Unit-I

Heat

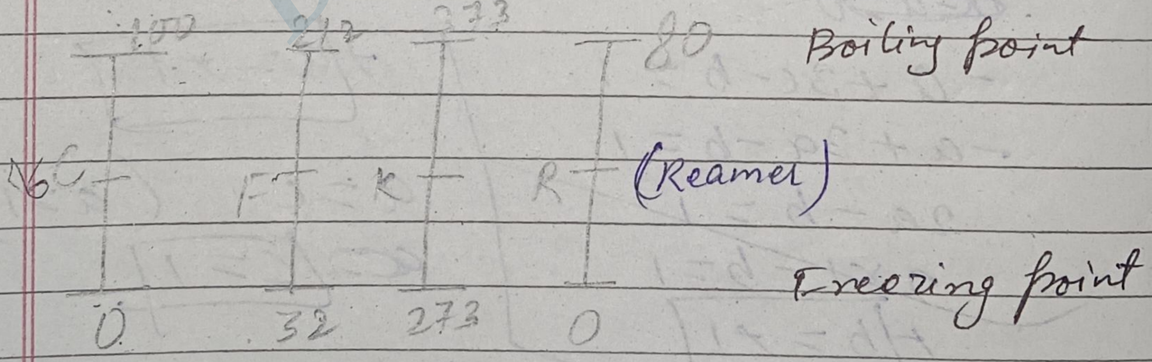
Heat is a form of energy that is transferred from one body to another due to temperature difference between two body.

Temperature :-

Temperature is a quantity which tells us the thermal state of a body (the degree of hotness or coldness of a body). It determines the direction of flow of heat when two bodies at different temperature are placed in contact.

C.G.S unit $\boxed{1J = 10^7 \text{ ergs}}$
S.I unit $\boxed{1 \text{ calorie} = 4.2 J}$

* Scales for temperature measurement



$$\frac{t_C - 0}{\cancel{100} - 0} =$$

$$\frac{t_C - 0}{100 - 0} = \frac{t_F - 32}{212 - 32} = \frac{t_K - 273}{373 - 273} = \frac{t_R - 0}{80 - 0}$$

$$\frac{t_C}{100} = \frac{t_F - 32}{180} = \frac{t_K - 273}{100} = \frac{t_R}{80}$$

$$\frac{t_C}{5} = \frac{t_F - 32}{9} = \frac{t_K - 273}{80} = \frac{t_R}{40}$$

$F_p = \frac{N m^2}{A m^2}$

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$$\frac{t_C-0}{100-0}=\frac{t_F-32}{212-32}=\frac{t_K-273}{373-273}=\frac{t_R-0}{80-0}$$

or $$\frac{t_C}{100}=\frac{t_F-32}{180}=\frac{t_K-273}{100}=\frac{t_R}{80}$$

or $$\frac{t_C}{5}=\frac{t_F-32}{9}=\frac{t_K-273}{\cancel{100}5}=\frac{t_R}{4}$$ (divide by 20)

* Relation btw C and F

> $\frac{t_C}{5}=\frac{t_F-32}{9}$

> $t_C=\frac{(t_F-32)5}{9}$

> $\boxed{t_C=\frac{5(t_F-32)}{9}}$

~~Relation btw C and~~

> $\frac{t_F-32}{9}=\frac{t_C}{5}$

> $t_F-32=\frac{t_C}{5}\times 9$

> $\boxed{t_F=\frac{(t_C+32)9}{5}}$

* Relation between C to K

> $\frac{t_C}{5}=\frac{t_K-273}{\cancel{5}\,\cancel{20}}$

> $\boxed{t_C=t_K-273}$

> $\frac{t_K-273}{5}=\frac{t_C}{5}$

> $\boxed{t_K=t_C+273}$

* Relation between C and R (Reamer)

> $\frac{t_C}{5}=\frac{t_R}{4}$

> $\boxed{t_C=\frac{t_R\times 5}{4}}$

$\frac{t_C}{5}=\frac{t_R}{4}$

> $\boxed{t_R=\frac{t_C}{5}\times 4}$

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Q→ What temperature C and F are same.

Sol: $\frac{t_c}{5} = \frac{t_F - 32}{9}$ (Put t_c in place of t_F)

⇒ $\frac{t_c}{5} = \frac{t_c - 32}{9}$

⇒ $t_c = \frac{5t_c - 160}{9}$

⇒ $9t_c = 5t_c - 160$

⇒ $\cancel{4}t_c = \frac{-160}{40}$

$t_c = -40°$

So, The temperature of -40 will be same in C and F.

Modes of Heat

Heat may be transfer from one point to another in 3 different modes.

i) Conduction :- It is the process by which heat flows the hot end to the cold end of the solid body without being any net movement of the particles of the body.

- Good conductor :- The substances which allow heat to pass through them faster are called good conductor of heat. E.g:- metals.
- Bad conductor :- The substances which do not allow heat to pass through them easily

vacuum = 15 lakh km

are called bad conductor of heat.
E.g:- Non-metals, Glass, mercury etc.

ii). Convection:- The process by which heat is transmitted through a substance from one point to another due to the actual bodily movement of the heated particles of the substance is called convection.

- In liquid and gases heat is transmitted by convection because their molecules are quite free to move.

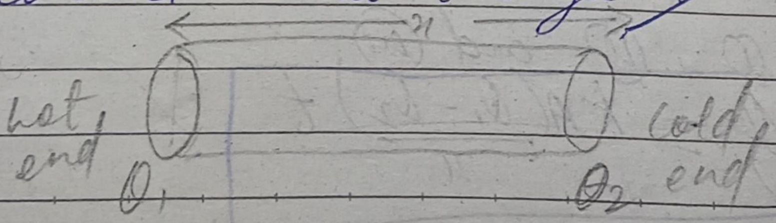
iii) Radiation:- The transfer of heat from one place to another in a straight line with the speed of light without heating the intervening medium is called radiation. (without any medium)

→ Electromagnetic waves or radiation.

Thermal Conductivity

Thermal conductivity of a solid is a measure of the ability of the solid to conduct heat through it.

⇒ The greater the thermal conductivity of a solid the greater its ability to conduct heat through it.



The fall of temperature with distance between the ends of the rod in the direction of flow of heat is called temperature gradient.

$$\boxed{\text{Temp. gradient} = \frac{\theta_1 - \theta_2}{x}}$$ (angle) distance

* coefficient of thermal conductivity. (K)

consider a cube of ~~heat~~ side 'x' and heat phases of crossection area is suppose its opposite forces are maintained at temp θ_1 and θ_2 where $\theta_1 > \theta_2$ and experiment shows under steady condition the quantity of heat ~~cube~~ Q that flows from hot phase to cold phase is:-

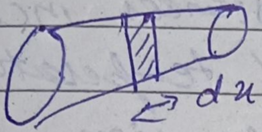
(i) $Q \propto \frac{1}{x}$ (Thickness)
(ii) $Q \propto A$ (crossection Area) —— (i)
(iii) $Q \propto \frac{\theta_1 - \theta_2}{x}$ (temp gradient) —— (ii)
(iv) $Q \propto t$ (time) —— (iii)

from (i), (ii) and (iii)

$$\boxed{Q = KA\left(\frac{\theta_1 - \theta_2}{x}\right)t}$$

$$\boxed{K = \frac{Q x}{A(\theta_1 - \theta_2) t}}$$, coeff. of thermal conductivity

$$K = \frac{J\, m}{m^2\, K\, s}$$



$$K = \boxed{J\, m^{-1} s^{-1} K^{-1}}$$

$$\boxed{\frac{dQ}{dt} = \frac{K A\, dT}{dx}}$$

when, $A = 1$ sq. unit, $\Delta T = 1$ unit, $t = 1$ unit,
$x = 1$ unit
then, $\boxed{K = Q}$

Examples of different modes of heat

①. Conduction:- Heat transfer through the passing of particles from one to another.

E.g. i). Holding a hot cup of coffee
ii). A metal spoon in a hot cup of soup.
iii). A building's Foundation, the heat from the earth is transferred to the building.

②. Convection:- The ~~movent o~~ actual movement of the particles from one place to another. the heat is transferred in all parts of object

Three types of Thermal Expansion:-

1. Linear — Denoted by 'α'
2. Superficial — Denoted by 'β'
3. Cubical — Denoted by 'γ' γ

The dimensions of the substances increases due to the increasing of temperature is known as <u>thermal expansion</u>.

i). <u>Linear Expansion</u>:- If the ~~kee~~ length of the substances increases due to increases of temperature is known as <u>linear expansion</u>.

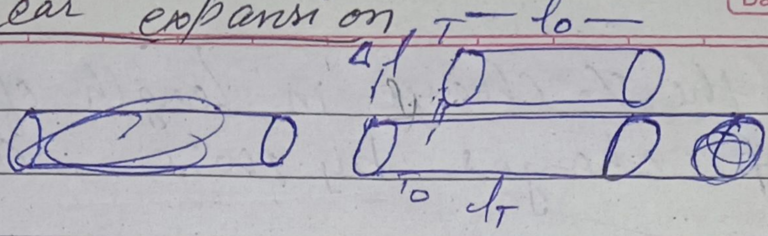
- It generally occurs in <u>solid</u> material.

ii). <u>Superficial or aerial expansion</u>:- When the area of a 2-D substances increases due to increasing of temperature is known as <u>aerial expansion</u>.

iii). <u>Cubical or volumetric Expansion</u>:- If the volume of the substances increases due to increases in temp. is known as <u>cubical expansion</u>.

- It generally occurs in <u>liquid</u> and gaseous materials.

* Linear expansion



$\Delta l = l_T - l_0$ (change in length), $\Delta T = T - T_0$ (Change in temperature)

⇒ $\frac{\Delta l}{l_0} \propto \Delta T \Rightarrow \frac{\Delta l}{l_0} = \alpha \Delta T$

→ Coefficient of linear expansion (α).

$$\boxed{\alpha = \frac{\Delta l}{l_0 \Delta T}}$$

when, $l_0 = 1m$, $\Delta T = 1°C$

then,

$$\alpha = \frac{\cancel{1m}}{\cancel{1m}\, 1°C} = C^{-1}$$

S.I unit of α is $1/°C$ or $°C^{-1}$

⇒ $\frac{\Delta l}{l_0} = \alpha \Delta T$, l_0 → original length

l_T → ~~change~~ New length.

Δl_0 → change in length

ΔT → change in temperature.

⇒ $\frac{l_T - l_0}{l_0} = \alpha \Delta T$

⇒ $l_T - l_0 = l_0 \alpha \Delta T$

⇒ $l_T = l_0 \alpha \Delta T + l_0$

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

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Q1 What the % change in length of 1m iron rod if temp. changes by 100°C, $\alpha = 2\times10^{-5}/°C$

Sol $\frac{l_0}{l_T} = \alpha\Delta T$

⇒ $\frac{l_0}{l_T} = 2\times10^{-5}\times100$

$= 2\times10^{-3}$

Now,

$\% \frac{l_0}{l_T} = 2\times10^{-3}\times100$

$= 2\times10^{-1} = 0.2\%$ Ans

Q→ A concrete slab of length 10 m at 0°C. Find its length at 35°C. It's α $1\times10^{-5}/°C$

Sol $l_0 = 10m$ (original length), $T_0 = 0°C$

$l_T = ?$ $T = 35°$

⇒ $l_T = l_0(1+\alpha\Delta T)$

⇒ $l_T = 10[1+10^{-5}\times(35-0)]$

⇒ $l_T = 10[1+10^{-5}\times35]$

⇒ $l_T = 10\times1.00035$

⇒ $\boxed{l_T = 10.0035}$ m Ans

$\alpha = \frac{\Delta l}{l_0\Delta T}$

$1\times10^{-5} = \frac{\Delta l}{10\times35}$ ✓

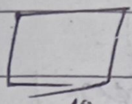
$\Delta l = 350\times10^{-5}$

$= 35\times10^{-4}$

$(l_0\Delta T)\alpha = l_T - l_0$

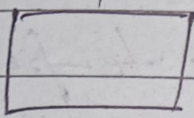
$\boxed{l_0(1+\alpha\Delta T) = l_T}$

②. Aerial or Superficial Expansion



A_0, T_0 (Original dimension)

↓ By increasing temperature



A_T, T (New dimension)

$\Rightarrow \Delta A = A_T - A_0$

$\Rightarrow \Delta T = T - T_0$

So,

$\Rightarrow \frac{\Delta A}{A_0} \propto \Delta T$

$\Rightarrow \boxed{\frac{\Delta A}{A_0} = \beta \Delta T}$

A_T = New area
A_0 = Original area
ΔA = Change in area
T_0 = Original temperature
T = New temperature
ΔT = Change in temperature

$\beta \rightarrow$ coefficient of areal expansion.

$\Rightarrow \beta = \frac{\Delta A}{A_0 \Delta T} = \frac{m^2}{m^2\,^\circ C} = /^\circ C$ or $^\circ C^{-1}$

$\Rightarrow$ when, $A_0 = 1\,m^2$, $\Delta T = 1^\circ C$

then, $\beta = \Delta A$.

So,

The S.I unit of β is $\underline{^\circ C^{-1}}$ $\underline{or /^\circ C}$ ($^\circ K^{-1}$ or $/^\circ K$)

Now,

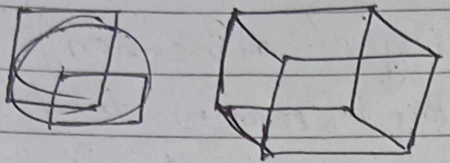
$\Rightarrow \frac{\Delta A}{A_0} = \beta \Delta T$

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

$\Rightarrow A_T - A_0 = A_0 \beta \Delta T$

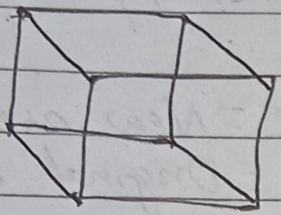
$\Rightarrow \boxed{A_T = A_0(\beta \Delta T + 1)}$ ✱

⑧. Volumetric Expansion



V_0, (volume)
T_0 (Temperature)

After increasing temperature



V_T, T (temperature)
(volume)

$\Delta V = V_T - V_0$

$\Delta T = T - T_0$

So,

$\Rightarrow \frac{\Delta V}{V_0} \propto \Delta T$

$\Rightarrow \frac{\Delta V}{V_0} = \gamma \Delta T$

ΔV = Change in volume
V_0 = Original volume
V_T = New volume
ΔT = Change in temperature
T_0 = Original temperature
T = New temperature

Coefficient of volumetric expansion is γ (gamma)

$\Rightarrow \boxed{\Delta V = V_0 \gamma \Delta T}$ $\boxed{\gamma = \frac{\Delta V}{V_0 \Delta T}}$

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

when, $V_0 = 1 m^3$, $\Delta T = 1°C$ (by applying)

$\boxed{\gamma = \Delta V}$

So,

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

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

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

$\alpha : \beta : \gamma = 1 : 2 : 3.$

Q→ The value of co-efficient of volume expansion of glycerine is $5\times10^{-4}\,K^{-1}$. The fractional change in the density of glycerene for a rise of 40°C is

Sol→ γ (coefficient of vol. expansion) $= 5\times10^{-4}\,K^{-1}$

$\Delta T = 40°C$ (~~40~~ or $40\,K$ (change in temp).

Now,

we know, ⇒ $\rho = \frac{m}{V} \Rightarrow V = \frac{m}{\rho}$

⇒ $\frac{\Delta\rho}{\rho_0} = \frac{\rho_0 - \rho_T}{\rho_0}$ $\left(\frac{\text{Initial density} - \text{final density}}{\text{Initial density}}\right)$

⇒ $\frac{\Delta\rho}{\rho_0} = \frac{\frac{m}{V_0} - \frac{m}{V_T}}{\frac{m}{V_0}}$

$= \frac{\cancel{m}\left(\frac{V_T - V_0}{V_T V_0}\right)}{\frac{\cancel{m}}{\cancel{V_0}}}$

$= \cancel{\frac{V_T}{V_T}} - \frac{V_0}{V_T}$

$\frac{\Delta\rho}{\rho_0} = 1 - \frac{V_0}{V_T}$

$\frac{\Delta\rho}{\rho_0} = 1 - \frac{V_0}{V_0(1+\gamma\Delta T)}$

$= \frac{\cancel{V_0}(1+\gamma\Delta T) - \cancel{V_0}1}{1+\gamma\Delta T}$

$= \frac{5\times10^{-4}\times40}{1+5\times10^{-4}\times40}$

$= \frac{200\times10^{-4}}{1+200\times10^{-4}}$

$= \frac{0.02}{1.02}$

$\boxed{\frac{\Delta\rho}{\rho_0} \approxeq 0.002}$ Ans

~~#~~ Relation between coefficient of linear expansion (α), Aerial expansion (β) and volumetric expansion (γ).

$l_T = l_0(1+\alpha\Delta T)$

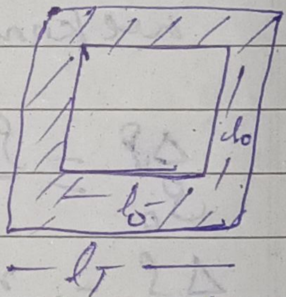
~~A_0~~ $A_T = A_0(1+\beta\Delta T)$

$V_T = V_0(1+\gamma\Delta T)$.

⇒ Relation between α and β.

If the ~~area~~ length of the square is replaced by 'l_0' then there area is '(l_0^2)'.

So,



⇒ $A_T = A_0(1+\beta\Delta T)$

⇒ $l_T^2 = l_0^2(1+\beta\Delta T)$

⇒ $[l_0(1+\alpha\Delta T)]^2 = l_0^2(1+\beta\Delta T)$

⇒ $\cancel{l_0^2}(1+\alpha\Delta T)^2 = \cancel{l_0^2}(1+\beta\Delta T)$

$\alpha = 2\times10^{-5}$

⇒ $1+\underline{\alpha^2\Delta T^2}+2\alpha\Delta T = 1+\beta\Delta T$

{The value of alpha is very small. So, it is neglected.}

⇒ $\cancel{1}+2\alpha\cancel{\Delta T} = \cancel{1}+\beta\cancel{\Delta T}$

⇒ $\boxed{2\alpha = \beta}$ ⇒ ~~α~~ $\boxed{\alpha = \frac{\beta}{2}}$ ——— ①

⇒ Relation between α and γ

Similarly, ~~If~~ Let the side of the of the cube is 'l_0' then their volume is 'l_0^3'.

Original volume = l_0^3

~~Or~~ New volume = l_T^3

$\gamma = 3\alpha \quad (2\alpha = \beta)$

$\gamma = 2\alpha + \alpha$

$\boxed{\gamma = \beta + \alpha}$

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

$\Rightarrow l_T^3 = l_0^3(1 + \gamma \Delta T)$

$\Rightarrow \{l_0(1 + \alpha \Delta T)\}^3 = l_0^3(1 + \gamma \Delta T)$

$\Rightarrow$

$\cancel{l_0^3}(1 + \alpha \Delta T)^3 = \cancel{l_0^3}(1 + \gamma \Delta T)$

$\Rightarrow \cancel{1} + 3\alpha \Delta T + \underline{3\alpha^2 \Delta T^2} + \underline{\alpha^3 \Delta T^3} = \cancel{1} + \gamma \Delta T$

$\Rightarrow$

$\Rightarrow 3\alpha \cancel{\Delta T} = \gamma \cancel{\Delta T}$

{ α^2 and α^3 have very small value so, it is neglected.

$\Rightarrow$

$\boxed{\gamma = 3\alpha}$, $\boxed{\alpha = \frac{\gamma}{3}}$ —— (II)

so,

from (I) and (II)

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

$\Rightarrow \boxed{\alpha : \beta : \gamma = 1 : 2 : 3}$

Q→ A circular hole of radius 1 cm in a brass sheet is kept at 293K. What will be the diameter of this hole when the sheet is heated to 393K coefficient of linear expansion (α) is 20×10^{-6} · centigrates.

Sol $\Delta T = 393 - 293 = 100K$

~~$\Delta A = A$. Area of hole $= \pi r^2$~~
~~$= \frac{22}{7} cm^2$~~

$\alpha = 20\times10^{-6}$ centrigrates

$\Rightarrow l_f = l_0(1+\alpha\Delta T)$
$\Rightarrow l_f = 1(1 + 20\times10^{-6}\times100)$
$\Rightarrow l_f = 1 + \frac{2}{1000}$
$\Rightarrow l_f = \frac{1002}{1000} = 1.002$ cm

Now, radius $= 1.002$ cm

$d = 2\times1.002 cm = \boxed{2.004 cm}$ Ans

Q→ A sheet of brass is 40cm long, 8 cm broad at 0° Centrigate. If the surface area at 100°C is $320.1 cm^2$ find the coeffieor of ~~linear~~ aerial expansion

$A_0 = 320\ cm^2$

$A_T = 320.1\ cm^2$

for brass.

$\Delta A = A_T - A_0$

$= 320.1 - 320$

$\Delta A = 0.1\ cm^2$

Sol Area = l × b

$A_0 = 40 \times 8 = 320 cm^2$

, $\Delta T = 100°C$

$\Rightarrow \frac{\Delta A}{A_0} = \beta \Delta T$

$\Rightarrow \frac{0.1}{320 \times 100} = \beta \quad \left(\frac{\Delta A}{A_0 \Delta T} = \beta \right)$

$\Rightarrow \beta = \frac{1}{32 \times 10^4}$

$\Rightarrow \boxed{\beta = 0.03125 \times 10^{-4} \text{ Centrigates}}$

$\Rightarrow \beta = 3.125 \times 10^{-6}$ Centrigates

Now,

$\Rightarrow \alpha = \frac{\beta}{2}$

~~β~~ $\boxed{\alpha = \frac{3.125 \times 10^{-6}}{2}}$ °Centigrates

$\Rightarrow \alpha = 1.5625 \times 10^{-6}$

$\boxed{\alpha = 15.625 \times 10^{-7}}$ °C

$320\ cm^2$, $\Delta T = 100°C$

$\Delta A = 320.1 - 320$

$= 0.1 cm^2$

$\Rightarrow \beta = \frac{\Delta A}{A_0 \Delta T}$

$\beta = \frac{0.1}{320 \times 100}$

$V \propto T$ $P \propto \frac{1}{V}$

$\frac{V}{T} = C$ $PV = $ con

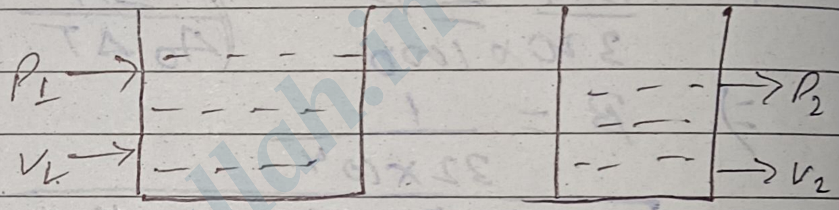
$\frac{PV}{c} = \frac{mRT}{c\,c}$

Boyle's Law

At ~~Cont~~ constant temperature, the pressure of a given mass of an ideal gas is inversely proportional to its volume.

$P \propto \frac{1}{V}$ at constant temp.

$P \cdot V = $ const. (k)



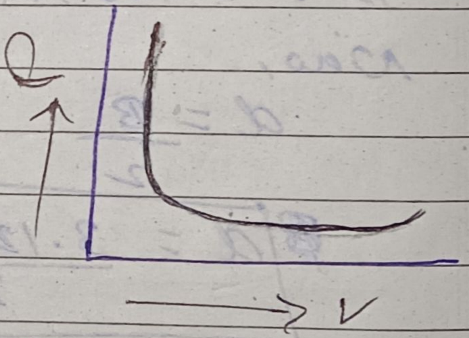
$P_1 V_1 = $ const. $P_2 \cdot V_2 = $ const.

so,

$$\boxed{P_1 \cdot V_1 = P_2 \cdot V_2 = \text{const.}}\ (k)$$

7 $PV = \frac{\cancel{m}}{c}\frac{\cancel{R}}{c}\frac{T}{c}$

-2 $$\boxed{P \cdot V = C}$$



Hyperbola

Charle's Law

At constant ~~temperature~~ Pressure, the volume of a given mass of an ideal gas is directly proportional to its temperature.

$V \propto T$

$$\boxed{\frac{V}{T} = \text{constant } (k)}$$

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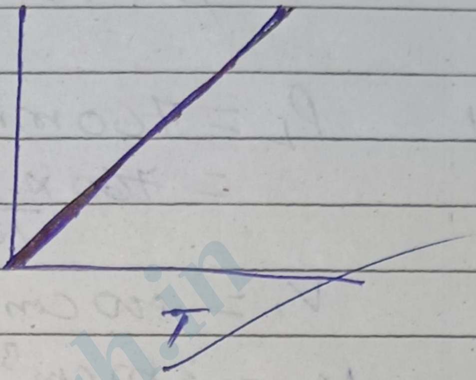
Ideal Gas equation

$$\boxed{\frac{PV}{T} = \text{constant}}$$

$$\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2} = \text{constant}}$$

$\Rightarrow$ $\underset{C}{P}\,V = \underset{C}{m}\,\underset{C}{R}\,T$

$\Rightarrow$ $\frac{V}{T} = C$



Gay-Lussac-Law

At constant volume, the pressure of a given mass of an ideal gas is directly proportional to temperature.

$\uparrow P \propto T \uparrow$ at const. volume

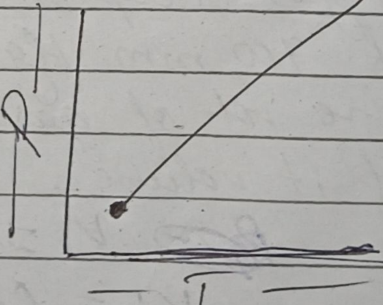
$\frac{P}{T}$ = const.

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ = const (K)

$P\,\underset{C}{V} = \underset{C}{m}\,\underset{C}{R}\,T$

$\Rightarrow$ $P = CT$

$\Rightarrow$ $\boxed{\frac{P}{T} = \text{const.}}$



$\frac{25}{100}$ 12.5 $\overset{2}{8}$ $800 \times \frac{\overset{2}{\cancel{760}}}{19} Hg = P_2 \times 3\cancel{80}$

12.5 $\cancel{600} \times \cancel{30} = \cancel{480} \times P$

$\underline{-5}$ 3   1 $160 = P_2$

7.5

600
$\underline{-120}$
480

Q→ A gas occupies 800 cm^3 under a pressure of 760 mm Hg. Find under what pressure the gas will occupy 380 cm^3 the temp. remains constant.

Sol→
$P_1 = 760 \text{ mm Hg}$
$= 760 \times \frac{1}{10} \text{ cm Hg} = 76 \text{ cm Hg}$

$V_1 = 800 \text{ cm}^3$

$V_2 = 380 \text{ cm}^3$, $P_2 = ?$

so,

$P_1 \cdot V_1 = P_2 \cdot V_2$

$76 \text{ cm Hg} \times 800 \text{ cm}^3 = P_2 \cdot 380$

$$P_2 = \frac{\cancel{76} \times 8\cancel{00} \text{ cm} \times \cancel{cm^3} \text{ Hg}}{3\cancel{80} \cancel{cm^3}}$$

$$\boxed{P_2 = 160 \text{ cm Hg}}$$ Ans

Q→ A gas occupies 600 cm^3 under a pressure of 700 mm Hg. Find under what pressure the vol. of gas will be reduced by 20% of it volume.

Sol→
$V_1 = 600 \text{ cm}^3$, $P_1 = 700 \text{ mm Hg}$

$V_2' = 600 - 20\% \text{ of } 600 \text{ cm}^3$

$= 600 - \frac{20}{\cancel{100}} \times 6\cancel{00}$

$= 600 - 120$

$V_2 = 480 \text{ cm}^3$

$P_2 = ?$

Now,

$$P_1 \cdot V_1 = P_2 \cdot V_2 = \text{const. temperature}$$

~~700mm Hg~~ :

$$7\cancel{0}\cancel{0} \times \frac{1}{\cancel{10}} \text{ cm Hg} \cdot 600 \text{ cm}^3 = P_2 \cdot 480 \text{ cm}^3$$

$$7\cancel{0} \times \overset{\cancel{600}\;25}{\cancel{600}} \text{ cm Hg} = P_2 \cdot \overset{\cancel{8}\;\;2}{\cancel{480}}$$

$$P_2 = \frac{25 \times 7}{2} \text{ cm Hg}$$

$$P_2 = 12.5 \times 7 \text{ cm Hg}$$

$$\boxed{P_2 = 87.5 \text{ cm Hg}}$$

Ideal Gas and Real Gas

①. IDEAL GASES

A hypothetical gas whose molecules occupy negligible space and have no force of attraction between their molecules, and which consequently obey the gas laws.

②. Real Gas

A real gas is a gas that doesn't behave like an ideal gas and have force of ~~attracte~~ attraction between their molecules and occupy space. A real gas is also known as non-ideal gas.

NOTE:- Any gas behave like real gas when pressure is low but temperature is high.

* Ideal Gas Equation

The ideal gas law, also called the general gas equations, the equation of state of a hypothetical ideal gas. It is a good approximation of the behaviour of many gases under many conditions, although it has several limitations

$-273.15°C$ let 0

$PV = mRT$ → char

$PV = nRT$

① $PV = nRT$

- P → Pressure
- V → volume
- n → No. of moles (amount of substances)
- R → Universal Gas constant ($8.314\ JK^{-1} mole^{-1}$)
- T → Temperature.

② $PV = mRT$

- P → Pressure
- V → volume of gas
- m → mass of the gases
- R → Characteristics of Gas constant
- T → Temperature.

① BT (Bahadur Tipu Sultan) — Boyles Law - Temp const
② CP (Chateshwar Pujara) — Charle's Law - Pressure const
③ GV (Gali-vali) — Gay's Law - Volume const.

Absolute zero Temperature

The temperature at which the molecular motion completely siezes On the Kelvin scale is called ~~abos~~ absolute zero temperature.

$$\boxed{0K = -273°C}$$

$Q \propto \Delta T$

$Q \propto m$

$$\boxed{Q = \overset{const.}{C} m \Delta T}$$

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

m = mass of gas.

Q = heat

ΔT = chnge in

Specific heat :- It is defined as the amount of heat required to increase a unit mass of a substance by unit temperature.

* Specific heat of gas

When a gas is heated there is an increase in volume as well as pressure in addition to rise in temperature. Therefere, gas has two specific heat.

i). Specific heat at constant volume (C_v)
ii). Specific heat at constant pressure (C_p)

Cp at constant volume

At constant volume, the amount of heat required to rise the temperature of 1gm of a gas to 1°C

- First Law of Thermodynamics

~~dQ~~

$$dQ = du + dw$$

heat — Internal work done — External work done

$$dQ = C_v dT$$

$$\boxed{C_v = \frac{dQ}{dT}}$$

$$C_v = \frac{Q}{m\Delta T} \Rightarrow C_v = \frac{dQ}{dT}$$

C_v = J/g°C units

Heat given to the system → +ve
Heat given by the system → -ve

2. C_p at Constant Pressure

At constant pressure, the amount of heat required to raise the temp. of 1gm of a gas to 1°C.

$$dQ = C_p\, dT$$

$$\boxed{C_p = \frac{dQ}{dT}}$$

- Relation between C_p and C_v

$$C_p\, dT = C_v\, dT + P\,dv$$
$$(C_p - C_v)\, dT = P\,dv$$
$$= (C_p - C_v)\, \cancel{dT} = R\, \cancel{dT}$$
$$= \boxed{(C_p - C_v) = R} \qquad C_p > C_v$$

$$C_v = \frac{f}{2} R$$

Molar

$$C_p = R + C_v$$
$$= R + \frac{f}{2} R$$
$$C_p = R\left(1 + \frac{f}{2}\right)$$

f = Degree of Freedom.

Monoatomic, Diatomic, Polyatomic
$f = 3$, $f = 5$, $f = 6$

- The ~~v~~ $(C_p - C_v)$ depends upon the atomicity of the elements.

$$\boxed{\gamma = \frac{C_p}{C_v}}$$

- Internal energy of ideal gas only depends upon temperature.

Isothermal and Adiabatic Changes

Isothermal changes	Adiabatic changes
1. Temperature is constant. ($dT = 0$)	1. Heat is constant.) ($dQ = 0$)
2. The system is thermally conducting to the surrounding.	2. The system is thermally insulated from surrounding.
3. The changes occur slowly in this process.	3. The changes occurs suddenly in this process.
4. The specific heat is infinite.	4. The specific heat is zero.
5. The internal energy will be constant.	5. The internal energy will be change.
6. Slope $= \frac{dp}{dv} = \frac{-P}{V}$	6. Slope $= \frac{dp}{dv} = -\gamma \frac{P}{V}$
7. The coefficient of Thermal Elasticity, $E_i = P$	7. The coefficient of adiabatic Elasticity is, $E_a = \gamma P$.
8. No change in the internal energy of the ~~process~~. system.	8. There is change in internal energy.
9. Eq. $PV = const.$	9. Eqn. $PV^{\gamma} = const.$

*# Isothermal Processes {Application of thermodynamics}

A thermodynamics process which takes place at constant temperature is called isothermal constant.

When a change in pressure and volume of a substance takes place but the temperature is constant, the changes is said to be isothermal changes.

$$dQ = du + dw$$

The internal energy of an ideal gas depends upon only on temperature. Since, temperature doesn't change in an isothermal, it means there will be no change in internal energy of the gas.

$$dQ = 0 + dW$$

$$\boxed{dQ = dW} \{Pdv\}$$

$$(dQ = Pdv)$$

* Isothermal expansion

When gas expands isothermally (dv is +ve then, dQ is also +ve). This means that isothermal expansion of gas and amount of heat equal to the workdone by the gas will have to be supplied from an external source in order to maintain constant temperature of the gas.

* ISOTHERMAL COMPRESSION

when gas is compressed isothermally (dv is -ve then dQ is also -ve). This means that isothermal compression of gas and amount of heat equal to the workdone by the gas must flow out of the gas if its temperature is not changed the heat depends to the heat reservoir.

Adiabatic Process

An adiabatic process is one which takes place in such a way that no heat enters or leaves the system during the process i.e, P, v and T change in the process.

$$dQ = du + dw \qquad | \quad Pv^{\gamma} = \text{const}$$

$$0 = du + dw$$

$$du = -dw$$

$$C_v dT = -P dv$$

$$\boxed{C_v dT + P dv = 0}$$

* Adiabatic Expansion

When gas expands adiabatically (dv is +ve also dW is positive)..This means that change in internal energy :- $du = -dW$ negative change in internal energy means that ~~internal~~ the internal energy of the gas decreases and temperature of the gas falls.

* Adiabatic Compression

When gas compressed adiabatically

Thus, when the gas compressed adiabatically it gain internal energy equal to the workdone on the gas and temperature of gas rises.