Date /05/23
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Thermal Expansion

Expansion on solid:

i) Linear expansion → The increase in length of the object is called linear expansion.

ii) Superficial expansion → The increase in area of the object is called superficial expansion.

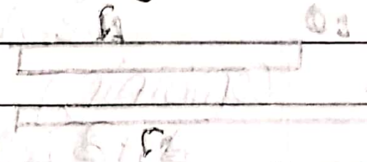
iii) Cubical expansion → The increase in volume of the object is called cubical expansion.

Coefficient of linear Expansion: [Linear expansion]

Consider a metal rod of length l_1 & at temperature θ_1°C when rod is heated to θ_2°C, length become l_2

Here, change in temp $\Delta\theta = \theta_2 - \theta_1$

change in length $\Delta l = l_2 - l_1$



Experimentally,

change in length is directly proportional to the change in temp.

i.e $\Delta l \propto \Delta\theta$ —— (i)

similarly, change in length is directly proportional to the original length.

i.e. $\Delta l \propto l_1$ —— (ii)

$\because \alpha$ depends in nature of the material.

α : coefficient of linear expansion

Combing (i) & (ii),

or, $\Delta l \propto l_1 \Delta\theta$

or, $\Delta l = \alpha l_1 \Delta\theta$, where α is proportionality constant called coefficient of linear expansion.

or, $\alpha = \dfrac{\Delta l}{l_1 \Delta\theta}$

$\therefore$ coefficient of linear expansion or linear expansivity is defined as the ratio of change in length to original length per degree change in temp. Unit is K^{-1} or $°C^{-1}$.

We have, $\Delta l = \alpha l_1 \Delta\theta$

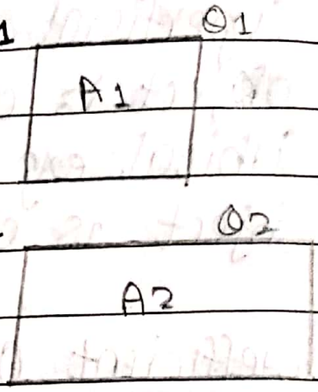
or, $l_2 - l_1 = \alpha l_1 \Delta\theta$

or, $l_2 = l_1 + \alpha l_1 \Delta\theta$

$\therefore l_2 = l_1 (1 + \alpha\Delta\theta)$

Coefficient of superficial expansion

Consider a metalic sheet of area A_1 at temperature θ_1°C when sheet ~~rod~~ is heated to θ_2 °C, area become A_2.



Here, change in temperature $\Delta\theta = \theta_2 - \theta_1$

change in area $\Delta A = A_2 - A_1$

Experimentally,
change in area is directly proportional to the change in temperature.

i.e $\Delta A \propto \Delta\theta$ — (i)

Similiary, change in area is directly proportional to the original area.

i.e $\Delta A \propto A_1$ — (ii)

Combining (i) & (ii),

$\Delta A \propto \Delta\theta A_1$

or, $\Delta A = \beta A_1 \Delta\theta$, where β is proportionality ~~to~~ constant

or, $\beta = \dfrac{\Delta A}{A_1 \Delta\theta}$ called coefficient of superficial expansion.

∴ Coefficient of superficial expansion or superficial expansivity is defined as the ratio of change in area to original area per degree change in temp

We have,

$$\Delta A = \beta A_1 \Delta\theta$$

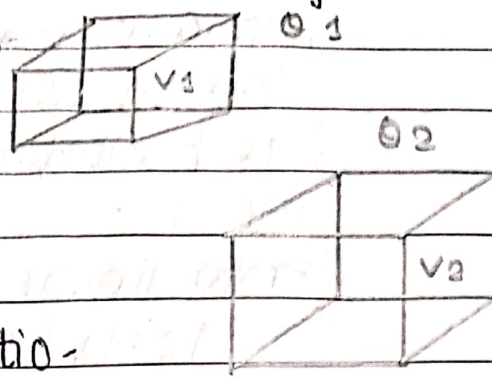
or, $A_2 - A_1 = \beta A_1 \Delta\theta$

or, $A_2 = A_1 + \beta A_1 \Delta\theta$

∴ $A_2 = A_1(1 + \beta\Delta\theta)$

Coefficient of Cubical expansion:

consider a metalic cube of volume V_1 at temperature θ_1°C when cube is heated to θ_2°C, volume become V_2.



Here, change in temperature $\Delta\theta = \theta_2 - \theta_1$
change in volume $\Delta V = V_2 - V_1$

Experimentally,
change in volume is directly proportional to the change in temperature.
i.e $\Delta V \propto \Delta\theta$ — (i)

Similarly, change in ~~area~~ volume is directly proportional to the original volume.
i.e $\Delta V \propto V_1$ — (ii)

combining (i) & (ii),
$\Delta V \propto \Delta\theta V_1$
or, $\Delta V = \gamma V_1 \Delta\theta$, where γ is proportionality constant called coefficient of cubic expansion.
or, $\gamma = \dfrac{\Delta V}{V_1 \Delta\theta}$

∴ coefficient of cubical expansion or cubical expansivity is defined as the ratio of change volume to original volume per degree change temperature.

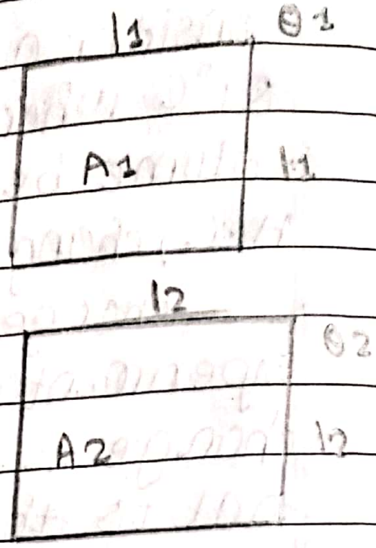
We have,

$$\Delta V = \gamma V_1 \Delta\theta$$
$$\text{or, } V_2 - V_1 = \gamma V_1 \Delta\theta$$
$$\text{or, } V_2 = V_1 \gamma V_1 \Delta\theta$$
$$\therefore V_2 = V_1(1+\gamma\Delta\theta)$$

Relation between α, β & γ.

Relation between α & β.

Consider a square metallic sheet of length l_1 at temp. θ_1°C. When it is heated to temp θ_2°C length becomes l_2.



From linear expansion.

$$l_2 = l_1[1+\alpha\Delta\theta] \quad \text{--- (i)}$$

where α is coefficient of linear expansion.

At temp, θ_2°C, Area of metallic sheet is A_2.

We have, $A_2 = l_2^2$

$$\text{or, } A_2 = \{l_1[1+\alpha\Delta\theta]\}^2$$

$$\text{or, } A_2 = l_1^2\{1+2\alpha\Delta\theta+\alpha^2\Delta\theta^2\}$$

$$\text{or, } A_2 = A_1\{1+2\alpha\Delta\theta+\alpha^2\Delta\theta^2\}$$

As, the value of α is very small, neglecting higher order term,

$$\text{or, } A_2 = A_1(1+2\alpha\Delta\theta) \quad \text{--- (ii)}$$

We have from superficial expansion

$$A_2 = A_1[1+\beta\Delta\theta] \quad \text{--- (iii)}$$

comparing (ii) & (iii)

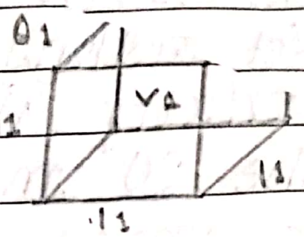
$$\beta = 2\alpha$$

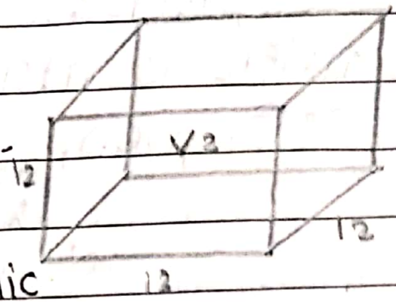
$\therefore$ Coefficient of superficial expansion is twice of the coefficient of linear expansion.

Also, $\alpha = \frac{\beta}{2}$

Relation between α & γ

Consider a metallic cube of length l_1 at temp. θ_1°C. When it is heated to temp θ_2°C length becomes l_2.





From linear expansion,

$l_2 = l_1[1+\alpha\Delta\theta]$ —— (i)

where α is coefficient of linear expansion.

At temp. θ_2°C, volume of metallic cube is V_2.

We have, $V_2 = l_2^3$

$= \{l_1[1+\alpha\Delta\theta]\}^3$

$= l_1^3\{1+3\alpha\Delta\theta+3\alpha^2\Delta\theta^2+\alpha^3\Delta\theta^3\}$

or, $V_2 = V_1\{1+3\alpha\Delta\theta+3\alpha^2\Delta\theta^2+\alpha^3\Delta\theta^3\}$

As, the value of α is very small, neglecting higher order term.

or, $V_2 = V_1[1+3\alpha\Delta\theta]$ —— (ii)

We have from cubical expansion

$V_2 = V_1[1+\gamma\Delta\theta]$ —— (iii)

comparing (ii) & (iii)

$\gamma = 3\alpha$

Coefficient of cubical expansion is thrice of the coefficient of linear expansion.

Also, $\alpha = \frac{\gamma}{3}$

$\therefore \alpha = \frac{\beta}{2} = \frac{\gamma}{3}$ //

Numericals:

1. The marking on a aluminum ruler & brass ruler are perfectly aligned at $0°C$. How far a part will the 20 cm marks be on the two rulers at $100°C$, if precise aligment of the left hand ends of the rulers is maintained? $\alpha_{al} = 2.4 \times 10^{-5} K^{-1}$, $\alpha_{brass} = 2 \times 10^{-5} K^{-1}$

Sol^n: Given, At $0°C$,

$l = 20$ cm

$\alpha_{al} = 2.4 \times 10^{-5} K^{-1}$ & $\alpha_{brass} = 2 \times 10^{-5} K^{-1}$

At $100°C$, $\Delta\theta = 100°C - 0°C = 100°C$

$l_b = l[1 + \alpha_{brass}\Delta\theta]$

$= 20[1 + 2 \times 10^{-5} \times 100]$

$\therefore l_b = 20.04$ cm

Now, $l_{al} = l[1 + \alpha_{al}\Delta\theta]$

$= 20[1 + 2.4 \times 10^{-5} \times 100]$

$= 20.048$ cm

$\therefore$ Distance between 20 cm marks at $100°C = l_{al} - l_b$

$= 20.048 - 20.04$

$= 0.08$ cm

2. A brass pendulum clock keeps correct time at $15°C$. How many seconds per day will it lose or gain at $0°C$? ($\alpha_{brass} = 2 \times 10^{-5} K^{-1}$)

Here, $T_{15} = 2\pi\sqrt{\frac{l_{15}}{g}}$ —— (i)

$T_0 = 2\pi\sqrt{\frac{l_0}{g}}$ —— (ii)

Now, dividing eq^n (i) & (ii),

$\frac{T_{15}}{T_0} = \sqrt{\frac{l_{15}}{\cancel{g}} \times \frac{\cancel{g}}{l_0}}$

or, $\frac{T_{15}}{T_0} = \sqrt{\frac{l_{15}}{l_0}}$

or, $\frac{T_{15}}{T_0} = \sqrt{\frac{l_0[1 + \alpha_b\Delta\theta]}{l_0}}$

$$or, \frac{T_{15}}{T_0} = \sqrt{1+\alpha_b \Delta\theta}$$

$$or, T_0 = \frac{T_{15}}{\sqrt{1+\alpha_b\Delta\theta}}$$

Let ~~a~~ $T_{15} = 2$ sec.

$$or, T_0 = \frac{2}{\sqrt{1+2\times10^{-5}\times15}}$$

$$\therefore T_0 = 1.999700067$$

In 2 sec, Pendulum gain $= (2-1.999700067)$ sec

$$= 0.0002999325 \text{ sec}$$

$$= 2.99933\times10^{-4} \text{ sec}$$

In 1 sec $= \frac{2.99933\times10^{-4}}{2}$ sec

In 1 day $= \frac{2.99933\times10^{-4}}{2} \times 24\times60\times60$ sec

$$= 12.95 \text{ sec}$$

3. An iron pendulum clock~~s~~ keeps correct time at 20°C. How many seconds will it gain or lose per day ~~at~~ when temperature rises to 30°C? ($\alpha_{iron} = 12\times10^{-6}$ per K^{-1}).

Here,

$$T_{20} = 2\pi\sqrt{\frac{l_{20}}{g}} \quad \text{—— (i)}$$

$$T_{30} = 2\pi\sqrt{\frac{l_{30}}{g}} \quad \text{—— (ii)}$$

Dividing eq^n (i) & (ii),

$$\frac{T_{30}}{T_{20}} = \frac{\cancel{2\pi}}{\cancel{2\pi}}\sqrt{\frac{l_{30}}{\cancel{g}} \times \frac{\cancel{g}}{l_{20}}}$$

$$or, \frac{T_{30}}{T_{20}} = \sqrt{\frac{l_{30}}{l_{20}}}$$

$$or, \frac{T_{30}}{T_{20}} = \sqrt{\frac{\cancel{l_{20}}(1+\alpha_{iron}\Delta\theta)}{\cancel{l_{20}}}} \qquad or, \frac{T_{30}}{T_{20}} = \sqrt{1+\alpha_{iron}\Delta\theta}$$

$T_{30} = T_{20}\sqrt{1+\alpha_{iron}\Delta\theta}$

Let, T_{20} be 2 sec,

$T_{30} = 2\times\sqrt{1+12\times10^{-6}\times10}$ $\quad\because \Delta\theta = 30-20 = 10°c$

$\therefore T_{30} = 2.0001\cancel{19996}$

In 2 sec, pendelum lose $= 2.000\cancel{119996} - 2$

$= (1.199964002\times10^{-4}$ sec$)$ 0.00012

In 1 sec, $= \left(\cancel{\dfrac{1.199964002\times10^{-4}}{2}}\text{ sec}\right)$ $\dfrac{0.00004}{2}$ sec

$= (5.999820011\times10^{-5}$ sec$)$ 2×10^{-5}

In 1 day $= 5.9998200112\times10^{-5}\times24\times60\times60$ sec

$= (\cancel{5.183844489}$ sec$)$ 1.728 sec

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Pullinger's Method to Measure the coefficient of Linear Expansion of solid

The experimental arrangement for the determination of the linear expansivity of a solid by using Pullinger's apparatus is shown in the figure.

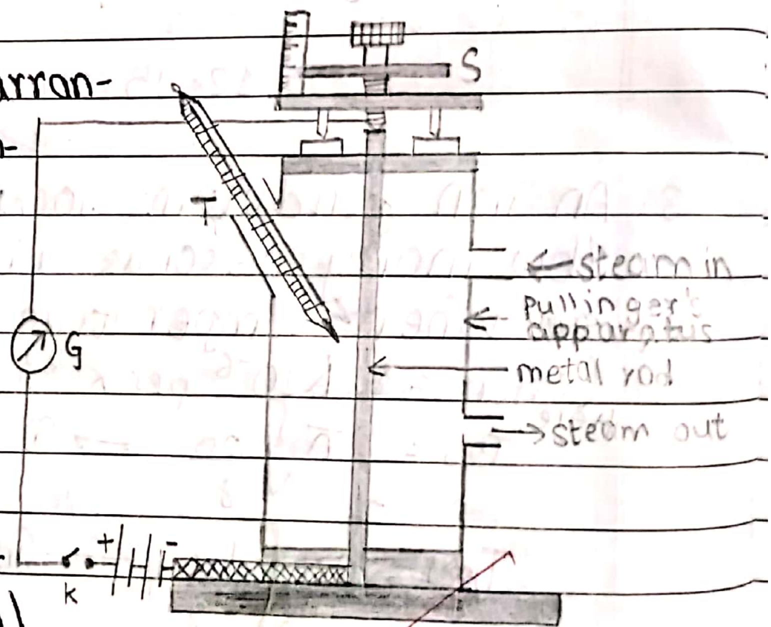


fig: pullinger's apparatus

It consists of a tall hollow wooden frame in which a metal rod is placed inside it. Steam is passed for the expansion of the rod. The temperature change is recorded with the help of a thermometer T. The increase in the length of the rod is measured with the help of the spherometer S that is kept on the top of the frame. An electric circuit with a galvanometer is connected between the spherometer S & the metal plate of the base of the rod.

In the beginning, the initial length of the rod is measured by using a meter scale. Its initial temperature is also recorded with the thermometer. When the spherometer shows the deflection, initial circular scale reading of the spherometer is noted. Now the screw of the spherometer is rotated about 5 times.

After this steam is passed inside the frame & the length of the rod is increased with the increase of temperature. On reaching the ~~terminat~~ thermal equilibrium, the final reading of the spherometer and thermometer are noted.

Now,

Initial length $= l_1$

Initial temp $= \theta_1 °C$

Initial spherometer reading $= R_1$

Final temp $= \theta_2 °C$

Final spherometer reading $= R_2$

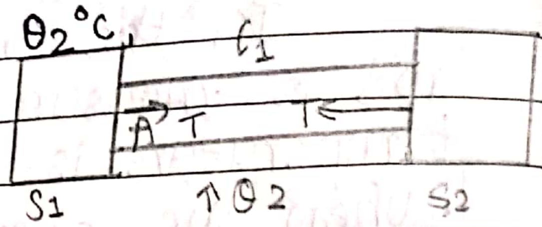
$$\alpha = \frac{\text{change in length}}{\text{original length} \times \text{change in temp}}$$

$$\therefore \alpha = \frac{R_2 - R_1}{l_1(\theta_2 - \theta_1)}$$

$$\alpha = \frac{l_2 - l_1}{l_1 \Delta\theta}$$

Force set up due to expansion & contraction:

Consider a metal rod of length l_1 at temp θ_1°C fixed at two rigid supports as shown in figure. When the rod is heated to θ_2°C, rod tries to expand to length l_2, but not able to do so. Due to which tension is produced in rod,



Now, $Y = \frac{\text{stress}}{\text{strain}}$ [Y = Young's modulus]

$$= \frac{\frac{\text{Tension}}{\text{Area}}}{\frac{\text{change in length}}{\text{original length}}}$$

$$Y = \frac{T/A}{\frac{l_2 - l_1}{l_1}} \quad \text{——— (1)}$$

We have, $l_2 = l_1[1 + \alpha\Delta\theta]$

$$l_2 - l_1 = l_1\alpha\Delta\theta$$

Eqn (1) becomes,

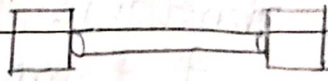
$$Y = \frac{T/A}{\frac{\cancel{l_1}\alpha\Delta\theta}{\cancel{l_1}}}$$

or, $Y\alpha\Delta\theta = T/A$

$\therefore T = YA\alpha\Delta\theta$

- A copper wire of diameter 0.5mm is stretched between two points at 25°C. Calculate the increase in tension in the wire if the temperature falls to 0°C. $Y = 1.2 \times 10^{11}$ N/m^2

  ~~line~~ α copper $= 18 \times 10^{-6} k^{-1}$



Given,

$d = 0.5mm = \frac{0.5}{1000} = 0.5\times10^{-3}m$

$Y = 1.2\times10^{11}\ N/m^2$

$\alpha = 18\times10^{-6}k^{-1}$

$A = \frac{\pi d^2}{4} = \frac{22/7 \times (0.5\times10^{-3})^2}{4} = 1.964285714\times10^{-7}$

$T = YA\alpha\Delta\theta$

$= 1.2\times10^{11} \times 1.964285714\times10^{-7} \times \cancel{25}\ 18\times10^{-6} \times 25$

$= (589285.7143)\ 10.6\ N$

Thus, the increase in temperature in tension in the wire if the temperature falls to 0°C is 10.6 N.

- A steel wire of 8mm & 4 mm in diameter is fixed to two digit supports. Calculate the increase in tension when temperature falls by 10°C. $Y = 2\times10^{11}\ N/m^2$, $\alpha = 1.2\times10^{-5}\ k^{-1}$

Soln: Here,

Length of steel wire (l) = 8 m

Diameter of steel wire (d) = 4 mm = $\frac{4}{1000}$ = 4×10^{-3} m

Young's modulus for steel (Y) = $2\times10^{11}\ N/m^2$

Linear expansively of steel (α) = $1.2\times10^{-5}\ K^{-1}$

Fall in temperature ($\Delta\theta$) = 10°C

Increase in ~~(temperature)~~ tension (T) = ?

We have,

$T = YA\alpha\Delta\theta$

$= \frac{Y\pi d^2 \alpha\Delta\theta}{4}$

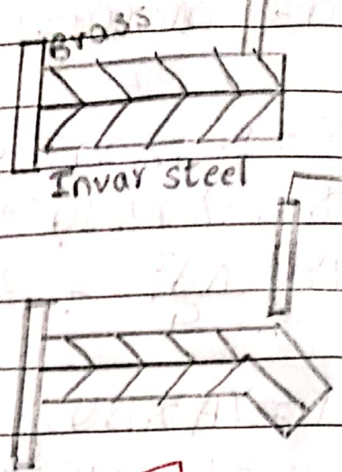
$= 2\times10^{11} \times \frac{\frac{22}{7}\times(4\times10^{-3})^2}{4} \times 1.2\times10^{-5} \times 10$

$= 301.76\ N$

Thus, the increase in tension on steel wire when the temperature falls by 10°C is 301.7 N.

Bimetallic thermostat.

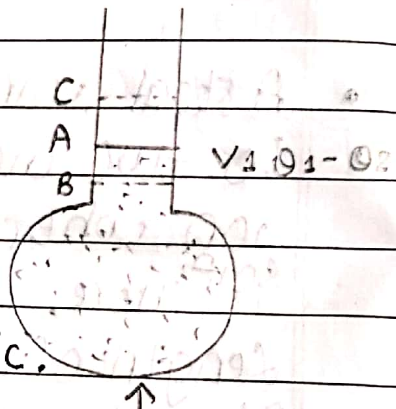
A thermostat is a device used to get desired temperature in systems like AC, iron, refregerator etc. It works on the principle of thermal expansion. In bimetallic thermostat two different metals having different coefficient of liner expansion are welded together.



Expansion on liquids:

Real & apparent expansion of liquids:

Consider a glass vessel having long neck with uniform bore filled with liquid up to level 'A' at temp. θ_1°C. Let 'v' be the original volume of liquid. Suppose system is heated to temp θ_2°C. As heat is supplied from outside, glass vessel receives heat earlier than the liquid does. As a result, capacity of vessel increases & level of liquid decrease to level 'B'. And after that, liquid expands to level 'C' because liquid is more expansible than glass vessel.



Now, BC = real expansion of liquid.

AB = expansion of vessel.

Therefore, Apparent expansion of liquid V_{AC} is the difference between real expansion of liquid V_{BC} & expansion of vessel V_{AB}.

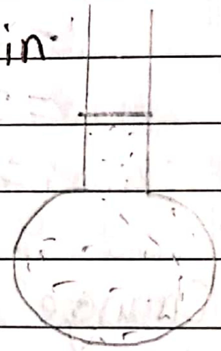
$\therefore V_{AC} = V_{BC} - V_{AB}$.

Coefficient of real expansion of liquid:
It is defined as the ratio of real increase in volume to original volume per degree rise in temp denoted by γ_r i.e $\gamma_r = \frac{\Delta V_r}{V \Delta \theta}$

Coefficient of apparent expansion of liquid
It is defined as the ratio of apparent increase in volume to original volume per degree rise in temperature.
$\gamma_a = \frac{\Delta V_a}{V \Delta \theta}$

coefficient of volume expansion of vessel.
It is defined as the ratio of increase in volume of vessel to orginal volume per degree rise in temp denoted by $\gamma_g = \frac{\Delta V_g}{V \Delta \theta}$

Imp Relation between real & apparent expansion of liquid
Consider a glass vessel of volume 'v' filled with liquid at temp θ_1°c. When system is heated to θ_2°c, the real increase in volume of liquid is given by
$\Delta V_r = \gamma_r V \Delta \theta$



Similarly, apparent expansion of liquid increase in volume of liquid
$V \Delta a = \gamma_a V \Delta \theta$
Also, increase in volume of vessel is given by
$\Delta V_g = \gamma_g V \Delta \theta$
Now,
Real expansion of liquid = apparent expansion of liquid + expansion of vessel
$\Delta V_r = \Delta V_a + \Delta V_g$
or, $\gamma_r V \Delta \theta = \gamma_a V \Delta \theta + \gamma_g V \Delta \theta$
$\therefore \gamma_r = \gamma_a + \gamma_g$ //

Numericals:

Q. A glass flask with volume 200 cm^3 is filled to the brim with mercury at 20°C. How much mercury overflows when the temp of the system is raised to 100°C. $\gamma_m = 18 \times 10^{-5} k^{-1}$, $\alpha_g = 0.4 \times 10^{-5} k^{-1}$.

Given,

$\gamma_m = 18 \times 10^{-5} k^{-1}$

$\alpha_g = 0.4 \times 10^{-5} k^{-1}$

Let, V be the volume of mercury & glass at 20°C,

$V = 200 cm^3$

At, 100°C,

Volume of mercury(V_m) $= V[1+\gamma_m \Delta\theta]$

$= 200[1+18\times10^{-5}\times 80]$

$\therefore V_m = 202.88 cm^3$

Again, Volume of glass(V_g) $= V[1+\gamma_g \Delta\theta] = V[1+3\alpha_g \Delta\theta]$

$= 200[1+3(0.4\times10^{-5})\times80]$

$= 200.2 cm^3$

Now, volume of mercury that overflows from vessel,

$= V_m - V_g$

$= \cancel{200}\ 202.88 - 200.2$

$= 2.68 cm^3$

Change in density of substance with change in temp.

Let m & V_1 be the mass & volume of a substance at θ_1°C.

Density of a substance at θ_1°C.

$\rho_1 = \frac{m}{V_1}$ —— (I)

When the substance is heated to θ_2°C, volume increases to V_2, then density at θ_2°C,

$\rho_2 = \frac{m}{V_2}$

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& we have, $V_2 = V_1[1+\gamma\Delta\theta]$

or, $\rho_2 = \dfrac{m}{V_1(1+\gamma\Delta\theta)}$

or, $\rho_2 = \dfrac{\rho_1}{1+\gamma\Delta\theta}$

∴ Density of a substance decreases as temp ~~is~~ increases.

Q. The density of silver at 0°C is 103 10 kg/m³ & the coefficient of linear expansion is 0.000019 °C⁻¹. Calculate the density at 100°C.

Given,

$\rho_0 = 10310\ kg/m^3$

$\alpha_s = 0.000019\ °C^{-1}$

$\rho_{100} = ?$

We have, $\rho_{100} = \dfrac{\rho_0}{(1+\gamma_s\Delta\theta)}$

$= \dfrac{\rho_0}{1+3\alpha_s\Delta\theta}$

$= \dfrac{10310}{1+3\times0.000019\times100}$

$\therefore \rho_{100} = 10251.56\ kg/m^3$

Q. A copper vessel with a volume of exactly 100 m³ at a temp of 15°C is filled with glycerol. If the temp raises to 25°C, how much glycerol will split out?

$\gamma_g = 5.3\times10^{-4}\ k^{-1}$

$\alpha_c = 16.7\times10^{-6}\ k^{-1}$

Given,
Let V be the volume of copper vessel & glycerol at 15°c,
$V = 100 m^3$

At 25°c,
$V_g = V[1+\gamma_g \Delta\theta]$
$= 100[1+5.3\times10^{-4}\times10]$
$= 100.53 m^3$

Again, $V_c = V[1+\gamma_c\Delta\theta]$
$= 100[1+3\alpha_c\Delta\theta]$
$= 100[1+3\times16.7\times10^{-6}\times10]$
$= 100.05 m^3$

Now,
volume of glycerol that spill out $= V_g - V_c$
$= 100.53 - 100.05$
$= 0.48 m^3$

Part I: Pg: 295 to 29

9. Solids expand when their temperature is increased, wh
→ When solids are heated, the supplied energy is used to increase the internal energy of molecules. Due to the increase in internal energy, molecules vibrate more rapidly causing an increase intermolecular distance. This causes to expand solid when the temperature is increased.

12. Why is it sometimes possible to loosen caps on screw top bottles by dipping the cap briefly in hot water?
→ When the cap is dipped in hot water briefly, the cap gets expanded whereas, the screw remains as it were. Hence, it is possible to loosen the cap on screw-top bottles by dipping the ~~cap~~ briefly in hot water.

13. Why does a thick glass tumbler crack when boiling water is poured into it?

→ Glass is a bad conductor of heat. As hot water is poured into it, the inner part of the glass expands more quickly than the outer part. Therefore, there is unequal expansion between inner & outer layers, which causes a crack.

Part II:

12. Does the coefficient of linear expansion depend on length? Explain.

→ Coefficient of linear expansion is defined as the ratio of the increase in the length of a solid substance per degree rise in temperature to its original length. It is denoted by α & is given by

$$\alpha = \frac{l_2 - l_1}{l_1(\theta_2 - \theta_1)} = \frac{\Delta l}{l_1 \Delta\theta}$$, where Δl = change (or increase) in length, l_1 = original length & $\Delta\theta$ = change in temperature. The unit of α is K^{-1} or $°C^{-1}$ in the SI system.

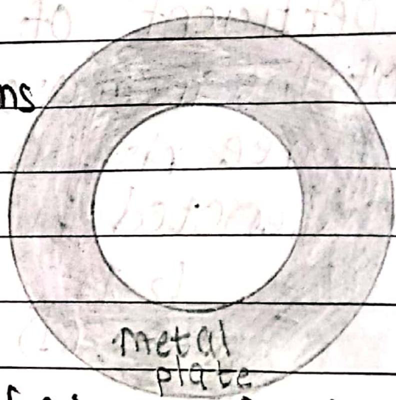
When the temperature of the substance is increased, its length is also increased so that the RHS value of the above equation is not changed. Thus, the coefficient of linear expansion doesn't depend on the length of the solid but depends on the nature of the material only.

9) Why does liquid have two types of cubical expansivities?

→ Since liquid needs a vessel to hold it, expansion of liquid always includes expansion of vessel. But, the expansion of solid is very small compared to that of liquid hence, expansion of vessel is hard to observe. If we neglect the expansion of the vessel, then we get the apparent expansion of the liquid. On the other hand, if we consider the expansion of the vessel, then we get the real expansion of the liquid. So, liquid has two types of cubical expansivities.

17. The circular metal plate has a concentric circular hole. If the plate is heated uniformly so that the outer circumference of the plate increases by 4%, then by what percentage the circumference of the hole will increase?

→ As the expansion of all dimensions of material depends upon the coefficient of linear expansion. For any material, the expansion of radius or circumference will take place in the same proportion whatever be its size. It means that for a uniformly heated plate if the outer circumference increases by 4%, the circumference of the hole will also increase by 4%. There should be uniform expansion within the plate. So, the percentage change would be the same for a similar dimension.



Anomalous Expansion of Water

When water is heated from 0°C to 4°C, volume of water decreases. And, volume of water increase only beyond 4°C. This unusual behaviour of water is known as Anomalous Expansion of water.

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12) No, the coefficient of linear expansion doesn't depend on length because as we know that $\alpha = \frac{\Delta l}{l \Delta \theta}$

where $\frac{\Delta l}{l}$ remains constant in every change in length. It generally depends on the nature of materials.

Note: Linear expansion depend on length.