = \frac{3}{1400} = 2 \times 10^{-3}$

Page No.
Date

(59) 30 gm H_2O at 80°C mixed with 10 gm ice at 0°C then find mass of ice and H_2O and temp' of the mixture.

10 gm ice at 0°C	30 gm H_2O at 80°C
↓ $dQ = mL$	↓
10 gm H_2O at 0°C	30 gm H_2O at 0°C
↓	
~~100~~ $dQ = 10\times80 = 800$ cal	$dQ = ms\Delta T = 30\times1(80) = 2400$ cal

$2400 - 800 = 1600$ cal

$\frac{1600}{40} = 40°C$

Soln 40 gm H_2O at 40°C

(60) 15 gm ice at 0°C mixed with 6 gm steam at 100°C then temp. of mixture.

$T_{mix} = 100°C$

(61) 80 gm Ice at 0°C is mixed with 20 gm steam at 100°C. Temp of mixture.

80 gm Ice	20 gm steam
↓ $dQ = mL = 6400$ cal	↓ $dQ = mL = 20\times540 = 10800$
80 gm H_2O at 0°	20 gm water at 100°C
	↓ $dQ = ms\Delta T = 20\times1\times100 = 2000$ cal
	20 gm water at 0°C

100 gm H_2O at 64°C

$dQ = 12800$ cal $- 6400 = 6400$

$\frac{6400}{100} = 64°C$

Date

(62) 200gm Ice at $-20°C$ is mixed with 500gm water at $20°C$ then find temp. and amount of ice/water in mixture

$(-20°C, 200gm$ Ice$)$

↓ $dQ = ms\Delta T = 200 \times \frac{1}{2} \times 20 = 2000 cal$

(Ice at $0°C$)

↓

(water at $0°C$)

$dQ = mL$
$= 200 \times 80$
$= 16000$

$dQ = 18000 cal$

500 gm water at $20°C$

$dQ = ms\Delta T$
$= 500 \times 1 \times 20$
$= 10000 cal$

Remaining heat $= 8000$

$\Rightarrow m'L = 8000$

$m' = \frac{8000}{80} = 100gm$

Ice $= 100gm$	at $0°C$
water $= 600gm$	

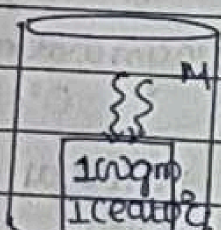
(63) 540 gm ice at $0°C$ mixed with 540gm H_2O at $80°C$ then find final temp.

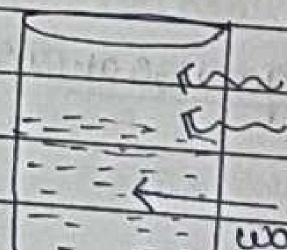
for ice: $dQ = 540 \times 80$

for H_2O: $dQ = 540 \times 80$

$T_{mix} = 0°$

(64) A vessel containing 100gm ice at $0°C$ steam passed into vessel to melt ice, neglecting thermal capacity of vessel find mass of H_2O in vessel when all the ice melt.





Mass of water
$= (100 + 12.5)$
$= 112.5 gm$

dQ_{gain} by Ice $= (dQ)_{steam}$

$mL = (mL + ms\Delta T)$

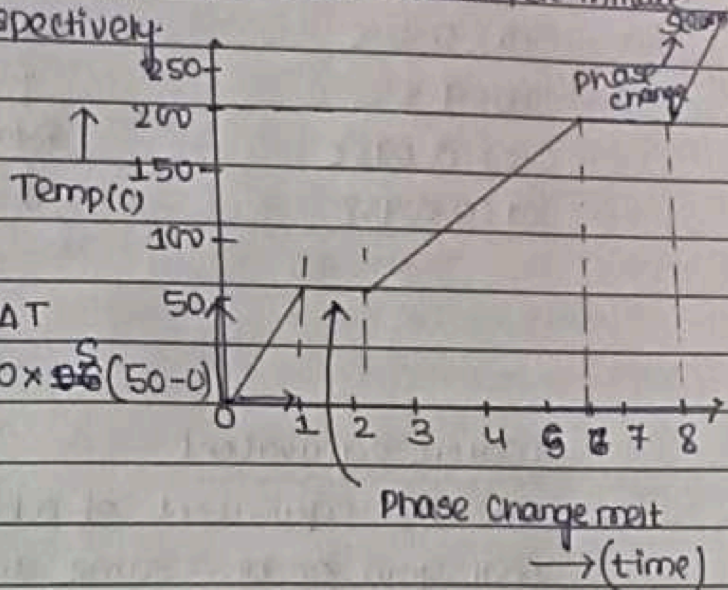
$100 \times 80 = m(540 + 100)$

$\Rightarrow m = \frac{100}{8} = 12.5 gm$. 640

$\frac{0.6 \times 4.2 \times 1000 J}{10^{-3} g}$

(65) A student takes 50gm wax (specific heat = 0.6 Kcal/kg°) and sit till it boils. The graph between temperature and time is as follows. Heat supplied to the wax per minute and boiling point are respectively.

(a) 500 cal, 50°C.
(b) 1000 cal, 100°C
(c) 1500 cal, 200°C
(d) 1400 cal, 100°C



$dQ = ms\Delta T$

$= 50 \times s(50-0)$

(66) A bullet of mass 10g moving with a speed of 20m/s hits an ice block of mass 990g kept on a frictionless floor and gets stuck in it. How much ice will melt if 50% of the lost KE goes to ice?
(Initial temp. of the ice block & bullet = 0°C)

(a) 0.001 g
(b) 0.002 g
(c) 0.003 g
(d) 0.004 g

10gm → 20m/s | 990g 0°C

$(KE)\ 50\% = m'L$

$= \frac{1}{2}\left(\frac{1}{2}\frac{m_1 m_2}{m_1+m_2}u^2\right) = m'\left(\frac{80 \times 4.2}{10^{-3}}\right)$

$m' = \frac{1}{4}\{ \quad m'\left(\frac{80 \times 4.2}{10^{-3}}\right) = \frac{1}{2}\frac{10 \times 10^{-3}}{1}(20)(20)\frac{1}{2}$

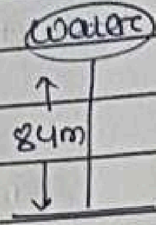
$m' \cdot 8 \times 4.2 \times 10^4 = \frac{400}{4} \times 10^{-2}$ (100)

$m' = \frac{10^{-4}}{8 \times 4.2} = \frac{10^{-1}}{8 \times 4.2}$ gm

Date

(67) Water falls from 84m high. Assuming that half the KE of the falling water gets converted into heat, the rise in temp. of water is ??

(a) 0.98°C
(b) 9.8°C
~~(c) 0.098°C~~
(d) 0.0098°C



$\frac{1}{2}(mgh) = ms\Delta T$

$\Delta T = \frac{gh}{2S}$

$= \frac{9.8 \times 84}{2 \times 4200}$

$= 0.098$

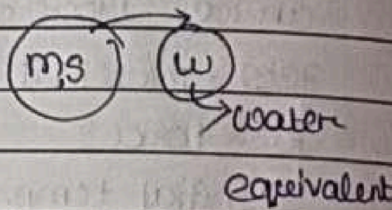
Water equivalent :-

The H_2O equivalent of a body is the mass of water that will gain or loss same amount of heat to change same change in temperature as body of mass m of specific heat S.

$(dQ)_{body} = (dQ)_{water}$

$ms\Delta T = w \times 1 \times \Delta T$

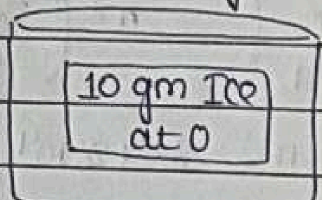
$\boxed{w = ms}$



(68) 10 gm of ice cubes at 0°C are released in a tumbler (H_2O equivalent 55g) at 40°C. Assuming that negligible heat is taken from the surrounding the temp. of H_2O in the tumbler becomes nearly (L = 80 cal/g)

(1988)

(a) 31°C
~~(b)~~ 22°C
(c) 19°C
(d) 15°C



$dQ_{loss} = ms\Delta T$

$= 55 \times 40$

$= 2200$ cal

$dQ_{req.} = ml$

$= 800$ cal

$T = \frac{1400}{65}$

$= 21.53$

Page No. Date

(69) Ice at $-20°C$ is added to 50 g of H_2O at $40°C$. When the temp of the mix reaches $0°C$, it is found that 20 g of ice is still unmelted. The amount of ice added to the H_2O was close to.
(S of H_2O = 4.2 J/g°C, Heat of fusion of H_2O at 0° = 334 J/g and S of ice = 2.1 J/g°C) (11 Jan, 2019 (Shift-1))

(a) 50g
(b) 100g
(c) 60g
(d) 40g ✓

for ice

$dQ = ml + ms\Delta T$

$= 10m$ ~~+334m+42m~~

$+(m-20)$ ~~376m~~
80

$= 90m - 1600$

~~90m+1600+2000~~ = ~~m'L~~
= ~~1160~~

$\Rightarrow$ ~~90m = 3600/9~~

for water

$dQ = ms\Delta T$

$= 50\times(4.2)\times 40$

$= 8400$ ~~cal~~ $= 2000$

~~8400−376m = 20(334)~~

$= 6680$

~~376m = 8400 − 6680~~

~~m = 2720/376~~

$90m - 1600 = 2000$

$90m = 3600$ ~~2000~~

$m = 40$

(70) A calorimeter of H_2O equivalent 20 g contains 180 g H_2O at 25°C. 'm' gram of steam at 100°C is mixed in it till the temp. of the mixture is 31°C. The value of 'm' is close to.
(Latent heat of H_2O = 540 cal g^{-1}, specific heat of H_2O = 1 cal g^{-1} $°C^{-1}$) [13 Sep, 2020 (Shift-II)]

(a) 2 ✓
(b) 3.2
(c) 2.6
(d) 4

for H_2O

m = 200 g at 25°C

$\Delta Q = 200\times1\times6$

$= 1200$ cal

for steam

m g at 100°C

$\Delta Q = ml + ms\Delta T$

$= m(540 + 1\times 35)$ ~~(69)~~

$= m575$

$m = \frac{1200}{575} = \frac{1200}{600}$

Date

(71) M gm of steam of 100°C is mixed with 200g of Ice at its melting pt. in thermally insulated container. If it produces liquid H_2O at 40°C, the value of M is ____

[7 Jan 2020 (Shift-II)]

for Ice

$dQ = mL + ms\Delta T$

$= 200 \cdot 80 + 200 \times 1 (40)$

$= 24,000 \text{ cal}$

for steam

$dQ = mL + ms\Delta T$

$= M540 + M \cdot 1 \cdot 60$

$= 600M$

$M = \frac{24000}{600} = 40°C$

(72) A bullet of mass 5g, travelling with a speed of 210m/s strikes a fixed wooden target. one half of its KE is converted into heat in the bullet while the other half is converted into heat in the wood. The rise of temp. of the bullet if the S of its material is 0.030 cal/(g-°C) close to

(5 Sep, 2020 Shift-1)

(a) 83.3°C

(b) 38.4°C

(c) 87.5°C

(d) 119.2°C

$\frac{1}{2}\left(\frac{1}{2}(5\times10^{-3})(210)^2\right) = 5\times0.03\times\Delta T$

$\frac{210\times210}{4} = \frac{0.03\times42}{10^{-3}}\Delta T$

$\Delta T = \frac{210\times210\times10^{-3}}{0.03\times4.2\times4}$

$= \frac{25\times21\times21}{3\times42\times2} = \frac{175}{2}$

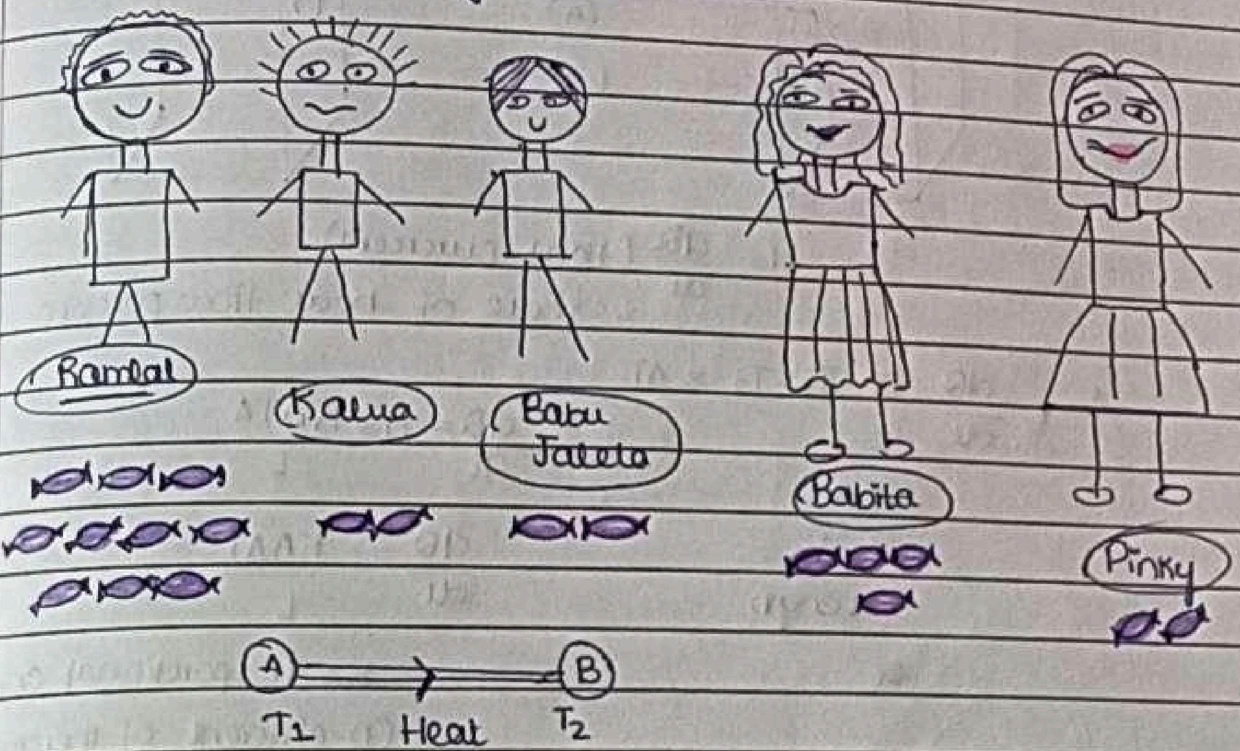
$= 87.5°C$

Page No.
Date

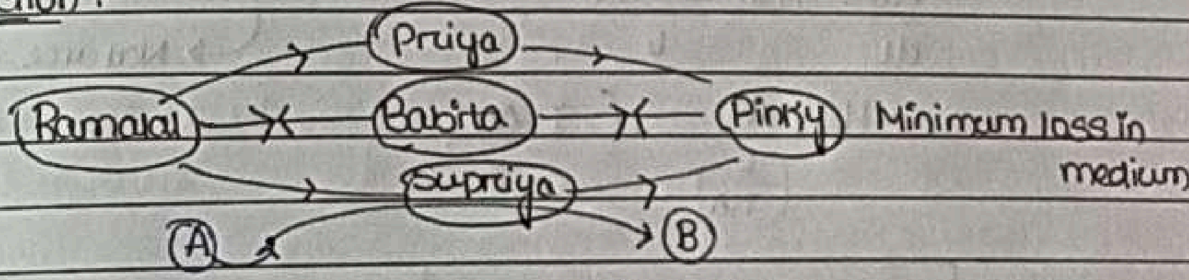
HEAT TRANSFER :-

Conduction

> Heat flows from hot end to cold end. Particles of the medium simply oscillate but don't leave their place.
> Medium is necessary for conduction

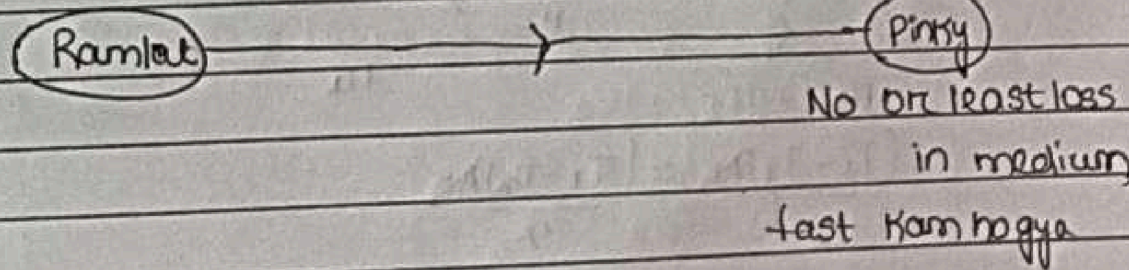


Convection :-



But Kab tk aisa chalega.

Radiation :-



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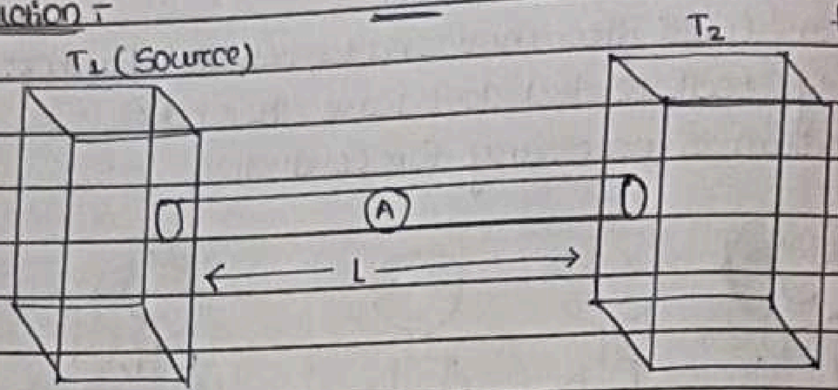
Conduction :-

$T_1 > T_2$ Heat flows from high temp to lower temp



$H = \frac{dQ}{dt}$ (Heat current)

= Rate of heat flow per sec.

$\frac{dQ}{dt} \propto T_1 - T_2 = \Delta T$

$\propto A$

$\propto \frac{1}{\text{Length}}$

$\frac{dQ}{dt} = H = \frac{K \Delta T A}{L}$

$\frac{dQ}{dt} = \frac{K A \Delta T}{L}$

K = Proportional const.

Co-efficient of thermal Conduction

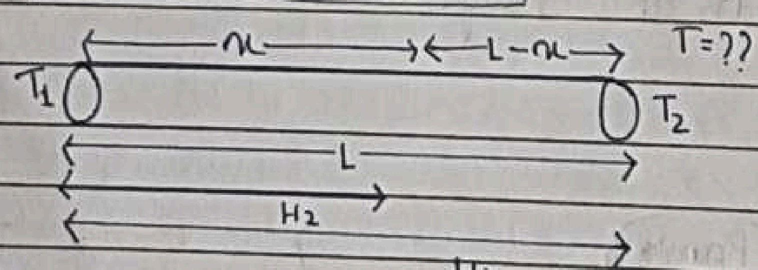
→ Nature of Solid.

$\frac{dQ}{dt} = H = \frac{\Delta T K A}{L}$

$H = \frac{\Delta T}{\left(\frac{L}{KA}\right)}$ $\left(I = \frac{\Delta V}{R} \right)$

Thermal resistance $= \frac{L}{KA}$

(73)



$T_1 > T_2$

$H_1 = H_2$

$\frac{(T_1 - T_2)AK}{L} = \frac{(T_1 - T_x)AK}{x}$

$$T_1 - T_x = (T_1 - T_2)\frac{x}{L}$$

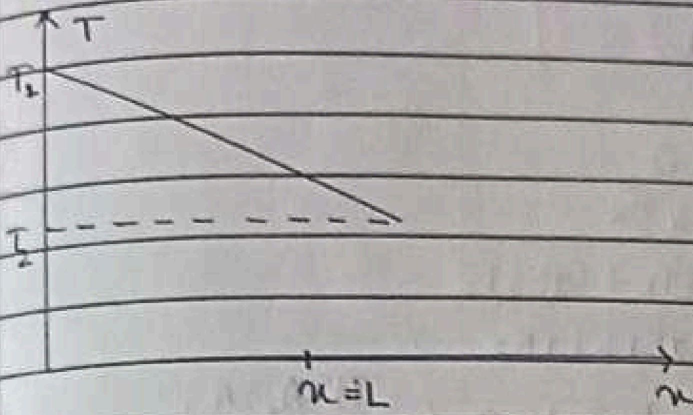
$$\boxed{T_x = T_1 - \frac{(T_1 - T_2)}{L} x}$$

MR*

If $x = 0$ $T_x = T_1$

If $x = L$ → $T_x = T_2$

② Dimension

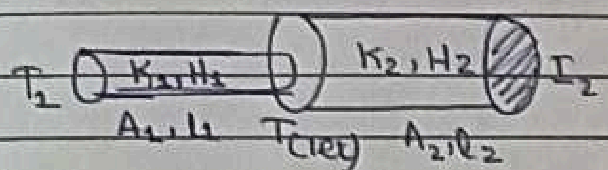


③ At $x = \frac{L}{2}$

$$T_x = T_1 - \frac{(T_1 - T_2)}{L} \cdot \frac{L}{2}$$

$$\boxed{T_x = \frac{T_1 + T_2}{2}}$$

Series Combination of conductor?



① find Req.

② Keq

③ Tmid = ??

④ Total heat current

$$H_1 = H_2$$

$$\frac{A_1 K_1 (T_1 - T)}{L_1} = \frac{A_2 K_2 (T - T_2)}{L_2}$$

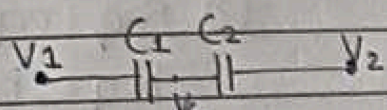
$$\frac{A_1 K_1 T_1}{L_1} - \frac{A_1 K_1 T}{L_1} = \frac{A_2 K_2 T}{L_2} - \frac{A_2 K_2 T_2}{L_2}$$

$$T\left(\frac{A_1 K_1}{L_1} + \frac{A_2 K_2}{L_2}\right) = \frac{A_1 K_1 T_1}{L_1} + \frac{A_2 K_2 T_2}{L_2}$$

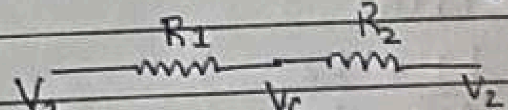
$$\boxed{T = \frac{\frac{A_1 K_1 T_1}{L_1} + \frac{A_2 K_2 T_2}{L_2}}{\frac{A_1 K_1}{L_1} + \frac{A_2 K_2}{L_2}}}$$

→ Junction

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



$$V_C = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$$



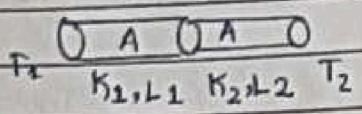
$V = IR$

$$\boxed{V_C = \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}}$$

Heat current → same

$$r_{cm} = \frac{m_1 r_1 + m_2 r_2}{m_1 + m_2}$$

$$T = \frac{\frac{A_1 K_1 T_1}{L_1} + \frac{A_2 K_2 T_2}{L_2}}{\frac{A_1 K_1}{L_1} + \frac{A_2 K_2}{L_2}}$$



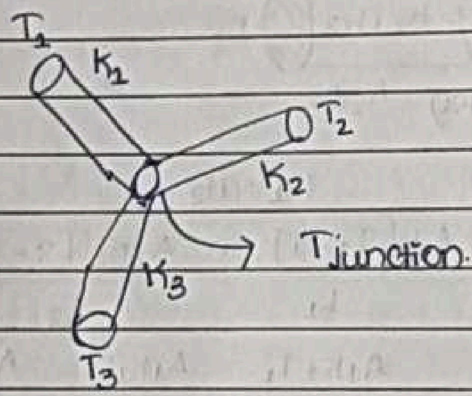
$$T = \frac{L_2 K_1 T_1 + L_1 K_2 T_2}{L_2 K_1 + L_1 K_2}$$

If $A_1 = A_2$, $L_1 = L_2$

$$T = \frac{K_1 T_1 + K_2 T_2}{K_1 + K_2}$$

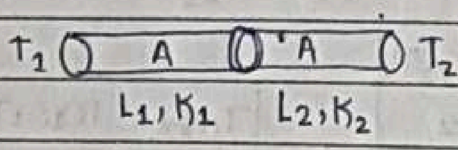
If $A_1 = A_2$, $K_1 = K_2$, $L_1 = L_2$

$$T = \frac{T_1 + T_2}{2}$$



$$T = \frac{K_1 T_1 + K_2 T_2 + K_3 T_3}{K_1 + K_2 + K_3}$$

Series combination of Rod :-



① Temp^r Junction

② Req (equivalent thermal resistance)

$R_{eq} = R_1 + R_2$

$$R_{eq} = \frac{L_1}{AK_1} + \frac{L_2}{AK_2}$$

③ Total heat transfer current

$$H_{total} = \frac{dQ}{dt} = \frac{T_1 - T_2}{dt}$$

(iv) eq. thermal Conductivity =

$R_{eq} = R_1 + R_2$

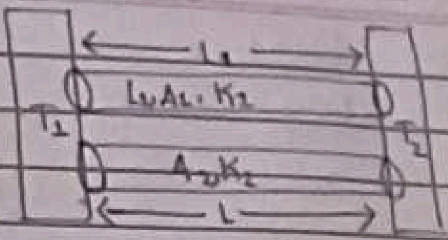
$$\frac{L_1 + L_2}{AK_{eq}} = \frac{L_1}{AK_1} + \frac{L_2}{AK_2}$$

$$\frac{L_1 + L_2}{K_{eq}} = \frac{L_1}{K_1} + \frac{L_2}{K_2}$$

$$K_{eq} = \frac{L_1 + L_2}{L_1/K_1 + L_2/K_2}$$

Parallel Combination:-

① Req
② Keq
③ Heq



$H_{total} = H_1 + H_2$

$$H_{total} = \frac{(T_1 - T_2) A_1 K_1}{L} + \frac{(T_1 - T_2) A_2 K_2}{L}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{A_1 K_2}{L} + \frac{A_2 K_2}{L}$$

$$\frac{(A_1 + A_2) K_{eq}}{L} = \frac{A_1 K_1}{L} + \frac{A_2 K_2}{L}$$

$$K_{eq} = \frac{A_1 K_1 + A_2 K_2}{(A_1 + A_2)}$$

(74) 2 rods A & B of different materials are welded together as shown in figure. Their thermal conductivities are K_1 & K_2. The thermal conductivity of the composite rod will be: NEET-2017

(a) $\frac{K_1 + K_2}{2} = \frac{2K}{2}$

(b) $\frac{3(K_1 + K_2)}{2}$ $\frac{3K}{2}$

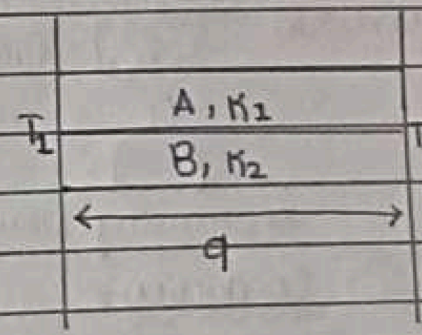
(c) $K_1 + K_2$ $2K$

(d) $2(K_1 + K_2)$ $4K$

Let $A_1 = A_2$

$$K_{eq} = \frac{K_1 A_1 + K_2 A_2}{A_1 + A_2}$$

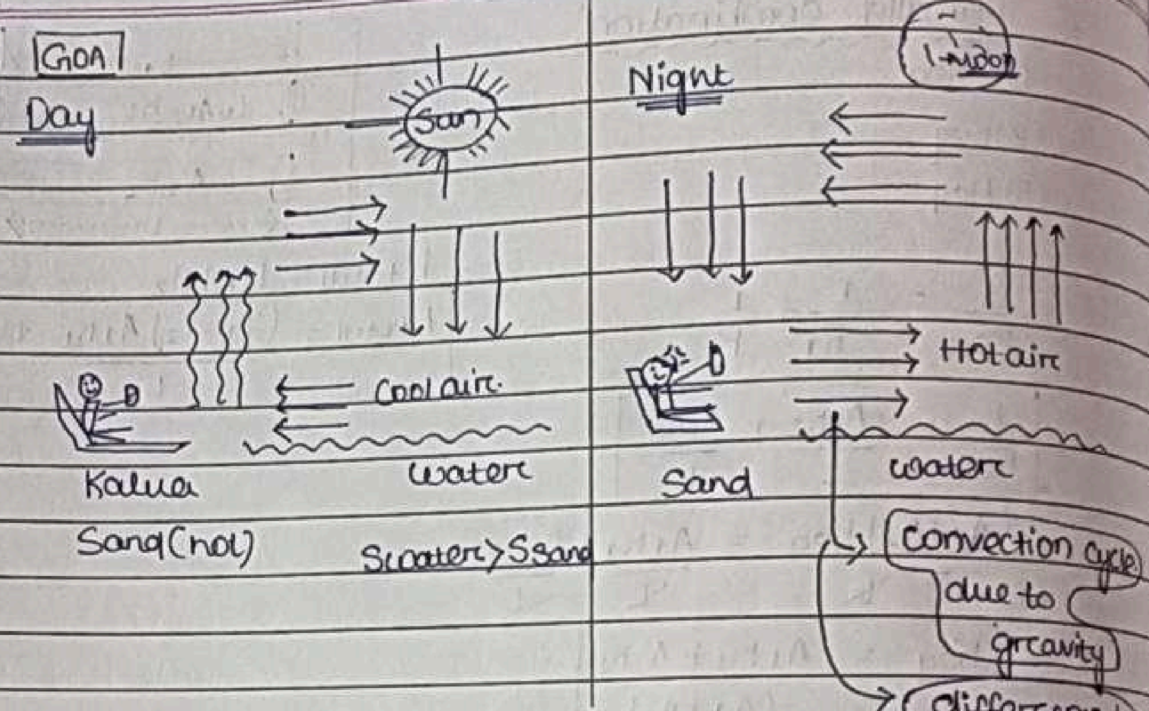
$$K_{eq} = \frac{K_1 + K_2}{2}$$

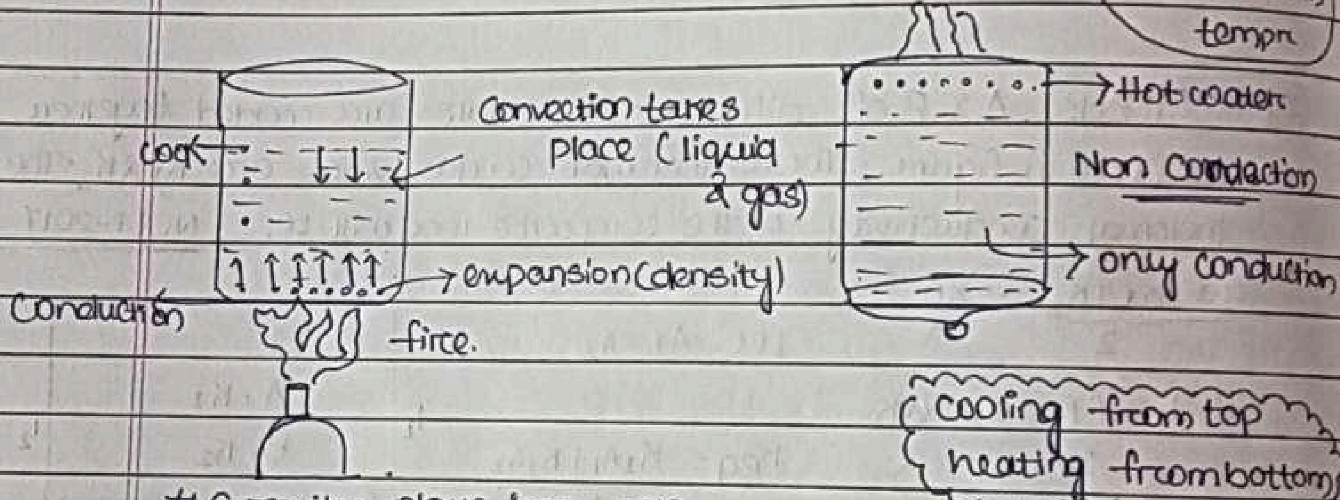


MRT Ka feel
If $K_1 = K_2$
Same matter
then
$K_{eq} = K$

L-07

Temp ↑ → Density ↓ → raise up
(Hot air rises up)

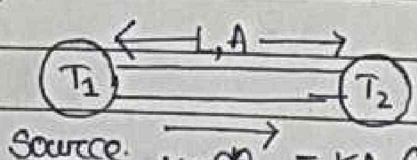




Gravity plays imp. role

Conduction :-

$T_1 > T_2$



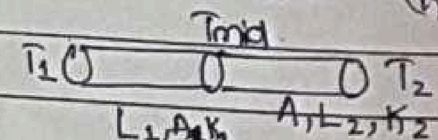
$$H = \frac{dQ}{dt} = KA(T_1 - T_2)$$

$$\boxed{H = \frac{KA(\Delta T)}{L}}$$

$$\boxed{H = \frac{\Delta T}{(L/KA)} = \frac{\Delta T}{R}}$$

thermal resistance

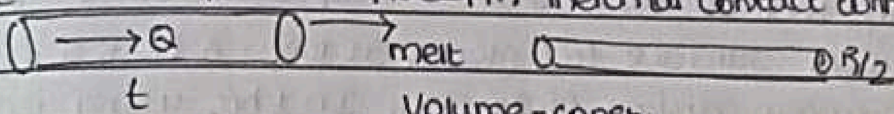
$$R = \frac{L}{KA} = \left(\frac{L}{K\pi r^2}\right)$$



(75) A cylindrical metallic rod in thermal contact with 2 reservoirs of heat at its 2 ends conducts an amount of heat Q in time t. The metallic rod is melted & the material is formed into a rod of half radius of the original rod. What is the amount of heat conducted by the new rod, when placed in thermal contact with the 2 reservoirs in time t? (AIPMT Pre-2010)

$$T = \frac{\frac{K_1T_1}{L_1} + \frac{K_2T_2}{L_2}}{\frac{K_1}{L_1} + \frac{K_2}{L_2}}$$

(75)



Volume = const

$\pi R^2 l = \pi (R/2)^2 L$

$L = \frac{l}{4}$

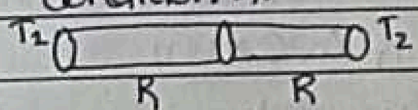
$$H = \frac{KA(T_1 - T_2)}{L} = \boxed{Q \propto \frac{A}{L}}$$

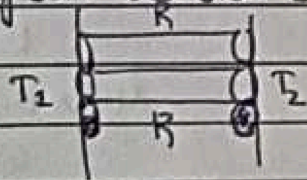
$$\frac{Q_1}{Q_2} = \frac{\pi R^2 / l}{\pi (R/2)^2 / 4l} = \frac{4R^2 \times 4l}{R^2 \times l} = 16$$

$\underline{Q_1 = 16Q_2}$

(76) The rod of same length and material transfer a given amount of heat in 12 sec, when they are joined end to end. But when they are joined lengthwise, then they will transfer same heat in same condition in.

(a) 24 s
(b) 3 s
(c) 1.5 s
(d) 48 s





$$H = \frac{Q}{t} = \frac{T_1 - T_2}{2R}$$

$$\frac{Q}{t_1} = \frac{T_1 - T_2}{R/2} \quad \text{—— (ii)}$$

$$\left(\frac{T_1 - T_2}{2R}\right) t = \frac{2(T_1 - T_2)}{R/2} t_1$$

$$\frac{t}{4} = t_1$$

$$t_1 = \frac{12}{4} = \underline{3 \text{ sec}}$$

NR#
Parallel में time कम आना चाहिए।

(77) The two ends of a metal rod are maintained at temperature 100°C and 110°C. The rate of heat flow in the rod is found to be 4.0 J/S. If the ens are maintained at temperature 200°C and 210°C the rate of heat flow will be (AIPMT- 2015)

* Heat current depend on temp difference

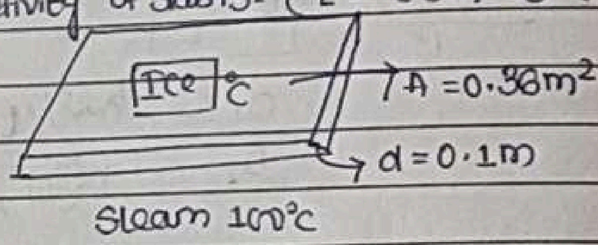
Page No.
Date

(a) 168 J/s
(b) 8.0 J/s
✓(c) 4.0 J/s
(d) 44.0 J/s

$\frac{dQ}{dt} = 4 J/s$

(77) A slab stone of area $0.36\ m^2$ and thickness 0.1 is exposed on the lower surface to steam at 100°C. A block of ice at 0°C rests on the upper surface of the slabs. In 1 hr 4.8 kg ice is melted. The thermal conductivity of slab is- ($L = 3.36 \times 10^5\ J\,kg^{-1}$)

(a) 1.29 J/m/s/°C
(b) 2.05 J/m/s/°C
(c) 1.02 J/m/s/°C
✓(d) 1.24 J/m/s/°C



$t = 60 \times 60$ sec.

$$\frac{dQ}{dt} = \frac{KA(T_1 - T_2)}{L}$$

$$\frac{mL}{t} = \frac{KA(T_1 - T_2)}{L}$$

$$\frac{4.8 \times 3.36 \times 10^5}{60 \times 60} = K\,\frac{0.36 \times 100}{0.1} \qquad = \frac{56}{45}$$

$$K = \frac{48 \times 336 \times 0.1}{36 \times 36 \times 10^5} = 1.24\ J/m/s/°C$$

(78) A cylinder of radius R made of a material of thermal conductivity K_1 is surrounded by cylindrical shell of inner radius R and outer radius 2R made of material of thermal conductivity K_2. The two ends of the combined system are maintained at 2 different temperatures. There is no loss of heat across the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is

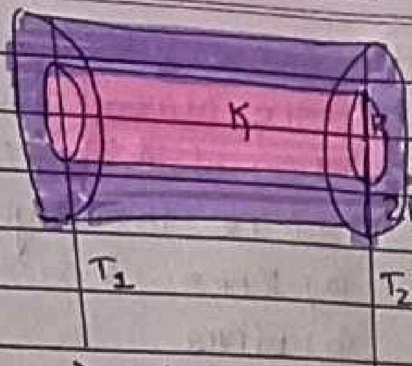
✗(a) $K_1 + K_2$
(b) $\frac{K_1 + 3K_2}{4}$
(c) $\frac{K_1 K_2}{K_1 + K_2}$ ✗
(d) $\frac{3K_1 + K_2}{4}$

Page No.
Date

MR

$K_1 = K_2 = 1$

$K_{eq} = 1$



$$K_{eq} = \frac{K_1A_1 + K_2A_2}{A_1+A_2}$$

$$K_{eq} = \frac{K_1\pi r^2 + K_2 3\pi R^2}{4\pi R^2} = \frac{\pi R^2(K_1+3K_2)}{4\pi R^2}$$

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

formation of ice slab on the surface of lake:-

$$\frac{dQ}{dt} = \frac{KA(\Delta T)}{x}$$

$$\frac{mL}{dt} = \frac{KA(\Delta T)}{x}$$

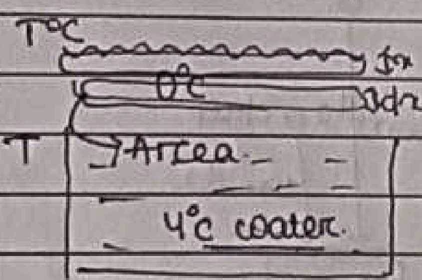
$$\frac{\rho A dx}{dt} = \frac{KA\Delta T}{x}$$

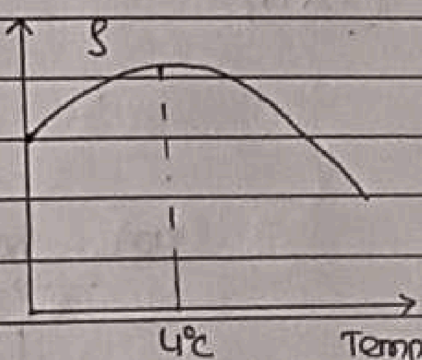
$$\int_{x_1}^{x_2} x\,dx = \int_0^t C\,dt$$

$$\left[\frac{x^2}{2}\right]_{x_1}^{x_2} = C't$$

$$t \propto (x_2^2 - x_1^2)$$

$x_1=0$, $x_2 = x$





$\boxed{t \propto x^2}$

$0 \to x$ (t_1) $\boxed{t_1 : t_2 = 1:4}$

$0 \to 2x$ (t_2) ↳ Same as Kinematics

$t_1 : t_2 = 1:3$

$0-x$ tha

$x \to 2x$

$(2x - 3x)$

$0 \to 3x$

$x = 0$ ↓ t | 4t | 9t

$x_1 = x$

$x_2 = 2x$

$x_3 = 3x$ | 16t

$x_4 = 4x$

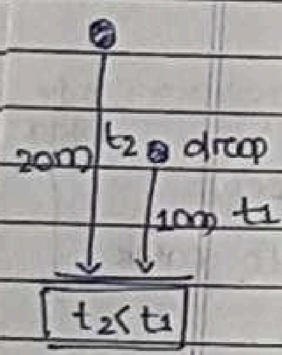
Date

(79) Ice starts forming in lake with water at 0°C and when the atmospheric temp. is −10°C. If the time taken for 1 cm of ice be 7 hrs then the time taken for the thickness of ice to change from 1 cm to 2 cm is.

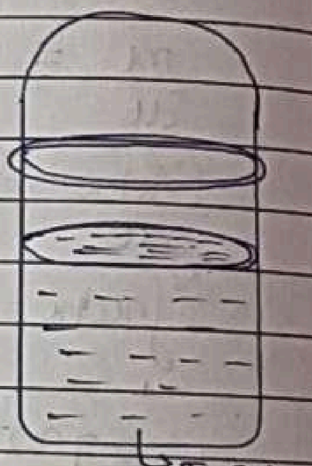
(a) 7 hrs
(b) 14 hrs
(c) Less than 7 hr
✓(d) More than 7 hrs.

Newtons law of cooling:-

Rate of cooling $\propto$ (Temp^r difference)



(a) add cold H_2O after coming from market
✓(b) add cold H_2O before going to market.



90°C → 80°C → 70°C → 60°C   50°C

t_1, t_2, t_3

$t_1 < t_2 < t_3$

(To room temp. = 40°C)

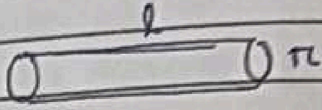
The Newton's law of cooling becomes falling of temp^r from $T_1 - T_2$ is (t)

$$\frac{T_1 - T_2}{t} = K\left(\frac{T_1 + T_2}{2} - T_0\right)$$

T_0 → atmospheric temp.

L-8

(84) Which of the following circular rods (given radius r and length l) each made of the same material and whose ends are maintained at the same temp will conduct most heat?



a) $r = r_0,\ l = l_0$
(b) $r = 2r_0,\ l = l_0$ ✓
(c) $r = r_0,\ l = 2l_0$
(d) $r = 2r_0,\ l = 2l_0$

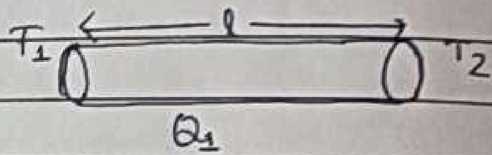
$\frac{dQ}{dt} = \frac{K\pi r_0^2 R}{l_0}$

$4\frac{dQ}{dt}$

$\frac{1}{2}\frac{dQ}{dt}$

$2\frac{dQ}{dt}$

(85) A cylindrical rod having temp. T_1 & T_2 at its end. The rate of flow of heat Q_1 cal/sec. If all the linear dimensions are doubled keeping temp. remain const. then rate of flow of heat Q_2 will be.



(a) $4Q_1$
(b) $2Q_1$ ✓
(c) $Q_1/4$
(d) $Q_1/2$

$l' = 2l$

$R' = 2R$

$\frac{dQ}{dt} = \frac{(T_1 - T_2)(\pi r^2)4 \cdot 2}{2l}$

(86) Heat is flowing through 2 cylindrical rods of same material. The diameters ~~having~~ of the rods are in the ratio 1:2 and their lengths are in the ratio 2:1. If the temp. diff. between their ends is same, then the ratio of amounts of heat conducted through them per unit time will be

(a) 1:1
(b) 2:1
(c) 1:4
(d) 1:8 ✓

$\frac{\frac{dQ_1}{dt}}{\frac{dQ_2}{dt}} = \frac{\Delta T K \pi r_1^2}{l_1} \times \frac{l_2}{2 \cdot 4 K \pi r_2^2 \Delta T}$

$= \frac{1}{8}$

Date

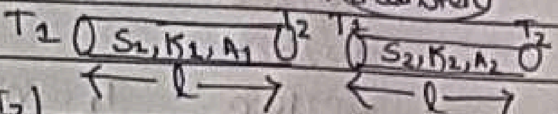
(87) Consider two rods of same length and different specific heats (S_1 & S_2) conductivities K_1 & K_2 and area of cross section (A_1 & A_2) & both having temp. T_1 & T_2 at their ends. If the rate of heat loss due to conduction is equal then. (transfer)

(a) ✓ $K_1A_1 = K_2A_2$

(b) $K_2A_1 = K_1A_2$

(c) $\frac{K_1A_1}{S_1} = \frac{K_2A_2}{S_2}$

(d) $\frac{K_2A_1}{S_2} = \frac{K_1A_2}{S_1}$



$$\frac{dQ}{dt} = \frac{KA(T_1-T_2)}{l}$$

$$mS\Delta T = \frac{KA(T_1-T_2)}{l}$$

(88) The energy that will be identify by a 100 KW transmitter in 1hr is

(a) $1\times10^5 J$

(b) ✓ $36\times10^7 J$

(c) $36\times10^4 J$

(d) $36\times10^5 J$

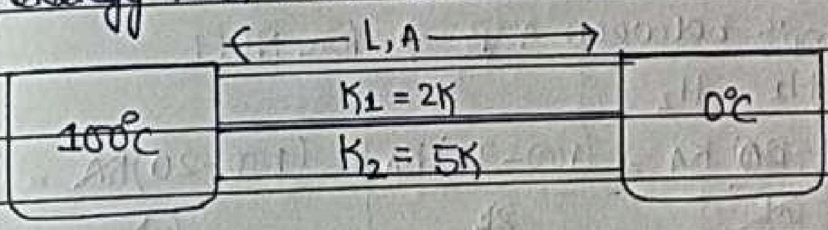
$$P = 100\times10^3 W$$

$$\frac{dE}{dt} = 100\times10^3$$

$$dE = 100\times10^3\, dt$$

$$E_{nd} = 100\times10^3 \times 60\times60 = 36\times10^7 J$$

(89) The energy find total heat current.

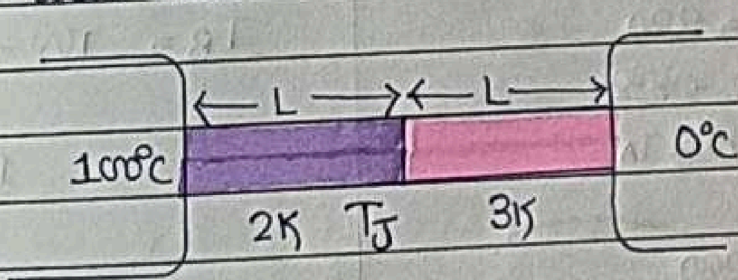


$$H = H_1 + H_2$$

$$= \frac{2K\,100\,A}{L} + \frac{5K\,100\,A}{L}$$

$$= \frac{700KA}{L}$$

(90) find total heat flow and temp. of junction.



$$R_{eq} = R_1 + R_2 = \frac{L}{2KA} + \frac{L}{3KA}$$

$$= \frac{5L}{6K^2A^2}$$

$$H = \frac{\Delta T}{R_{eq}} = \frac{100\times6\times KA}{5L}$$

$$= \frac{120KA}{L}$$

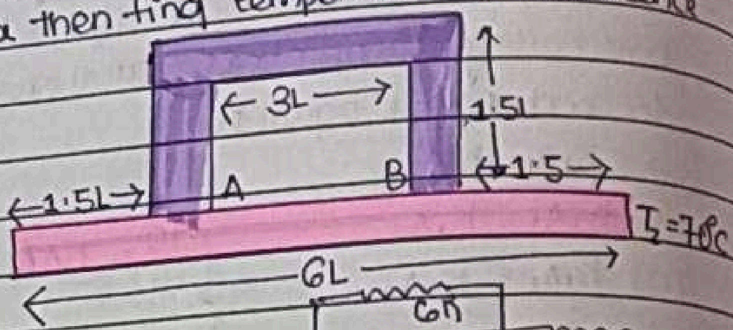
$$T = \frac{2K\times100 + 3K\times0}{5K}$$

$$= \frac{200}{5} = 40°C$$

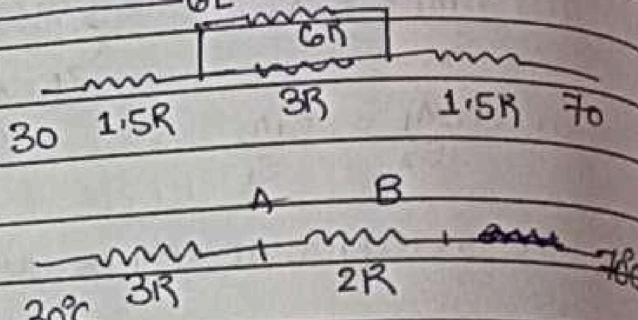
Date

(91) Given arrangement is formed of same material and same cross section area then find temperature difference b/w point A & B.

(a) 20°C
(b) 32°C
(c) 16°C
(d) 40°C



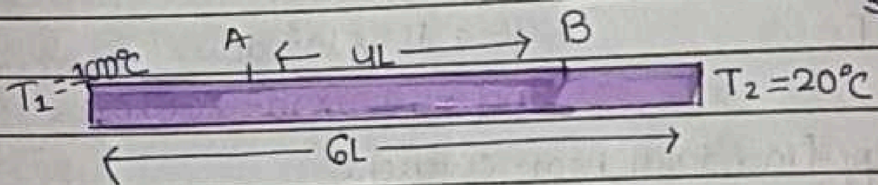
$R = \frac{L}{KA}$ (Let)



$I = \frac{40}{5R}$

$\Delta T = I(2R) = \frac{40}{5R} \times 2R = 16°C$

(92)



find Temp^r between A & B → for NEET

Sol^n $H_1 = H_2$

$\frac{(100-20)KA}{6L} = \frac{(100-T_A)KA}{2L}$

$\frac{80}{6} = 300 - 3T_A$

$\frac{40}{3} = 100 - T_A$

$T_A = \frac{260}{3}$

$\frac{(100-20)KA}{6A} = \frac{(100-T_B)KA}{5A}$

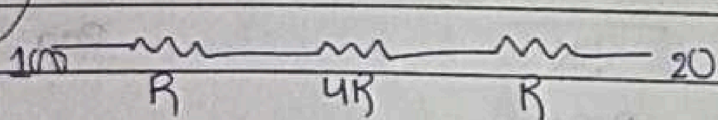
$100 - T_B = \frac{5 \cdot 80}{6} = \frac{200}{3}$

$T_B = 100 - \frac{200}{3}$

$= \frac{100}{3}$

$I = \frac{\Delta V}{R}$

$V_{AB} = IR_{AB}$

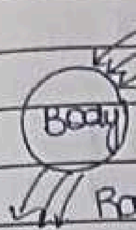


$H = \frac{80}{6R}$

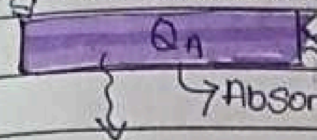
$\Delta T_{AB} = \frac{80}{6R} \times 4R$

$= \frac{80 \times 2}{3} = \frac{160}{3}$

RADIATION:-



Q_0 = Incident radiation.



Q_t = transmitted radiation

e.g.:- Mr. India.

Coefficient of reflection = Q_r/Q_0

Cofficient of transsmission = Q_t/Q_0

Cofficient of absorption = Q_a/Q_0

$\boxed{Q_0 = Q_r + Q_t + Q_a}$ $\boxed{r+t+a = 1}$

(Q3) Emissive power of any surface (e), Absorptive power (a), Reflecting Power (r) and transmission power (t) are related as-

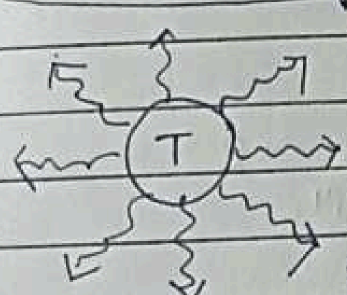
(a) $a+e+t=1$

(b) $a+r+t=1$ ✓

(c) $r+e+t=1$

(d) $r+e+a=1$

Emitted energy



Stephen's বাৰা ⇒ for black body

⇒ Heat radiation from per unit area per sec from the black body is directly proportional to 4th power of temperature.

Total energy from area A in time t $\left(\frac{E}{AT}\right)$ = radiated energy per unit time per unit area.

$\frac{E}{At} \propto T^4 \Rightarrow \boxed{\frac{E}{At} = \sigma T^4}$

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

↳ Stefan's const.

Unit of σ = ??

$\left(\frac{E}{At}\right) = \sigma T^4$

$\frac{J}{Sm^2K^4}$ ($\because$ watt = J/S)

$\frac{watt}{m^2} = \sigma T^4$

$\frac{watt}{m^2 K^4} = \sigma$

(94) Energy radiated from a body in time t is — when A is area of the body.

(a) $\sigma T^4 t$

(b) $\sigma T^4 tA$ ✓

(c) σT^4

(d) $\frac{\sigma T^4}{At}$

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

$E = At\sigma T^4$

↳ Total radiated energy.

For any body:

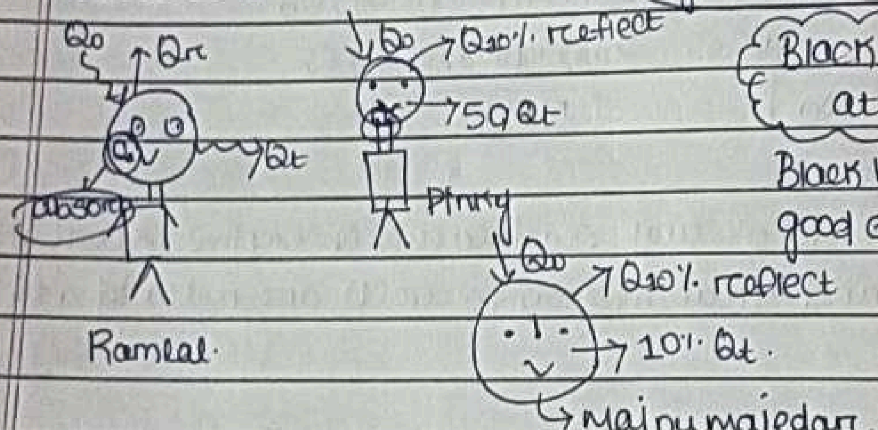
Kirchoff's law

good absorber is a good emitter

Black body at T

Normal body T

Black body is good emitter



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

↳ emisivity.

$\left(\frac{E}{At}\right)_{\text{Black body}} = \sigma T^4$

$\frac{\text{Emmissive power of body}}{\text{emmisive power of black body}} = \frac{e\sigma AT^4}{A\sigma AT^4} = e$

$e = \frac{\text{Emissive Power of normal body}}{\text{Emmissive power of black body}}$

↓ emissivity

Perfect

Black body $e=1$ $a=1$

(Q5) 2 bodies of same nature & same dimension at tempr 50°C & 100°C then energy radiation per unit time from per unit area will be.

50°C A.e | 100°C A.e

(a) 1:2

(b) 1:16

(c) 16:1

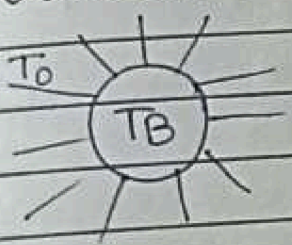
(d) None of the above.

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

$$\frac{\left(\frac{E}{At}\right)_1}{\left(\frac{E}{At}\right)_2} = \frac{e\sigma(273+50)^4}{e\sigma(273+100)^4}$$

Prevost theory:- A body at temp T_B placed in atmosphere where temp. of atmosphere is T_0 then body will radiate and absorb radiation simultaneously.

Stefan's- Boltzmann's law:-



$\left(\frac{E}{At}\right)$ net = radiation emitted $\left(\frac{E_{emitted}}{At}\right) - \left(\frac{E_{absorbed}}{At}\right)$

$= e\sigma T_B^4 - e\sigma T_0^4$

$$\left(\frac{E}{At}\right) = \sigma e\left(T_B^4 - T_0^4\right)$$

If $T_B = T_0$

$\left(\frac{E}{At}\right)$ net emitted radiation $= 0$

If $T_B > T_0$

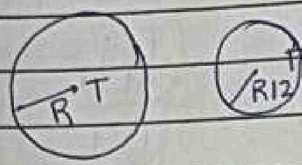
$\left(\frac{E}{At}\right)$ net emitted radiation $= +ve$

If $T_0 > T_B$

$\left(\frac{E}{At}\right)$ net emitted radiation $= -ve$.

(96) 2 identical metal balls at temp. 200°C & 400°C kept in air at 27°C. The ratio of net heat loss by these bodies is

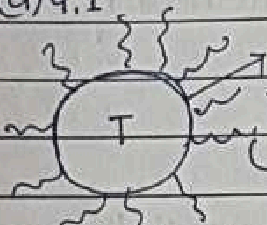
(a) 1/4
(b) 1/2
(c) 1/16
✓(d) $\frac{473^4 - 300^4}{673^4 - 300^4}$

(97) 

Two body of same material at same same tempr as show then find ratio of heat loss per unit time per unit area will be.

✓(a) 1:1
(b) 1:2
(c) 2:1
(d) 4:1

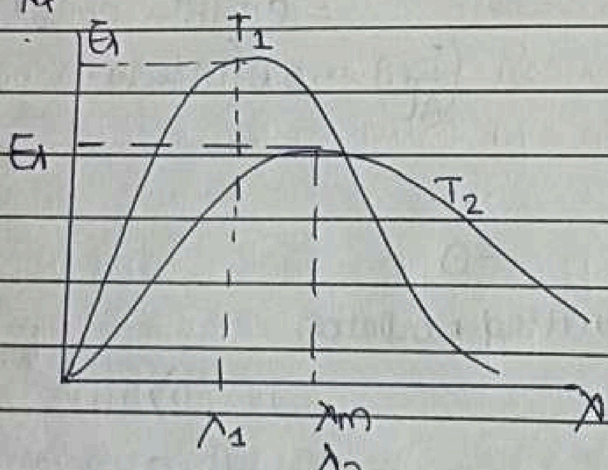
Wien's displacement law

(98) 

A body at tempr T emits energy of all wavelength

Tempr↑
↳ emitted energy↑ (λ↓)

from $\lambda_i = 0$ to $\lambda_f = \alpha$



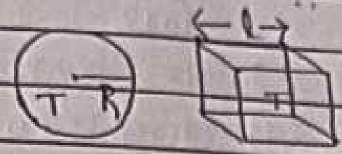
$T_1 > T_2$

Page No.
Date

(99) Solid Sphere and solid cube of same material and of same volume at same Temp^r then rate of heat loss per sec??

(a) More in solid sphere
(b) More in cube ✓
(c) Same in both.

$\frac{dE}{A\,dt} = \sigma T^4$ (same)



$\frac{dE}{dt} \propto Area$

Area cube $= 6l^2 = 6(4)^{2/3}R^2$

Area of sphere $= 4\pi R^2$
$= 12R^2$

Volume equal.

(Almost $3 = \pi$) $\frac{4}{3}\pi R^3 = l^3$

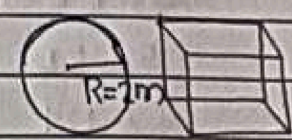
$\sqrt[3]{4}\,R = l$

$6l^2 = 6 \times 2.5 \times R^2$
$= 15R^2$

(100) Solid Sphere and solid cube of same material and of same area at same temp. then rate of heat loss?

(a) More in solid sphere
(b) More in cube
(c) Same. ✓

(101)



$4\pi R^2$ ← $l=2m$ →

$6l^2$

In this case more in solid sphere.

(102) If transmission power of a surface is 1/6 and reflective power is 1/3, then its absorptive power will be.

(a) 1/3
(b) 1/2 ✓
(c) 1/6
(d) 1/12

$t = 1/6$

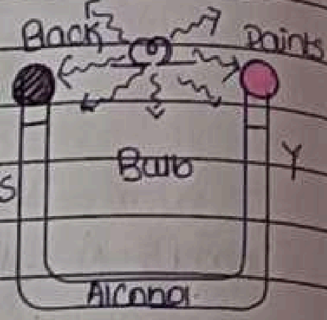
$r = 1/3$

$a = 1 - \left(\frac{1}{3} + \frac{1}{6}\right)$

(103) The following figure shows two air-filled bulbs connected by a U-tube partly filled with alcohol. what happens to the levels of alcohol in the limbs X & Y when an electric bulb placed midway b/w the bulbs is lighted.

(a) The level of alcohol in limb X falls where that in limb Y rises
(b) The level of alcohol in limb X rises while that in limb Y falls
(c) The levels of alcohols falls in both limbs.
(d) There is no change in the levels of alcohol in the 2 limbs.

(Temp) air high will X expands



(104) Two black metallic spheres of radius 4m. at 2000 K and 1m at 4000 K will have ratio of energy radiation as

(a) 1:1
(b) 4:1
(c) 1:4
(d) 2:1

$E = \sigma A T^4 t$

$$\frac{E_1}{E_2} = \frac{r_1^2 T_1^4}{r_2^2 T_2^2}$$

$$= \left(\frac{4}{1}\right)^2 \times \left(\frac{2000}{4000}\right)^4$$

$$= 16 \times \frac{1}{16} = 1:1$$

(105) Temp. of a piece of metal is increased from 27°C to 327°C. The rate of emission of radiation by a metal will become

(a) Double
(b) four times
(c) Eight times
(d) Sixteen times.

27°C —— 327°C

$\left(\frac{dE}{dt}\right)_{initial} \propto (300)^4$ $\left(\frac{dE}{dt}\right)_{final} = (600)^4 = 2^4$

(106) If same amount of ice is placed in black & rough black then ice in rough black cloth will melt more

Page No.
Date

(107) If the temp. of a black body is increased by 50% then the amount of radiation emitted by it will

(a) Increase by 400%.
(b) Decrease by 400%.
(c) Decrease by 50%.
(d) Increas by 50%.

Initial temp. = T_0

final temp. $T_0 + 50\% \, T_0$

$= \frac{3T_0}{2}$

$\frac{dE}{dt} \propto T_0^4$

$\left(\frac{dE}{dt}\right)_f = \left(\frac{3T_0}{2}\right)^4 = \frac{3^4}{2^4} T^0 = \frac{81}{16} \left(\frac{dE}{dt}\right)$

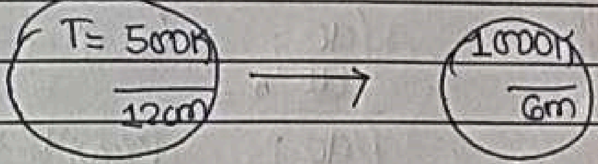
$= 5 \frac{dE}{dt} = 500\%$

Amount of radiation increases to 500%.

amount of Radiation increases by 400%.

(108) A spherical black body with a radius of 12 cm radiates 450 watt power at 500K. If the radius were halved & the temp doubled that power radiated in watt would be (NEET-2017)

(a) 125
(b) 450
(c) 1000
(d) 1800



$\frac{dE}{dt} \propto AT^4$

$\propto r^2 T^4$

$\propto \left(\frac{r}{2}\right)^2 (2T)^4$

$= \frac{1}{4} \times 16$

(109) The total radiant energy per unit area, normal to the direction of incidence, recieved at a distance R from the centre of a star of radius r, whose outer surface radiates as a black body at a temp. TK is given by- [AIPMT (Pre)-2010]

(a) $\sigma r^2 T^4 / R^2$
(b) $\sigma \pi r^2 T^4 / 4\pi r^2$
(c) $\sigma r^4 T^4 / r^4$
(d) $4\pi r^2 T^4 / R^2$

(110) If the radius of a star is R and it acts as a black body, what would be the temp. of the star, in which the rate of energy production is Q? (AIPMT (Pre) - 2012)

(a) $(4\pi R^2 Q/\sigma)^{1/4}$

~~(b)~~ $(Q/4\pi R^2\sigma)^{1/4}$

(c) $Q/4\pi R^2\sigma$

(d) $(Q/4\pi R^2\sigma)^{1/2}$

$$\frac{dE}{dt} = Q = \sigma 4\pi R^2 T^4$$

$$T = \left(\frac{Q}{\sigma 4R^2\pi}\right)^{1/4}$$

(111) Two bodies A & B are kept in an evacuated chamber at 27°C. The temp. A & B are 327°C and 427°C respectively. The ratio of rates of loss of heat from A and B will be.

~~(a)~~ 0.52

(b) 0.25

(c) 1.52

(d) 2.52

$T_0 = 27 + 273$

$= 300K$

$T_A = 327 + 273 = 600K$

$T_B = 427 + 273 = 700K$

$$\frac{\left(\frac{dE}{dt}\right)_A}{\left(\frac{dE}{dt}\right)_B} = \frac{(600)^4 - (300)^4}{(700)^4 - (300)^4}$$

$$= \frac{(6)^4 - (3)^4}{(7)^4 - (3)^4} = \underline{0.52}$$

(112) A copper ball 2cm in radius is heated in a furnace to 827°C. If its emissivity is 0.3, at what rate does it radiate energy? [AIIMS - 2015]

(a) 1.72 W

(b) 2.73 W

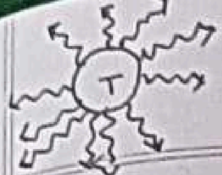
~~(c)~~ 11.0 W exact soln is not required

(d) 2.15 W

$$\frac{dE}{dt} = e\sigma T^4 A$$

$$= \frac{3}{10} \times 5.67 \times 10^{-8} \times 4\pi (2\times10^{-2})^2 \times (600)^4$$

$$= \frac{3}{10} \times 5.7 \times 10^{-8} \times 4\pi \times 4 \times 10^{-4} \times 6^4 \times 10^8$$

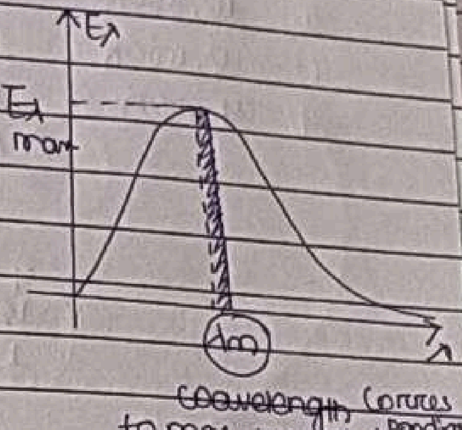


λ 0 to ∞

Spectral emmisive power :- Heat radiation from a body from a unit area in unit time of unit wavelength

Wins displacement law :-

$dE_\lambda = \frac{dE}{A\,dt\,d\lambda} \propto T^4$



$dA = dE_\lambda d\lambda$

$\int dE = \int \frac{dE}{A\,dt\,d\lambda} d\lambda$

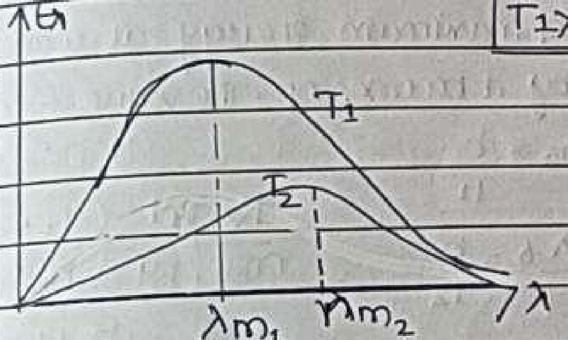
Area $= \frac{E}{A\,time} \propto T^4$

Area $\propto T^4 \propto$ radiated energy per unit area per sec.

$\lambda_m \propto \frac{1}{Temp.} = \frac{b}{Temp.}$

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

$T_1 > T_2$



(113) PYQ The wavelength of maximum energy of maximum energy released during an atomic explosion was 2.93×10^{-10} m. Given that Wien's constant is 2.93×10^{-3} m-K. The maximum temp. attained must be of the order of

(a) 10^{-7} K

(b) 10^{7} K ✓

(c) 10^{-13} K

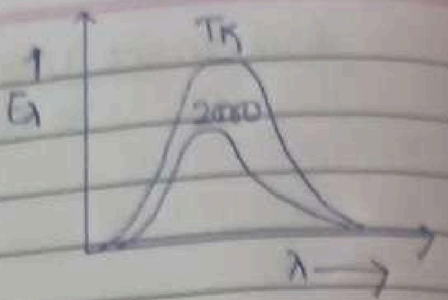
(d) 5.86×10^{7} K

$\lambda = \frac{b}{T}$

$T = \frac{b}{\lambda} = \frac{2.93 \times 10^{-3}}{2.93 \times 10^{-13}} = 10^{7}$ K

(114) The adjoining diagram shows the spectral energy density distribution of a black body at two different temperatures. If the areas under the curves are in the ratio 16 : 1, the value of temperature T is,

(a) 32,000K
(b) 16,000K
(c) 8,000K
~~(d)~~ 4,000K



Area ∝ T^4

$\frac{A_1}{A_2} \propto \left(\frac{T_1}{T_2}\right)^4$

$\left(\frac{16}{1}\right)^{1/4} = \frac{T}{2000K}$

$T = 4000K$

(115) The power radiated by a black body p and it radiates max energy at wavelength (λ_0). If the temp of the black body is now changed so that it radiated maximum energy at wavelength $3\lambda_0/4$. The power radiated by it becomes np. The value of n is (NEET-2018)

(a) 3/4
(b) 4/3
~~(c)~~ 256/81
(d) 81/256

$P \to \lambda_0 \to \lambda_0 = \frac{b}{T_1}$

$nP \to \frac{3\lambda_0}{4}$ $\quad \frac{3\lambda_0}{4} = \frac{b}{T_2}$

$\frac{4}{3} = \frac{T_2}{T_1}$

$\frac{P = T_1^4}{nP = T_2^4} = \left(\frac{T_1}{T_2}\right)^4$

$\frac{1}{n} = \left(\frac{3}{4}\right)^4$

$n = \left(\frac{4}{3}\right)^4 =$

$= \frac{256}{81}$

(116) On observing light from 3 different stars, P, Q and R (AIIMS-2015) it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is max^m in the spectrum of R and the intensity of red colour is max^m in the spectrum of Q if T_P, T_Q, T_R are the respective absolute temp. of P, Q, and R, Then it can be concluded from the observation that

~~(a)~~ $T_P > T_R > T_Q$
(b) $T_P < T_R < T_Q$
(c) $T_P < T_Q < T_R$
(d) $T_P > T_Q > T_R$

(P) Violet, (Q) Red, (R) green

VIBGYOR

⟶ λ↑

T↓

$E = \frac{hc}{\lambda}$ only aplicable for (photon) $E \propto \frac{r(hc)}{\lambda}$ fixed

Date

(117) If for a black body the graph of change is emissive power at different temp. $T_1, T_2 \& T_3$ with wavelength is according to the figure then.

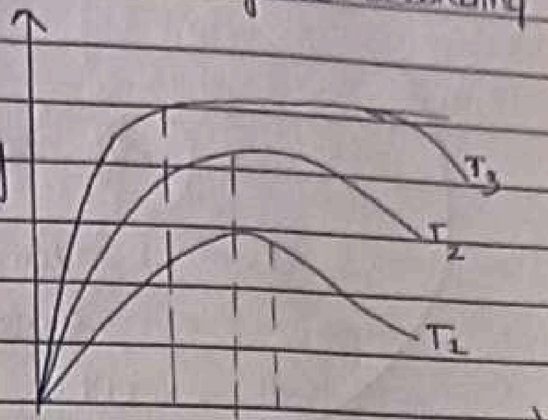
(a) $T_1 = T_2 = T_3$

✓(b) $T_3 > T_2 > T_1$

(c) $T_1 > T_2 > T_3$

(d) $T_3 > T_1 > T_2$

$A \propto T^4$



(118) A black body is at a temp of 5760K. The energy of radiation emitted by the body at wavelength 250 nm is U_1, at wavelength 500 nm is U_2 and that at 1000nm is U_3. Wien's constant, $b = 2.88 \times 10^6$ nmK. which of the following is correct [NEET -2016]

(a) $U_1 = 0$

(b) $U_3 = 0$

(c) $U_1 > U_2$

✓(d) $U_2 > U_1$

(5760)

$\lambda_1 = 250 \rightarrow U_1$

$\lambda_2 = 500 \rightarrow U_2$

$\lambda_3 = 1000 \rightarrow U_3$

$\lambda_m = \frac{b}{T} = \frac{2.88 \times 10^6 nmK}{5760K}$

$= 5 \times 10^{-4} \times 10^6 nm$

$= 500 nm$

(119) The condition under which a microwave oven heats up a food item containing H_2O molecules most effectively is

NEET 2013

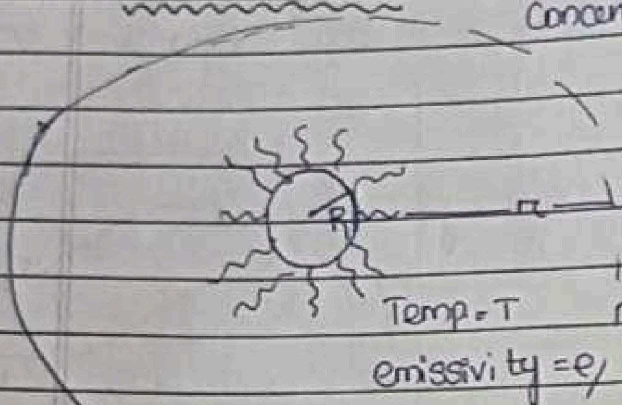
(a) Infra-red waves produce heating in a microwave oven.

✓(b) The frequency of the microwave must match the resonant frequency of the water molecules

(c) The frequency of microwave has no relation with natural frequency of water molecule.

(d) Microwaves are heatwaves, so always produce heating

Solar constant :-



Concentric hollow sphere

Heat radiation falling on hollow sphere

$E = \sigma e T^4 (4\pi R^2) t$

→ Intensity of radiation falling on sphere of radius (r)

$$\frac{dE}{A\,dt} = \sigma e T^4$$

$$\boxed{dE = \sigma e T^4 4\pi R^2 dt}$$

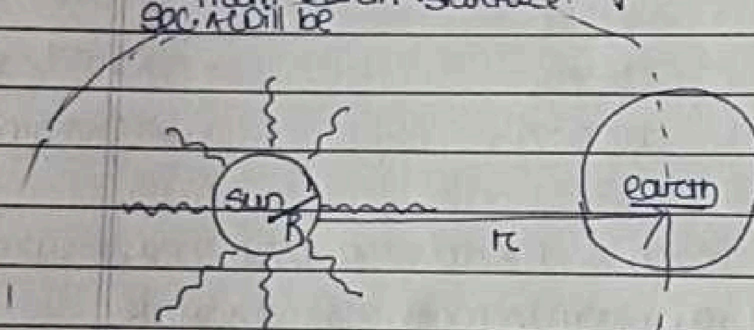
$$E = \sigma e T^4 (4\pi R^2) t$$

$$I = \frac{E}{(t)\ \text{Area of sphere}}$$

$$= \frac{\sigma e T^4 4\pi R^2 t}{4\pi r^2 t}$$

$$I = \sigma e T^4 \left(\frac{R^2}{r^2}\right)$$

Heat energy falling on the earth surface per unit per sec. Area will be from earth surface.



$$\text{Power of radiation from sun} = \frac{dE}{dt} = e\sigma T^4 4\pi R^2$$

$$S = \frac{dE}{A\,dt} = \frac{e\sigma T^4 4\pi R^2}{}$$

$$S = e\sigma T^4 \left(\frac{R}{r}\right)^2$$

$$\boxed{1.4\ \text{Kwatt/m}^2}$$

$$T^4 = \frac{S}{\sigma}\left(\frac{r}{R}\right)^2$$

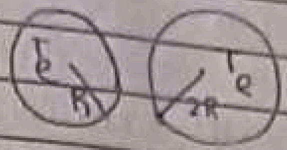
$$T = \left(\frac{S}{\sigma}\left(\frac{r}{R}\right)^2\right)^{\frac{1}{4}}$$

(120) 2 sphere of same material at same temp of diff size, then rate of cooling

(a) fast in A sphere

(b) fast in B sphere

(c) same



$$\frac{dE}{dt} = A\sigma T^4$$

$$\frac{ms\Delta T}{dt} = A\sigma T^4$$

$$\frac{\Delta T}{dt} = \frac{A\sigma T^4}{ms} \rightarrow \text{same} \quad = \frac{\text{Area}}{\text{volume}}$$

$$\frac{\Delta T}{dt} = \frac{\text{Area}}{\text{Volume}} = \frac{4\pi R^2}{\frac{4}{3}\pi R^3}$$

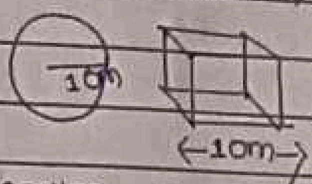
$$\boxed{\frac{\Delta T}{dt} \propto \frac{1}{R}}$$

(121) Solid sphere and cube made of same material at same temp. Then rate of cooling

(a) faster in sphere

(b) faster in cube

(c) same



Rate of cooling

$$= \frac{A}{V} = \frac{4\pi r^2}{\frac{4}{3}\pi r^3} = \frac{3}{r} = 0.3$$

Rate of cool

$$\frac{A}{V} = \frac{600}{1000} = 0.6$$