1. UNITS AND DIMENSIONS

① UNIT :- Unit is a standard to measure any physical quantity.

② physical quantity :- The quantity which can be measured is called physical quantity.

⇒ physical quantities can be measured in four systems they are ① C.G.S
② M.K.S
③ F.P.S &
④ S.I.

⇒ Units are two type
- fundamental units
  eg:- ~~t~~, m, ~~time~~
  meter, kg, sec
- Derived units
  eg:- N, J, watts.

⇒ physical quantities are 2 types
- fundamental
  eg:- Length, mass time
- Derived.
  Eg:- force, power energy.

⇒ Magnitude of physical quantity = numerical value × unit

→ nu = constant ⇒ $\boxed{n \propto \frac{1}{u}}$

* $\boxed{n_1u_1 = n_2u_2}$ eg = 1kg = 1000 gm.

⇒ SYSTEM INTERNATIONAL

⇒ fundamental.	unit	symbol
① Mass	Kilogram	kg
② Length	Meter	m
③ Time	second	s
④ electric current	ampere	A
⑤ Temperature	kelvin	k
⑥ Quantity of substance	Mole	mole
⑦ Luminious intensity	candela	cd.

⇒ Supplementary [Dimension less]

① plane angle	radian	rad
② solid angle	steradian	sr.

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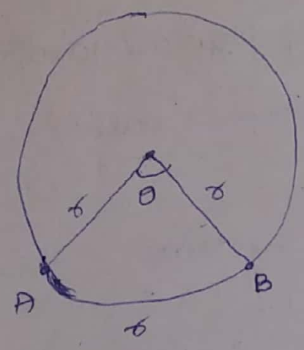
⇒ radian

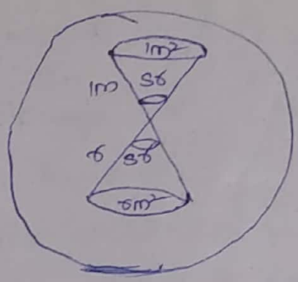


2π radians $= 360°$

$1 \text{ rad} = \frac{360}{2\pi}$

$1 \text{ rad} = 57° 18'$

⇒ steradian



surface area of sphere $= 4\pi r^2$

1 sphere $= 4\pi$ Sr.

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* UNITS OF Lengths :-

1 light year $= 9.5 \times 10^{15}$ m

1 par sec (parallel sec) $=$ 3.26 light years

1 Astronomical unit $= 1.49 \times 10^{11}$ m

1 micron $= 10^{-6}$ m

1 nanometer $= 10^{-9}$ m

1 Angstron unit $= 10^{-10}$ m

X ray unit $= 10^{-13}$ m

1 fermi $= 10^{-15}$ m.

1 mm $= 10^{-3}$ m

1 cm $= 10^{-2}$ m

1 m $= 10^{-3}$ Km

1 inch $=$ 2.54 cm.

1 ft $=$ 12 inch $=$ 30.4 cm

1 Yard $=$ 3 ft $=$ 0.91 m

1 mile $=$ 1.6 Km

$1 \frac{\text{km}}{\text{hr}} = \frac{1000 \text{ m}}{3600} = \frac{5}{18}$ m/s

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⇒ DIMENSIONAL FORMULA :

This is an equation which shows the relation among the fundametal physical quantities and a derived physical quantities.

⇒ Dimensions :
The powers of the fundamental physical quantities in a dimensional formula are called dimensions

⇒ DIMENSIONAL FORMULA :

		formula	units
① Area.	$L \times L$	L^2	m^2
② volume	$L \times L \times L$	L^3	m^3
③ Density $= d = \frac{M}{V}$	$\frac{M^1}{L^3}$	M^1L^{-3}	$Kg\,m^{-3}$
④ velocity, speed $V = \frac{S}{t}$	$\frac{L^1}{T^1}$	L^1T^{-1}	$m s^{-1}$
⑤ Acceleration, Intensity of gravitational field $\left[\frac{F}{m}\right]$ $a = g = \frac{v}{t} = \frac{L^1T^{-1}}{T^1}$ $\left[E = \frac{F}{m} = \frac{W}{m} = \frac{mg}{m} = g\right]$		L^1T^{-2}	$m.s^{-2}$ $N.kg^{-1}$
⑥ Force, weight, Tension $F = ma = M^1 \times L^1T^{-2}$		$M^1L^1T^{-2}$	Newton
⑦ work, energy, Torque $W = F.S = ML^1T^{-2} \times L^1$		ML^2T^{-2}	Joules N-m
⑧ Power $= \frac{\text{Workdone}}{\text{time taken}} = \frac{M^1L^2T^{-2}}{T^1}$		$M^1L^2T^{-3}$	watt

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⑨ Pressure, stress, elastic modulus

$P = \frac{F}{A} = \frac{M^1L^1T^{-2}}{L^2}$ — $M^1L^{-1}T^{-2}$ | Pascal

⑩ Momentum, Impulse $[F \times t]$ ☆

$P = mv = M^1 \times L^1T^{-1}$ — $M^1L^1T^{-1}$ | $kg\,m\,s^{-1}$, $N\text{-}s^{-1}$

⑪ Gravitational constant $[G]$ ☆

$F = G.\frac{m_1m_2}{d^2} \Rightarrow G = \frac{Fd^2}{m_1m_2} = \frac{M^1L^1T^{-2}L^2}{M^2}$ — $M^{-1}L^3T^{-2}$ | $NM^2\,kg^{-2}$

$$\left[G = 6.6 \times 10^{-11}\ N\text{-}m^2\right]$$

⑫ Angular velocity, frequency ☆

$\omega = \frac{\theta}{t}$ $\quad V = r\omega \Rightarrow \omega = \frac{V}{r} = \frac{L^1T^{-1}}{L^1}$ — T^{-1} | $rad\,s^{-1}$, hertz

⑬ Angular acceleration ☆

$\alpha = \frac{\omega}{t} = \frac{T^{-1}}{T^1}$ — T^{-2} | $rad\,s^{-2}$

⑭ Angular momentum, Planks Constant $[E = h\nu]$ ☆

$L = mvr = \frac{nh}{2\pi} = M^1L^1T^{-1} \times L^1 =$ — $M^1L^2T^{-1}$ | $kg\,m^2s^{-1}$, $J.S$

$$\left[h = 6.625 \times 10^{-34}\ J.S\right]$$

⑮ Moment of Inertia

$I = MR^2 = M^1 \times L^2$ — M^1L^2 | $kg\,m^2$

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$L^{1}T^{-2}$ | Pascal

T^{-1} | $kg\,m\,s^{-1}$

$N\text{-}s^{-1}$

$NM^2\,kg^{-2}$

rad s^{-1}

hertz

rad s^{-2}

$kg\,m^2 s^{-1}$

J.s

$kg\,m^2$

(16) surface Tension, force constant

$$T = \frac{F}{L} = \frac{M^1L^1T^{-2}}{L^1}$$ M^1T^{-2} | Nm^{-1}

(17) co-efficient of viscosity (η)

$$F = \eta A \frac{dv}{dx} \Rightarrow \eta = \frac{F}{A}\frac{dx}{dv} = \frac{M^1L^1T^{-2}}{L^2L^1T^{-1}}$$ $M^1L^{-1}T^{-1}$ | Pa.s

=10 poise

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★

(24) Magnetic pole strength (m) — I^1L^1 — A-m

★

(25) Magnetic moment (M) — I^1L^2 — $A \cdot m^2$

$M = m \times 2l \Rightarrow I^1L^1 \times L^1$

(26) Magnetic induction (B) — $M^1T^{-2}I^{-1}$ — Tesla

$B = \frac{\Phi}{A}$, $F = BIl \Rightarrow B = \frac{F}{Il} = \frac{M^1L^1T^{-2}}{I^1L^1}$

(27) Magnetic flux (ϕ) — $M^1L^2T^{-2}I^{-1}$ — weber

$\phi = BA = M^1T^{-2}I^{-1} \times L^2$

(28) Magnetic permiability (μ) — $M^1L^1T^{-2}I^{-2}$ — henry m^{-1}

$F = \frac{\mu}{2\pi} \frac{m_1m_2}{d^2} \Rightarrow \mu = \frac{Fd^2}{m_1m_2} \Rightarrow \frac{M^1L^1T^{-2}L^2}{I^2L^2}$

(29) ~~Mag~~

Intensity of magnetic field [H] — $I^{1}L^{-1}$ — $A \cdot m^{-1}$

$\mu = \frac{B}{H} \Rightarrow H = \frac{B}{\mu} \Rightarrow \frac{M^1T^{-2}I^{-1}}{M^1L^1T^{-2}I^{-2}}$

(30) Electric current — I^1 — Ampere

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(31) Electric charge

$q = It$ $\quad I^1 T^1$ | coloumb

(32) Electric potential, emf

$V = \frac{W}{q} = \frac{M^1 L^2 T^{-2}}{I^1 T^1}$ $\quad M^1 L^2 T^{-3} I^{-1}$ | volt

(33) Electric resistance (R)

$V = IR \Rightarrow R = \frac{V}{I} \Rightarrow \frac{M^1 L^2 T^{-3} I^{-1}}{I^1}$ $\quad M^1 L^2 T^{-3} I^{-2}$ | ohm

* (34) Conductance (G)

$G = \frac{1}{R} = \frac{1}{M^1 L^2 T^{-3} I^{-2}}$ $\quad M^{-1} L^{-2} T^3 I^2$ | mho

(35) Specific resistance (Resistivity).

$R = \rho \frac{l}{A} \Rightarrow \rho = \frac{RA}{l} \Rightarrow \frac{M^1 L^2 T^{-3} I^{-2} \times L^2}{L^1} = M^1 L^3 T^{-3} I^{-2}$ | ohm-m

(36) Conductivity (σ)

$\sigma = \frac{1}{\rho} = \frac{1}{M^1 L^3 T^{-3} I^{-2}}$ $\quad M^{-1} L^{-3} T^3 I^2$ | mho-m

(37) Capacitance

$C = \frac{q}{V} = \frac{I^1 T^1}{M^1 L^2 T^{-3} I^{-1}}$ $\quad M^{-1} L^{-2} T^4 I^2$ | farad

(38) electric permitivity (ε)

$\varepsilon = \frac{1}{4\pi\varepsilon} \frac{q_1 q_2}{d^2} = \varepsilon = \frac{q_1 q_2}{Fd^2} = \frac{I^2 T^2}{M^1 L^1 T^{-2} L^2}$

$M^{-1} L^{-3} T^4 I^2$ | farad m^{-1}

(39)

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Uses of dimensional formula :-

① To convert one system of units into another system.

$$\boxed{n_1 u_1 = n_2 u_2}$$

Ex:- 1 Newton = ? dyne

$$1\left[kg \cdot \frac{m}{s^2}\right] = n_2\left[gm \frac{cm}{s^2}\right]$$

$$1\left[1000gm \ \frac{100cm}{s^2}\right] = n_2\left[\frac{gm\ cm}{s^2}\right] \Rightarrow n_2 = 10^5$$

1 Newton = 10^5 dyne

② To verify the correctness of the given equation

[Rule of homoginity]

[all terms in the equation must have same dimensions]

Eq.① :- $s = ut + \frac{1}{2}at^2$

$$L^1 = L^1T^{-1}T^1 + LT^{-2}T^2$$

$$L^1 = L^1 + L^1$$

Eq ② :- $s_n = u + a\left(n - \frac{1}{2}\right)$

$$s_n = u = L^1T^{-1}$$

$$s_n = L^1T^{-1} + L^1T^{-2}T^1$$

$$s_n = L^1T^{-1} + L^1T^{-1}$$

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③ To express the possible relation among the physical quantities. [or derive the expression]

Ex :- for a simple pendulum

Time period

$T \propto L$ [length]

$T \propto m$ (mass)

$T \propto g$ [gravity]

$\rightarrow T \propto L^a m^b g^c$

$T = K L^a m^b g^c$

$M^0 L^0 T^1 = K m^b L^a g^c$

$= K [L^1]^a [M^1]^b [L^1 T^{-2}]^c$

$M^0 L^0 T^1 =$

* Limitations of dimensional methods :-

① Propotionality constants cannot be determined

② Trignometrical functions cannot be determined

③ when an equation is the sum of the terms that equation cannot be derived.

④ when equation contains more than '3' fundamental physical quantities that equation cannot be derived.

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Problems:-

① The units of M, L, T are doubled then the unit of pressure changes by $\frac{1}{4}$

$P_1 = M^1 L^1 T^{-2}$

$P_2 = (2M)(2L)(2T)^{-2}$

$P_2 = 2^1 \times 2^1 \times 2^{-2} [M^1 L^1 T^{-2}]$

$P_2 = \frac{1}{4} P_1$

$\therefore \frac{1}{4}$ times

Q In the above problem power changes by no change

$P_1 = ML^2T^{-3}$

$P_2 = [2M][2L]^2[2T]^{-3}$

$= 2 \times 2^2 \times 2^{-3} [ML^2T^{-3}]$

$= \cancel{2^3} \times 2^{-3} \; MLT^{-3}$

$P_2 = P_1$

$\therefore$ No change.

Q In two systems the ratio of masses is 1:2 lengths are 2:3 times are 1:3 the ratio of pressures is ______

Sol

$M_1 : M_2 = 1:2$

$L_1 : L_2 = 2:3$

$T_1 : T_2 = 1:3$

$P = M^1 L^{-1} T^{-2}$

$P_1 : P_2 = \left[\frac{1}{2}\right]^1 \left[\frac{2}{3}\right]^{-1} \left[\frac{1}{3}\right]^{-2}$

$P_1 : P_2 = \frac{1}{2} \times \frac{3}{2} \times \frac{3^2}{1}$

$= \frac{27}{4}$

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Q In a system force, length, time are fundamental dimensional formula of mass is ______

$F = M L^1 T^{-2}$

$\frac{F}{L^1 T^{-2}} = M^1$

$F^1 L^{-1} T^2 = M$

$\therefore \quad M = F^1 L^{-1} T^{-2}$

Q In a system work, mass, length are fundametals the dimension formula of time.

$W = M L^2 T^{-2}$

$\frac{W}{M L^2} = T^{-2}$

$W M^{-1} L^{-2} = \frac{1}{T^2}$

$W^{-1} M^1 L^2 = T^2$

$T = \sqrt{W^{-1} M^1 L^2}$

$= W^{-\frac{1}{2}} M^{1/2} L^1$

Q In a system gravitational constant [G], planck's constant (h), velocity of light (c) are fundamentals. The dimensions of mass is ______

$G = M^{-1} L^3 T^{-2}$

$h = M^1 L^2 T^{-1}$

$c = L^1 T^{-1}$

$\frac{hc}{G} = \frac{M^1 L^2 T^{-1} \; L^1 T^{-1}}{M^{-1} L^3 T^{-2}}$

$\frac{hc}{G} = M^2$

$M = \sqrt{\frac{hc}{G}} = \frac{h^{1/2} c^{1/2}}{G^{1/2}}$

$\boxed{M = h^{1/2} c^{1/2} G^{-1/2}}$

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$M \propto G^a h^b c^a$.

$M^1 \propto [M^{-1}L^3T^{-2}]^a \cdot [M^1L^2T^{-1}]^b \cdot [L^1T^{-1}]^c$.

$M^1 \propto M^{-a+b} \; L^{3a+2b+c} \; T^{-2a-b-c}$

$-a+b=1$

$3a+2b+\cancel{c}=0$
$-2a-b-\cancel{c}=0$ } add

$a+b=0$
$-a+b=1$

$2b=1$.

$\boxed{b=\frac{1}{2}}$

$-a+\frac{1}{2}=1$

$\boxed{a=-\frac{1}{2}}$

$c=\frac{1}{2}$

$M = G^{-1/2} h^{1/2} c^{1/2}$

Q In a system unit of mass is 10gms, $l=10cm$, time 1min. , unit of force is ___

$F = M^1L^1T^{-2}$

$= (10)(10)(60)^{-2}$

$= 100 \times \frac{1}{60^2}$

$= \frac{100}{3600}$

$F = \frac{1}{36}$ dyne

Q In a system velocity of light $v=3\times10^8 m/s$ gravity $= 10m/s^2$, Pressure $= 10^5 N/m^2$ are fundamentals the units of MLT are ___

$g=\frac{v}{T} \Rightarrow T=\frac{v}{g}$

$v=\frac{L}{T} \Rightarrow L=v.T$

$P=\frac{F}{A} \Rightarrow P=\frac{m.g}{L^2} = M=\frac{PL^2}{g}$.

① $T = \frac{3\times10^7}{10}$

$T = 3\times10^7$ sec.

② $L = 3\times10^8 \times 3\times10^7$

$L = 9\times10^{15}$

③ $M = \frac{10^5 \times [9\times10^{15}]^2}{10}$

$= \frac{10^5 \times 81 \times 10^{30}}{10}$

$M = 81 \times 10^{34}$ ~~Kg~~ gms

Q. In a system a force is 10N. In another system mass is 10kg, length is 10m. Time is 5 sec. The force in that system is ____

$n_1u_1 = n_2u_2$

$10\left[kg \frac{m}{s^2}\right] = n_2\left[10kg \cdot \frac{10m}{5^2 s^2}\right]$

$10 = n_2 \frac{\cancel{100}\,4}{25}$

$\cancel{\boxed{0.5 = n_2}}$

$\boxed{n_2 = \frac{10}{4}\,2.5}$

$\boxed{n_2 = 2.5n_1}$

Q. $g = 980\ cm/s^2$, its value in Km/min^2 is ____

$n_1u_1 = n_2u_2$

$980\left[\frac{cm}{s^2}\right] = n_2\left[\frac{1000\times100cm}{60^2\times s^2}\right]$

$980 = n_2\left[\frac{10^5}{60\times60}\right]$

$980 = n_2 \frac{10^5}{3600}$

$36 \times 980 = n_2\, 10^3$

$n_2 = \frac{36\times98}{100}$

$n_2 = \frac{3528}{100}$

$= 35.28.$

Q $G = 6.67\times10^{-11}\ Nm^2/Kg^2$ its value in CGS is ____

CGS = $dyne\ cm^2/gm^2$

$= 6.67\times10^{-11}\times10^{5}\,dyne\ 10^{4}\,cm^2 / 10^{6}\,gm^2$

$= \dfrac{6.67\times10^{-11}\times10^{9}}{10^{6}}$

CGS $= 6.67\times10^{-8}\ dyne\,cm^2/gm^2$

Q velocity of particle is $V = At^2 + Bt + C$ where t is time the dimensions of ABC are. ______

$V = At^2$

$A = \dfrac{V}{t^2}$

$A = \dfrac{LT^{-1}}{T^2} \Rightarrow LT^{-3}$

$\boxed{A = LT^{-3}}$

$V = Bt$

$B = \dfrac{V}{t} = \dfrac{LT^{-1}}{T^1}$

$\boxed{B = L^1T^{-2}}$

$V = C$

$\boxed{C = L^1T^{-1}}$

Displacement of a particle is $S = \dfrac{a}{F} + \dfrac{b}{W} + \dfrac{c-d}{P}$ where F is force, W is work, P is power. dimensions of a, b, c, d is ____

$S = \dfrac{a}{F}$

$a = S.F$

$= L^1M^1L^1T^{-2}$

$= M^1L^2T^{-2}$

$S = \dfrac{b}{W}$

$b = S.W$

$= L^1ML^2T^{-2}$

$= M^1L^3T^{-2}$

$c-d = P.S$

$= M^1L^2T^{-3}.L^1$

$= M^1L^3T^{-3}$

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Q. Gas equation is $\left[P+\frac{a}{V^2}\right](V-b) = nRT$. where P is pressure V is volume. The dimensions of a & b are ______

$\frac{a}{V^2} = P \Rightarrow a = PV^2$

$a = M^1 L^{-1} T^{-2} [L^3]^2$

$\boxed{a = M^1 L^5 T^{-2}}$

$\boxed{b = V = L^3}$.

$\frac{a}{b} = \frac{M^1 L^5 T^{-2}}{L^3} = \boxed{M^1 L^2 T^{-2}}$

Q. velocity of a freely falling body from a height h is $V \propto g^a h^b$ then a & b are ______

$V \propto g^a h^b$

$LT^{-1} \propto [L^1 T^{-2}]^a [L]^b$

$LT^{-1} \propto L^{a+b} T^{-2a}$.

$T^{-1} = T^{-2a}$

$\boxed{a = \frac{1}{2}}$

$L^1 = L^{a+b}$

$a+b = 1$

$\frac{1}{2} + b = 1$

$b = 1 - \frac{1}{2}$

$= \frac{2-1}{2}$

$\boxed{b = \frac{1}{2}}$

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HEAT & T.D

Standard text book :- P.K Nag, Rajput, R.S Khurmi

ECET MARKS :- $\boxed{2-3}$

Every question - < 54 sec

- Notes
- Material
- previous
  - ECET
  - EAMCET

Ranker — $\boxed{\text{Short Notes}}$

HEAT

- energy (J.P Joule) unit : Joule
- ~~fluid~~ (L. calorie). unit : calorie

$\boxed{1\ cal = 4.2\ Joule}$

ENERGY

- Storage [dU] to internal energy
- Transit
  - Heat transfer [δQ]
  - work transfer [δW]

$$\therefore \boxed{\delta Q = dU + \delta W}$$

Diff eq for F.L.T.D.

$\boxed{\text{Heat energy = internal energy + work done}}$

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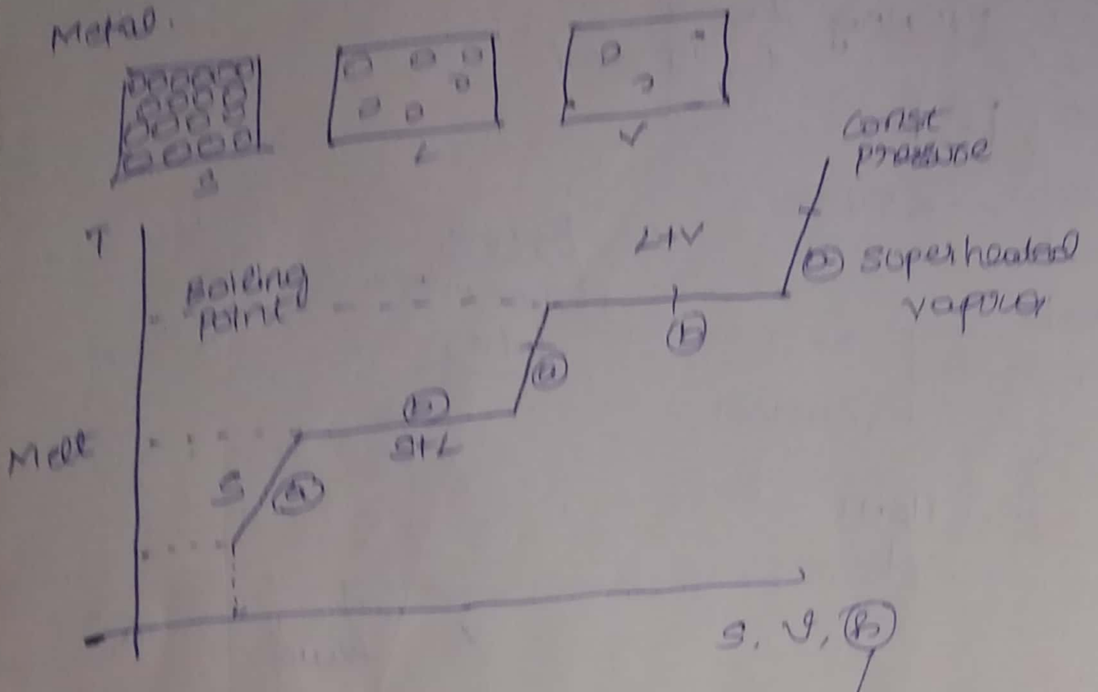
⇒ Phase Transformation Curves:-



Enthalpy :- Total heat energy.

→ Degree of hotness & coldness

⇒ Temp :- level of ~~K.E~~ $\boxed{\text{internal Kinetic energy}}$

⇒ entropy (S) :- Level of unstability in molecules when heat is supplied.

* Degree of disorders of molecules

(a) sensible heat → Temp changes → phase constant

(b) Latent heat → Temp const, phase changes

Internal energy :-

Internal Kinetic energy (UK)

→ Motion → $\boxed{\text{molecular collision}}$ ***

Friction → $\boxed{\text{Temp} \uparrow}$ ***

Internal potential (Up)

→ gap

→ $\boxed{\text{phase changes}}$

Note :- Temp change → sensible heat

Note :- Up is related with Latent heat

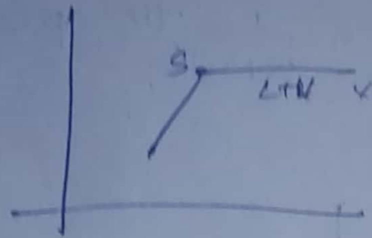
Q H_2O at latent 100°c, condition is

(a) Liq (sat liq)

(b) Liq + vapour (wet steam)

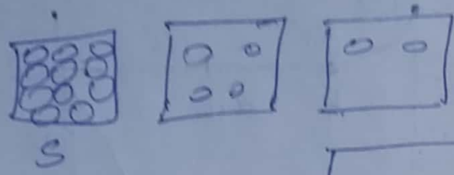
(c) vapour (sat vap)

(d) All ✓



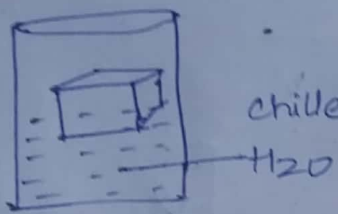
** entropy (S):-

$$\boxed{dS = \frac{dQ}{T}}$$ **



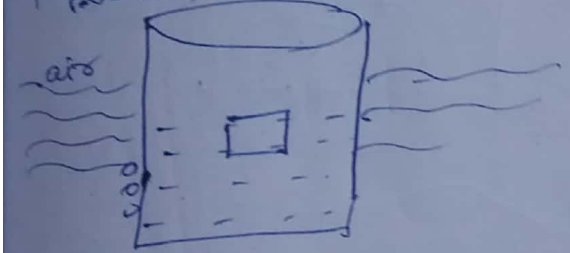
S_{gas} >
S_{liq} >
S_{solid}

system



ice cuble melts → S↑ system

* surrounding:-



→ condensing of H_2O from Air

vapour → liquid

$S_{surrounding}$ ↓

* ice melts in water
⇓
cooling
⇓
water temp ↓

Uk ↓

ECET :-

Q when ice cube melts in water then

system :- increases

Uk :- decreases

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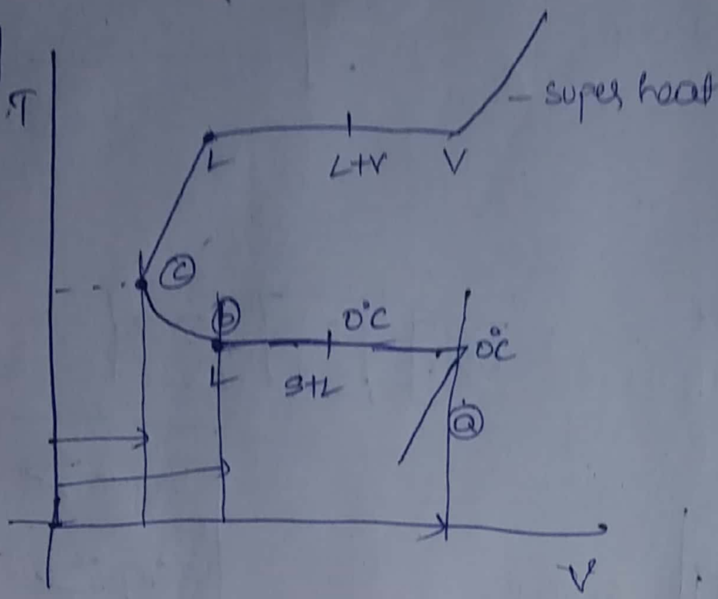
* Units of Temp: Kelvin

Kelvin = $\frac{1}{273.16}$ th part of $\boxed{\text{triple point of water}}$

$\boxed{\text{Water}}$



$\vartheta_c < \vartheta_b < \vartheta_a$

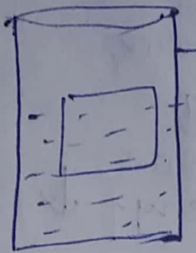
$d_c > d_b > d_a$

$d_{water\ 4°C} > d_{water\ 0°C} > d_{ice\ 0°C}$

$\vartheta = \frac{1}{\text{density}}$

$\vartheta = \frac{V}{m}$

$d = \frac{m}{V}$



$d_{ice} = 900\ kg/m^3$

$= 0.9\ gm/cm^3$

$0.9\ gm = 1cc$

$\boxed{1gm = 1.1cc}$
ice

$d_{water} = 1000\ \frac{kg}{m^3}$

$= 1\ gm/cm^3$

$\boxed{1gm = 1cc}$
water

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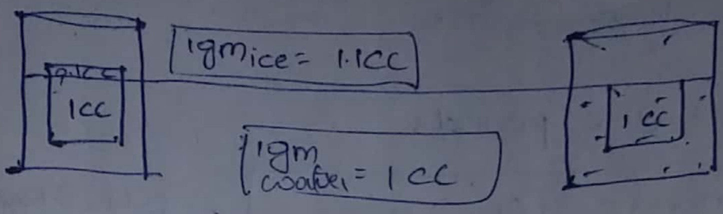
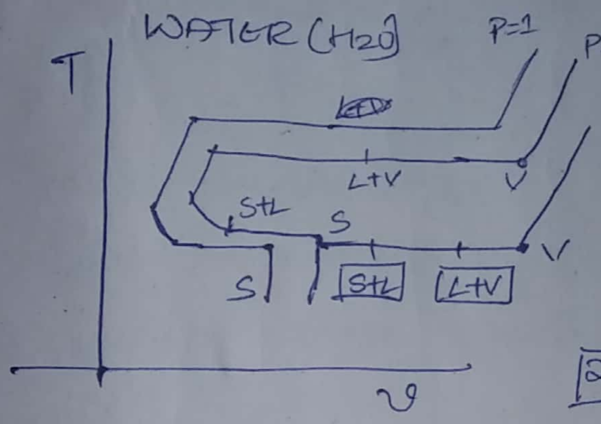


ECET:-

Q when ice cube floating in water melts then level of water of water remains same



0°C

$\boxed{273.16K}$

611 pa

0.00611 bar

Patmospheric:-

= 760mm of Hg

= 0.76 m of Hg.

= $\boxed{10.34 \text{ of } H_2O}$

= 101325 $\frac{N}{m^2}$ (or) Pa

= $1.01 \times \boxed{10^5 \frac{N}{m^2}}$ bar

= 1 bar

** = 14.5 psi

$\frac{\text{Pound}}{(\text{inch})^2} = \frac{14.5 \text{ lb}}{\text{inch}^2}$

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#Note: Mass units :- Kgs, Pounds

1 Kg = 2.2 pounds

$\boxed{1 \text{ pound} = 1 lb = 453 gm}$ = 0.453 Kg.

#Note: Gravitational unit of force

$\boxed{1F = 1 kgf = 1 kg = 9.81 N}$

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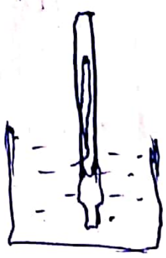
Zeroth Law of T.D Thermal equilibrium

↳ base for thermometry
(temp measurement)



$$\boxed{T_{Hg} = T_{bulb} = T_{H_2O}}$$

⇒ when two bodies are in Thermal equilibrium with third body then they are in equilibrium with eachother

⇒ Zeroth Law of thermodynamic is base for thermometry.

Types of Thermometers:-

① Liquid thermometer :- mercury, alchohal.

② constant volume gas themometer:-

⇒ $\frac{PV}{T} = C$

⇒ $P \propto T$

③ Thermo electric Thermometer

① Rapid change in temp

② Temp of small bodies (Insects).

NOTE:- Two dissimilar metals joined so that a potential difference generated between the point of contact is a measure of temperature difference between the points.

⇒ seebeck effect ↑

④ Magnetic thermometer:-

CURIS LAW:- Magnetic susceptibility is inversly propotional to temperature.

⇒ A magnet looses its properties as temperature increases

⇒ for iron temperature is around 700-900°C and called as curis temperature.

$\chi \propto \frac{1}{T}$ ⇒ $\boxed{\frac{\chi_1}{\chi_2} = \frac{T_2}{T_1}}$

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NOTE:- Very high temperatures can be measured by Pyrometer, thermopile, Bolometer.

NOTE:- Very low temperature can be measured by magnetic thermometer.

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* Types of scales:-

	F.P L.F.P ice point	B.P U.F.P Steam point	F.I UFP-LFP
① Centigrate (°C)	0	100	100
② Kelvin	273	373	100
③ Fahrenheit [°F]	32	212	180
④ Ran Kine [°Ra]	492	672	180
⑤ Reamer [°R]	0	80	80

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Thermometric principle:-

$$\boxed{\frac{T-LFP}{UFP-LFP} = C} \rightarrow \boxed{\frac{T-LFP}{F.I} = C}$$

$$\frac{°C-0}{100-0} = \frac{K-273}{373-273} = \frac{°F-32}{212-32} = \frac{°Ra-492}{672-492} = \frac{R-0}{80-0}$$

$$\frac{°C}{100} = \frac{K-273}{100} = \frac{F-32}{180} = \frac{Ra-492}{180} = \frac{R}{80}$$

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Relation b/w C & F

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

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

* $\boxed{C=F} \longrightarrow T = ?$

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

$$9C = 5F - 5\times32$$

$$4F = -5\times32$$

$$F = -40.$$

$$\therefore \boxed{-40^\circ C = -40^\circ F}$$

$$C_2 = \frac{5}{9}F_2 - \frac{5}{9}\times32$$

$$C_1 = \frac{5}{9}F_1 - \frac{5}{9}\times32$$

$$\boxed{\Delta C = \frac{5}{9}[\Delta F]}$$

* $C_1 = 0$ $\quad K_1 = 273$

$C_2 = 100$ $\quad K_2 = 373$

$\Delta C = 100$ $\quad \Delta K = 100$

$$\boxed{\Delta C = \Delta K}$$

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

$$= \Delta K$$

⇒ °C & °F are same = -40

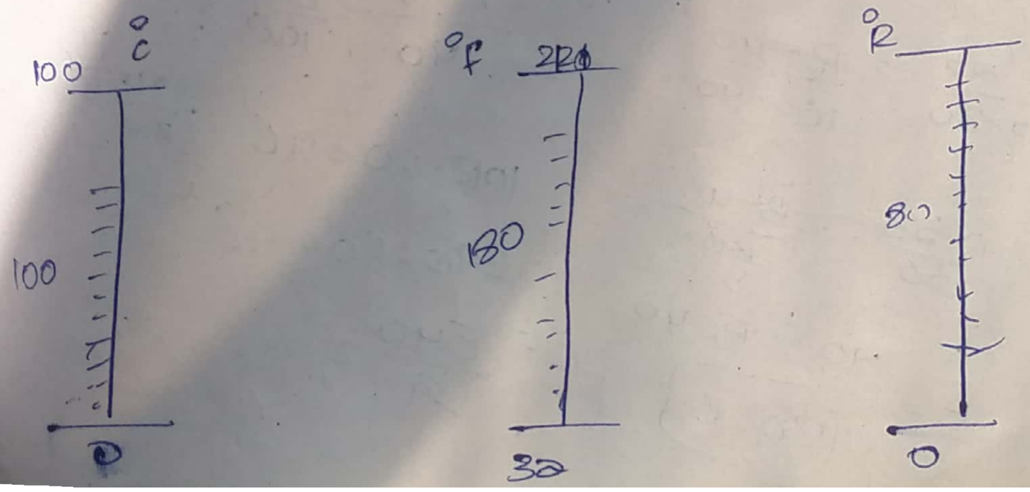
°C & °K are same = 0

°F & K are same = 574.26

°F & °R are same = -25.6.

⇒ 1°temp is maximum in Reamer

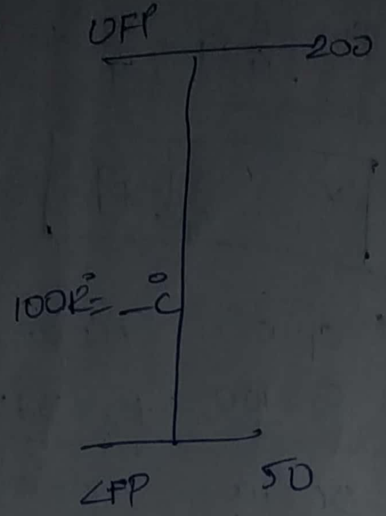
1° temp minimum in Fahrenhite



$\boxed{1^\circ R > 1^\circ C > 1^\circ F}$

* Temp scale is oribitary scale

Rohit's



$$\frac{°C-0}{100-0} = \frac{R°-LFP}{UFP-LFP}$$

$$\frac{°C}{100} = \frac{R°-50}{100-50}$$

$$\frac{°C}{\cancel{100}_2} = \frac{R°-50}{\cancel{150}_3}$$

$$°C = \frac{2}{3}[R°-50]$$

$$°C = \frac{2}{3}[100-50]$$

$$\boxed{°C = 33.3°}$$

Question papers

Q2

$F = 2C$

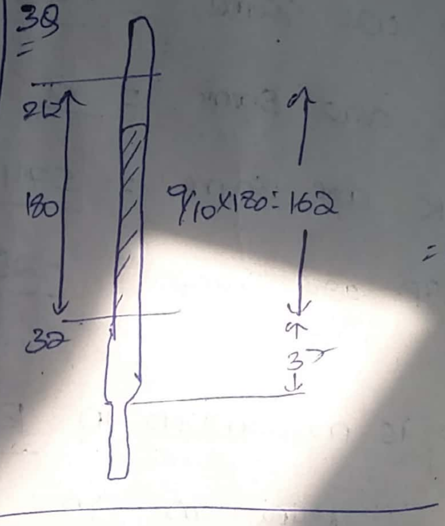
$C = F/2$

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

$\frac{F}{2} = \frac{5}{9}[F-32]$

$9F = 10F - 320$

$\boxed{320 = F}$



$= 162 + 32 = 194$

$\frac{R-5}{90} = \frac{C}{100}$

$20 = 180$

$5 = ?$

$\frac{5 \times 180}{20} = 9$

$10R - 50 = 9C$

$= 40$

$590 - 50 - 9C$

$\frac{540}{9} = 60$

$\frac{A-20}{40-20} = \frac{B-40}{100-40}$

$\frac{A-20}{20} = \frac{B-40}{60}$

$90 = B - 40$

$130° = B$

(7)

$$\frac{A-20}{40} = \frac{B-40}{100}$$

$$\frac{500-200}{4} = B-40$$

$$300 = 4B-160$$

$$460 = 4B$$

115

$$\boxed{B = 115^\circ}$$

(8) $R_t = R_0[1+\alpha(\Delta T)]$

$$4 = 2[1+[0.0125]t]$$

$$\frac{4}{2} = [1+[0.0125]t]$$

$$\frac{1}{0.0125} = t$$

$$t = 80$$

(9).

$$\boxed{\frac{F-100}{1000-100} = \frac{K-273}{}}$$

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

$$= \frac{5}{9}[1000-100]$$

$$= \frac{5}{\cancel{9}} \times \cancel{900}^{100}$$

$$\boxed{\Delta K = 500}$$

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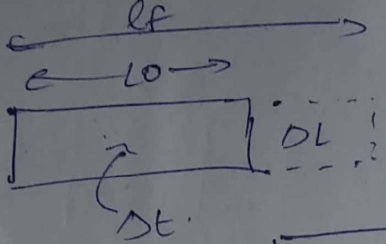
Expansion of solid:

① Linear $[\alpha]$

② Area (or) Superficial $[\beta]$

③ volume (or) cubical $[\gamma]$

Coefficient of expansion = $\dfrac{\text{change in dimension}}{\text{original dimension} \times [\Delta T]}$



$$\boxed{\alpha = \frac{\Delta L}{L_0[\Delta T]}}$$

$$\alpha = \frac{L_f - L_0}{L_0(\Delta T)}$$

$$L_0 \alpha \Delta T = L_f - L_0$$

$$L_f = L_0 + L_0 \alpha \Delta T$$

$$\boxed{L_f = L_0[1 + \alpha \Delta T]}$$

$$\boxed{A_f = A_0[1 + \beta \Delta T]}$$

$$\boxed{V_f = V_0[1 + \gamma \Delta T]}$$

Note

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

$$\beta = 2\alpha$$

$$\gamma = 3\alpha$$

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Note:

α (+) = Expands on heating.

Ex:- Metals.

α (-ve) = contracts on heating

Ex:- Cast Iron

: Rubber etc.

Note:

→ Substance which expands equally in all directions is called isotropic substance.

→ If does not expands equally in all directions it is an isotropic material.

Ex:- crystals.

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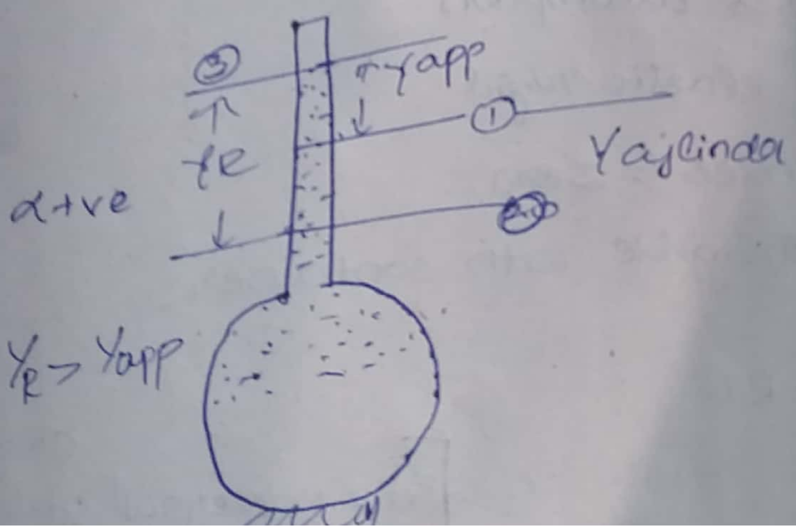
* Expansion of Liquids:-

↳ Real volume expansion → material of liq

↳ Apparent volume expan → material of liq q. container



$\gamma_R > \gamma_{app}$

$\gamma_R = \gamma_{app} + \gamma_{cylinder}$

$$\boxed{\gamma_R = \gamma_{app} + 3\alpha}$$

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* Expansion of gases

① Volume coefficient of exp (α) → P = const.
- Regnaults apparatus

② pressure coefficient of exp (β) → V = const
- Jolly's bulb experiment.

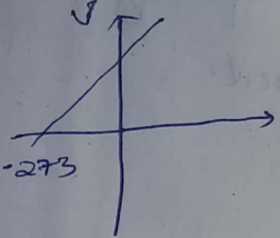
$$V_f = V_0 [1+\alpha t]$$
$$V_1 = V_0 [1+\alpha t_1]$$
$$V_2 = V_0 [1+\alpha t_2]$$
$$\frac{V_1}{V_2} = \frac{[1+\alpha t_1]}{[1+\alpha t_2]}$$

$$V_1 + V_1 \alpha t_2 = V_2 + V_2 \alpha t_2$$
$$V_1 - V_2 = V_2 \alpha t_1 - V_1 \alpha t_2$$

$\alpha = \frac{V_1 - V_2}{V_2 t_1 - V_1 t_2}$	$\beta = \frac{P_1 - P_2}{P_2 t_1 - P_1 t_2}$

$$\boxed{\alpha = \beta = \frac{1}{273.16}}$$

① P = 760mm of Hg
② T = 0°C = 273K
③ V = 22.4 litres



⇒ Vanderwall's equation:-

$$\left[P + \frac{a}{V^2}\right][V-b] = RT$$

a = molecular attraction
b = Volume occupied.

Kinetic theory of gases assumption
* Molecules are perfectly elastic rigid
* attraction b/w molecules = zero.
* volume of gas is negligible with container

$$\left[P + \frac{a}{V^2}\right]^{a=0} [V - \cancel{b}]^{b=0} = RT$$

$$\boxed{PV = RT}$$ **

[Ru = universal gas constant
= 8.313 J/mole K
Ru = mR]

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(ii) $Pv = nR_uT$

$n =$ no of moles

$\left[\frac{m}{M}\right] = \frac{\text{mass}}{\text{Mol wt}} = \frac{\text{no of molecules}}{\text{Avagadro no}} = \left[\frac{m}{M}\right]$

$PV = \frac{m}{M} R_u T$

$PV = mRT \Rightarrow \frac{m}{V} RT \Rightarrow \boxed{P = dRT}$ **

$P\frac{V}{m} = RT$

$\boxed{Pv = RT}$

$\boxed{\frac{V}{m} \Rightarrow \text{specific volume } (v)}$

⇒ Joules Law :- ~~ΔT~~ [Temp]

(cu) $V \Rightarrow F(\text{Temp})$

$U \propto T$

$du = C_v dT$

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

$\boxed{U = \text{internal energy}}$

~~$C_v = \frac{R}{\gamma - 1}$~~

Enthalpy

(cp)

$h \propto T$

$dh \propto dT$

$dh = c_p dT$

$c_p = \frac{dh}{dT}$

$\boxed{h = \text{heat energy}}$

Air constant Values

$C_p = 1.005$
$C_v = 0.717$
$R = 0.287$
} KJ/kg K

$\gamma = 1.4$

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* $c_p >>>>>> C_v$

$c_p - c_v = R$

$\frac{C_P}{C_V} = \gamma \Rightarrow$ adiabatic index

$\boxed{C_v = \frac{R}{\gamma - 1}}$ $\boxed{c_p = \frac{\gamma R}{\gamma - 1}}$

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* Translational K.E of molecules:-

1) $V_{rms} = \sqrt{\dfrac{3R_uT}{M}}$

2) $K.E = \frac{1}{2}mv^2$

$= \frac{1}{2} m \times \left[\sqrt{\dfrac{3R_uT}{M}}\right]^2$

$\boxed{\therefore \dfrac{m}{M} = n}$

$$\boxed{E = \frac{3}{2} n R_u T} \; **$$

$\Rightarrow$ $E = \frac{3}{2} n R_u T$

$E = \frac{3}{2} \dfrac{\text{no of molecules}}{N} \times R_u T$

$\boxed{\therefore n = \dfrac{\text{no of molecules}}{\text{Avagadro no.}}} \; **$

$E = \frac{3}{2} \dfrac{R_u}{N} \times T$

$$** \; \boxed{E = \frac{3}{2} KT}$$

$\Rightarrow$ Boltzman constant (K) = $\dfrac{\text{universal gas constant}}{\text{Avagadro number}}$

$K = \dfrac{R_u}{N} = \dfrac{8.314}{6.023 \times 10^{23}}$

$= 1.032 \times 10^{-23}$ J/K

$\dfrac{N\text{-}m}{K}$

$Kg\, m/s^2$

$ML^2T^{-2}K^{-1}$

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Q Density of gas = ____
when mass of a molecule = m

(a) $\frac{KT}{mP}$ (b) $\frac{mP}{KT}$ (c) $\frac{nP}{KT}$ (d) $\frac{m}{V}$

Sol $d = \frac{mass}{volume} = \frac{m \times \text{no of molecules}}{Volume}$

$\therefore PV = nRT$

$\boxed{\frac{P}{RT} = \frac{n}{V}}$

$d = \frac{P}{RT} \times \text{no of molecules}$

$d = \frac{P}{RT} \times \frac{mN}{M}$

$\boxed{\therefore n = \frac{m}{M} = \frac{\text{no of molecules}}{N}}$

$d = \frac{P}{RT} \times \frac{mN}{M}$

$\boxed{\therefore \frac{m}{M} = \frac{\text{No of molecules}}{N}}$

$d = \frac{mPN}{R_u T}$

$= \frac{mP}{\frac{R_u}{N} T}$

$\boxed{d = \frac{mP}{KT}}$

10Q constant pressure

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{100}{27+273} = \frac{V_2}{57+273}$

$\frac{100}{300} = \frac{V_2}{330}$

$V_2 = 110 cc$

11Q $\frac{PV}{T} = C$ $\therefore \frac{V_1}{T_1} = \frac{V_2}{T_2}$

$V = \pi r^2 l$

$\frac{\pi r^2 l}{273} = \frac{\pi r^2 (l+10)}{373}$

$373 l = 273 l + 2730$

$100 l = 2730$

$\boxed{l = 27.3 cm}$

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14 Given

$T_1 = 27^\circ c + 273 = 300K$ $\quad P \propto \frac{V}{T}$

$T_2 = ?$

$P_1 = P$

$P_2 = 2P$

$= \frac{P_1}{T_1} = \frac{P_2}{T_2}$

$= \frac{\cancel{P}}{300} = \frac{2\cancel{P}}{T_2}$

$\boxed{T_2 = 600\ K}$

15 Given

$T_1 = 27^\circ c + 273 = 300K$ $\boxed{P \propto T}$

$T_2 = 87^\circ c + 273 = 360K$.

$\frac{P \propto T}{T} = \frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \frac{P_2}{P_1} = \frac{T_2}{T_1}$

$\left[\frac{P_2 - P_1}{P_1} \times 100\right]$

$= \left[\frac{P_2}{P_1} - 1\right] \times 100 \Rightarrow \left[\frac{T_2}{T_1} - 1\right] \times 100$

$= \left[\frac{\cancel{360}^{6}}{\cancel{300}_{5}} - 1\right] \times 100$

$= \frac{1}{5} \times 100$

$= 0.2 \times 100 = 20\%$

16

$\Delta T = 1^\circ c = 1K$

$\boxed{\Delta C = \Delta K}$ $\Rightarrow \left[\frac{P_2}{P_1} - 1\right] \times 100 = 0.4 \Rightarrow \frac{1}{T_1} = \frac{0.4}{100} = \frac{4}{1000}$

$\left[\frac{T_2}{T_1} - 1\right] \times 100 = 0.4$ $\quad T_1 = \frac{1000}{4}$

$\boxed{T_1 = 250K}$

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(17) $\frac{PV}{\cancel{T}} \Rightarrow P_1V_1 = P_2V_2$

Given

$V_1 = 10\,lt$

$P_1 = 76\,cm$

$V_2 = 10+9\,l = 19\,l.$

$P_2 = ?$

$$P_2 = \frac{P_1V_1}{V_2}$$

$$= \frac{\cancel{76}^{4} \times 10}{\cancel{19}} = 40\,cm\ of\ Hg$$

(18) Given

let.

$P_1 = 100.$

$P_2 = 100+50 = 150.$

$\frac{PV}{\cancel{T}}$ $P_1V_1 = P_2V_2$

$\frac{V_2}{V_1} = \frac{P_1}{P_2}$

$$\frac{PV}{\cancel{T}} = \left[\frac{V_2 - V_1}{V_1}\right] \times 100$$

$$PV = \left(\frac{V_2}{V_1} - 1\right) \times 100$$

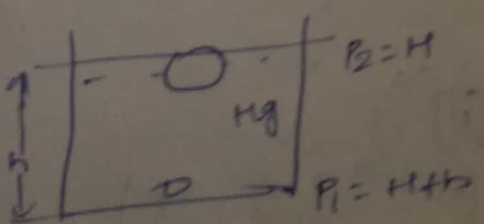
$$PV = \left[\frac{P_1}{P_2} - 1 \times 100\right]$$

$$= \left(\frac{\cancel{100}^{2}}{\cancel{150}_{3}} - 1\right) \times 100$$

$$= \frac{-1}{3} \times 100 \quad 33.3$$

$$= -\underline{33.3\%}$$

20 $H_{atm} = 76\,cm\ of\ Hg$



V_2 2·6

$\boxed{P_1V_1 = P_2V_2}$

V_1 8

$P_1V_1 = P_2V_2$

$(H+h)\frac{4}{3}\pi r_1^3 = H\frac{4}{3}\pi r_2^3$

$[H+h]\cancel{\frac{4}{3}\pi} r_1^3 = H\cancel{\frac{4}{3}\pi}[n^3 r_1^3]$

$H+h = Hn^3$

$h = Hn^3 - H$

$h = H[n^3-1]$

$h = 76[2^3-1]$

$h = 76\times7 = 532$ cm of Hg.

$H_{atm} = 10$ m

If Hg column is water

$h = H[n^3-1]$

$= 10[2^3-1]$

$= 70$ m of H_2O

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24 Given

$T, P, V = C$

$x = ?$ $m_{O_2} = 16$

$m_{H_2} = x$

$\therefore \cancel{PV} = nRuT$

$n = c$

$\frac{m}{M} = c$

$\frac{m_{O_2}}{M_{O_2}} = \frac{m_{H_2}}{M_{H_2}}$

$\frac{16}{32_2} = \frac{x}{2}$

$\boxed{x = 1 gm}$

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(25) $P = ?$

adiabitically. $\boxed{PV^\gamma = C}$

$P_1 = P$ $V_2 = \frac{1}{4}V$

$V_1 = V$ $P_2 = ?$

$\boxed{\gamma = 1.5}$

$\left[\frac{P_2}{P_1}\right]^{\frac{1}{\gamma}} = \left[\frac{V_1}{V_2}\right]^{1}$

$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^\gamma$

$P_2 = \left[\frac{V_1}{V_2}\right]^\gamma P_1$

$= \left[\frac{V}{\frac{1}{4}V}\right]P = [4]^{3/2}P$

$= [2^2]^{3/2}P$ $\boxed{P_2 = 8P}$

$U = \frac{n}{2} RT$

$dU = \frac{n}{2} R dT$

$\frac{dU}{dT} = \boxed{C_V = \frac{nR}{2}}$

Enthalpy [h]

$dQ = dU + dW$

$\boxed{h = U + PV}$ ****

$h = \frac{n}{2} RT + RT$

$h = RT \left[\frac{n}{2} + 1\right]$

$dh = RdT \left[\frac{n}{2} + 1\right]$

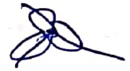
$\frac{dh}{dT} = C_P = R\left[\frac{n}{2} + 1\right]$

$\gamma = \frac{C_P}{C_V}$

$\gamma = \frac{R\left[\frac{n}{2} + 1\right]}{\frac{nR}{2}} \Rightarrow \frac{n+2}{n} = \boxed{1 + \frac{2}{n}}$ **

$\boxed{\gamma = 1 + \frac{2}{n}}$

Types of gases	Translational D.O.F	Rotational	Total (n)
Monoatomic			

Types of gas	Translation D.o.f	Rotational	Total D.o.f (n)	diagram	$C_P = R\left[\frac{n}{2}+1\right]$	$C_V = \frac{nR}{2}$	$\gamma = \frac{C_P}{C_V}$
Monoatomic Ar, He.	3	0	3		$\frac{5R}{2}$	$\frac{3R}{2}$	1.66
diatomic [Air]	3	2	5		$\frac{7R}{2}$	$\frac{5R}{2}$	1.4
Polyatomic CO_2 NO_2	3	3	6		4R	3R	1.33

Mixtures:-

$$C_{P\,mix} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 + n_2}$$

$$C_{V\,mix} = \frac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2}$$

$$\gamma_{mix} = \frac{C_{P\,mix}}{C_{V\,mix}} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 C_{V_1} + n_2 C_{V_2}}$$

$$R_{mix} = \frac{n_1 R_1 + n_2 R_2}{n_1 + n_2}$$

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(36) no of moles = 1.

$$\gamma_{mix} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 C_{V_1} + n_2 C_{V_2}}$$

mono

diatom

$$= \frac{1 C_{P_1} + 1 C_{P_2}}{1 C_{V_1} + 1 C_{V_2}}$$

$$= \frac{\frac{5R}{2} + \frac{7R}{2}}{\frac{3R}{2} + \frac{5R}{2}}$$

$$= \frac{\frac{12R}{2}}{\frac{8R}{2}} = \frac{3}{2} = \underline{\underline{1.5}}$$

$\underline{\underline{37}}$ $\frac{PV}{T}$ $T_1 = 27 + 273 = 300\,k.$

$V_1 = 1$

$V_2 = \boxed{\frac{1}{4}V} \times \quad V + \frac{V}{4} = \frac{5V}{4}.$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$\frac{\cancel{V}}{\frac{5\cancel{V}}{4}} = \frac{300}{T_2}$$

$$\frac{4}{5} = \frac{300}{T_2}$$

375

$$T_2 = \frac{\overset{75}{\cancel{300}}}{\cancel{4}} \times 5$$

$$T_2 = 375\,K.$$

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(28)

	(1)	(2)	(3)
	$P_1 = 2P$	$P_2 = 3P$	$V_3 = 2V$
	$V_1 = 3V$	$V_2 = 4V$	$P_3 = P = ?$

$n_1 + n_2 = n_3$

$P_1V_1 + P_2V_2 = P_3V_3$

$2P\,3V + 3P\,4V = P_3\,2V$

$6PV + 12PV = P_3\,2V$

$\overset{9}{18}PV = 2V P_3$

$\boxed{P_3 = 9P}$

(29)

$\frac{dP}{P} \times 100 = 1$

$\frac{dV}{V} \times 100 = 1.$

$\frac{dT}{T} \times 100 = ?$

$PV = CT$

$\Rightarrow$

$\log P + \log V = \log T + \log C$

$\frac{1}{P}\frac{dP}{dT} + \frac{1}{V}\frac{dV}{dT} = \frac{1}{T} + 0$

$\frac{1}{dT}\left[\frac{dP}{P \times 100} + \frac{dV}{V \times 100}\right] = \frac{1}{T} \times 100$

$\frac{dP}{P} \times 100 + \frac{dV}{dV} \times 10 = \frac{dT}{T} \times 100$

$1 + 1 = \frac{dT}{T} \times 100$

$\boxed{\frac{dT}{T} \times 100 = 2 =}$

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(32) $P = dRT$

$$\frac{P}{dT} = R$$

$$76\ \frac{P_1}{d_1 T_1} = \frac{P_2}{d_2 T_2}$$

d_1: 1×10^{-1}, T_1: $0+273 = 273$, P_2: 228 cm, T_2: $27+273$, $d_2 \to ?$

(33) $P^2 V = \text{const}$

$PV = RT$ — $P = \frac{RT}{V}$

$T_1 = T$

$V_1 = V$

$V_2 = 2V$

$T_2 = ?$

$$\frac{R^2 T^2}{V^{\cancel{2}}} \cancel{\times V} = \text{const.}$$

$$\frac{\cancel{R}^2 T^2}{V} = C$$

$$\frac{T_1^2}{V_1} = \frac{T_2^2}{V_2}$$

$$\left(\frac{T_1}{T_2}\right)^2 = \frac{V_1}{V_2}$$

$$T_1^2 = \frac{2\cancel{V}}{\cancel{V}}$$

$$T_1 = \sqrt{2}\,T$$

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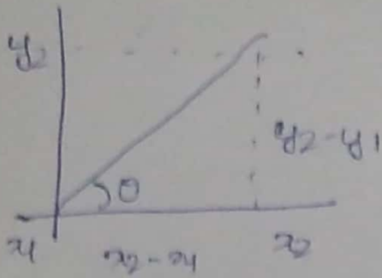
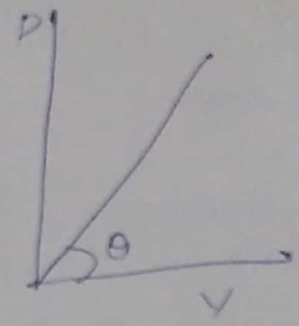
slopes.



$$\tan\theta = \frac{y_2 - y_1}{x_2 - x_1} = \frac{dy}{dx}$$

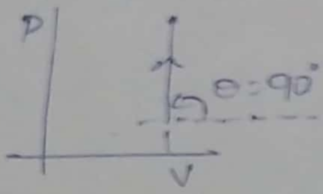
$\Rightarrow$ slope



$$\frac{dy}{dx} = \frac{dP}{dV}$$

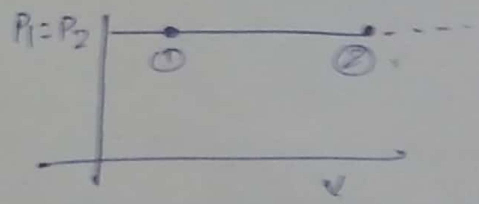
① const volume

$$\left.\frac{dP}{dV}\right]_{V=c} = \infty$$

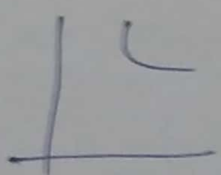


② const pressure.

$$\left.\frac{dP}{dV}\right]_{P=c} = 0$$



③ const temp. $PV = c \longrightarrow \boxed{xy = c} \longrightarrow$ rectangular hyperbola



$PV = c$

$d(PV) = d(c)$

$PdV + VdP = 0$

$VdP = -PdV$

$$\boxed{\frac{dP}{dV} = \frac{-P}{V}}$$

④ Rev. adiabatic

$PV^{\gamma} = c$

$$\boxed{\frac{dP}{dV} = -\frac{\gamma P}{V}}$$

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$$\frac{\text{slope of adiabatic}}{\text{slope of isothermal}} = \frac{-\gamma P/V}{-P/V} = \gamma$$

42

$\frac{dV}{V} \times 100 = -2.5$

$\frac{dP}{P} \times 100 = ?$

Adiabatic process.

diatomic $\gamma = 7/5$

$\boxed{\frac{dP}{dV} = -\gamma \frac{P}{V}}$ $\boxed{100 \times \frac{dP}{P} = -\gamma \frac{dV}{V} \times 100}$

$= \frac{-7}{5} \cdot \frac{5}{2}$

$= 3.5$

43

adiabatic process

$$\left[\frac{V_1}{V_2}\right]^{\frac{1}{1}} = \left[\frac{P_2}{P_1}\right]^{\frac{1}{\gamma}} = \left[\frac{T_2}{T_1}\right]^{\frac{1}{\gamma-1}}$$

given $P \propto T^{c}$

$P^{\frac{1}{\gamma}} \propto T^{\frac{1}{\gamma-1}}$

$P \propto T^{\frac{\gamma}{\gamma-1}}$

$c = ?$

$\gamma = 5/3$

$$\frac{\frac{5}{3}}{\frac{5}{3}-1} \Rightarrow \frac{5}{2} = 2.5$$

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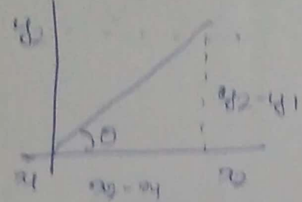
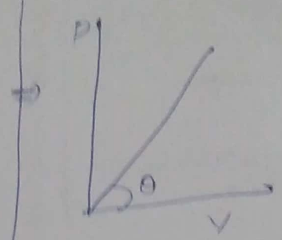
slopes.



$\tan\theta = \frac{y_2 - y_1}{x_2 - x_1} = \frac{dy}{dx}$

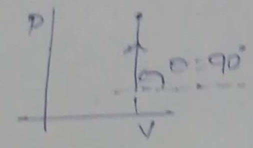
slope



$\frac{dy}{dx} = \frac{dP}{dV}$

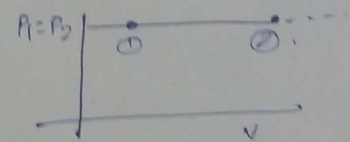
① const volume

$\left.\frac{dP}{dV}\right]_{V=c} = \infty$

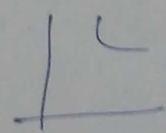


② const pressure.

$\left.\frac{dP}{dV}\right]_{P=c} = 0$



③ const temp. $PV = c \longrightarrow \boxed{xy = c} \longrightarrow$ rectangular hyperbola.



$PV = c$

$d(PV) = d(c)$

$PdV + VdP = 0$

$VdP = -PdV$

$\boxed{\frac{dP}{dV} = \frac{-P}{V}}$

④ Rev. adiabatic $\boxed{\frac{dP}{dV} = -\frac{\gamma P}{V}}$

$PV^{\gamma} = c$

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36 Given

$P_1 = 30$ cm of Hg.　　$m_1 = m$

$P_2 = ?$　　$m_2 = m + \frac{m}{4}$　　$\frac{5m}{4}$

$P\cancel{V} = \cancel{n}R\cancel{T}$

c.　　c

$P = m \Rightarrow P \propto m$

$\frac{P_1}{m_1} = \frac{P_2}{m_2}$

$\frac{30}{\cancel{m}} = \frac{P_2}{\frac{5\cancel{m}}{4}}$

$\frac{5}{4} \times 30 = P$

$\boxed{P_2 = 37.5 \text{ cm}}$

37 Given

$P_1 = 90$ cm　　$m_1 = m$

$P_2 = ?$　　$m_2 = m - \frac{1}{3} = \frac{2m}{3}$

$P\cancel{V} = n\cancel{R}\cancel{T}$

$\frac{P_2}{P_1} = \frac{m_2}{m_1}$

$P_2 = \frac{\frac{2\cancel{m}}{\cancel{3}}}{\cancel{m}} \times \cancel{90}^{30}$

$\boxed{P_2 = 60 \text{ cm}}$

38

$P_1 = 12$ atm　　$P_2 = ?$

$T_1 = 27 + 273 = 300K$　　$T_2 = 127 + 273 = 400$

$m_1 = m$　　$m_2 = m - \frac{m}{2} = \frac{m}{2}$

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$P\cancel{V} = m\cancel{R}T$

$$\frac{P_1}{m_1 T_1} = \frac{P_2}{m_2 T_2}$$

$$P_2 = \frac{\cancel{12}^{4}}{\cancel{m} \times \cancel{300}} \times \cancel{400}^{200} \times \frac{\cancel{m}}{\cancel{2}}$$

$$\boxed{P_2 = 8 \text{ atm}}$$

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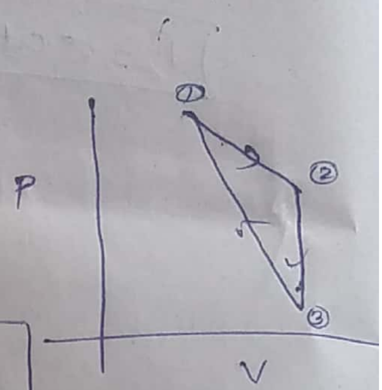
THERMODYNAMICS

⇒ Thermodynamics is a science which deals with conversi of heat energy to work energy (or) vice versa in a given system

⇒ First Law of thermodynamics:-

$$\oint dQ \propto \oint dW$$

$$Heat)_{cycle} = Work)_{cycle}$$



$$\boxed{Q_{1-2} + Q_{2-3} + Q_{3-1} = W_{1-2} + W_{2-3} + W_{3-1}}$$

⇒ Work

+ve	-ve
→ expansion	compression
→ generating	consumption
→ by the system	on the system

⇒ Heat

+ve	-ve
supply	rejection
gained	loss

differential eq for 1 Law of Th

$$\boxed{dQ = dU + dW}$$

$$Q \propto W$$

$$W \propto Q$$

$$W \propto Heat$$

$$W \propto H$$

$$\boxed{W = JH}$$

$$= \frac{Joule}{cal} \times cal$$

$$= Joule.$$

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

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Application:

① A bullet of mass (m) moving with velocity 'v' is made to stop by metal plate then change in temperature of bullet is

sensible heat → msθ
temp change
phase constant

Latent heat → mL
phase change
temp constant

$W = JH$

$\frac{1}{2}\cancel{m}v^2 = J\cancel{m}s\theta$

$$\boxed{\theta = \frac{v^2}{2JS}}$$

$\boxed{\theta = \text{change in Temp}}$

② Rise in Temperature of water, mass 'm' if potential energy of water fall is converted to heat energy.

$W = JH$

$mgh = J\,\cancel{m}s\theta$

$$\boxed{\theta = \frac{gh}{JS}}$$

$\boxed{J = 1}$ → Joule

$\boxed{J = 4.2}$ → calorie

$\frac{1}{2^1 \times}$

---

① $m = 4.2\ gm = 4.2 \times 10^{-3}$

$v = 1 km/s = 1000 m/sec$

$W = J\ H$.

$\therefore$

$\frac{1}{2} mv^2 = J\ H$.

$= \frac{1}{2}[4.2 \times 10^{-3}][10^3 \times 10^3] = 4.2\ H$

$H = 500\ cal$

$H = 500(4.2)\ J$

$= 2100\ J$.

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(2) $v = 210\ m/s$

$\theta = ?$

$$\theta = \frac{v^2}{2JS}$$

$$\theta = \frac{210 \times 210}{2 \times 4.2 \times 0.03 \times 10^3}$$

$$\theta = \frac{105 \times 105}{2.1 \times 0.03 \times 10^3}$$

$$\frac{105 \times 105 \times 10^2}{2.1 \times 3 \times 10^3}$$

$$= \frac{10.5 \times 105}{6.3 \times 10}$$

$$= \frac{105 \times 105}{63}$$

$$= \frac{15\cancel{75}}{\cancel{63}}$$

$$= 175^0 C$$

$$\begin{array}{r} 105 \\ \times 105 \\ \hline 525 \\ 000\times \\ 1105\times \\ \hline 15775 \end{array}$$

6

(3) $P = \frac{W}{t}$

$$= \frac{JH}{time} = \frac{J \times mL}{time}$$

$$= \frac{1 \times 100 gm \times 336 J}{6\cancel{0} sec\ \ gm}$$ Joule/sec

$$= 560 watt$$

(4) $m = 42 kg$

$H = 980 cal$

height = ?

$W = JH$

$mgh = JH$

$42 \times 10 \times h = 4.2 \times 980$

420

$= \frac{4.2 \times 980}{420}$

$h = 9.8 m$

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(5) $\theta = ?$

$h = 840m$

$S = 4200 J/Kg \cdot K$

$W = JH$

$mgh = J\,msθ$

$\boxed{\theta = \frac{gh}{JS}} \Rightarrow = \frac{9.8 \times \cancel{840}^{2}}{\cancel{4200}_{10} \times 1}$

$= \frac{19.6}{10}$

$\theta = 1.96K$

(I) $h = 8.4m$ $\Rightarrow 8.4 - 4.2 = 4.2m$

$h_2 = 4.2$

$\theta = ?$

$\theta = \frac{gh}{JS}$

$= \frac{9.8 \times \cancel{4.2}}{\cancel{4.2} \times 0.1 \times 10^3}$

$= \frac{9.8}{10^2}$

$= 0.098\,°C$

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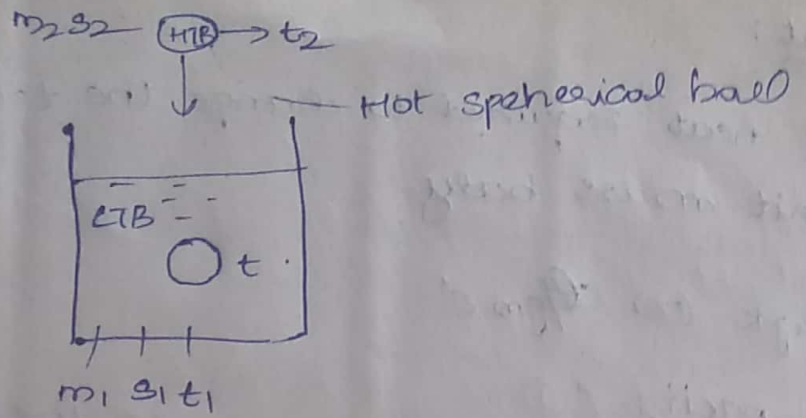

$$m_2 s_2 [t_2 - t] = m_1 s_1 [t - t_1]$$

$$m_2 s_2 t_2 - m_2 s_2 t = m_1 s_1 t - m_1 s_1 t_1$$

$$m_2 s_2 t_2 + m_1 s_1 t_1 = m_1 s_1 t + m_2 s_2 t$$

$$\boxed{t = \frac{m_2 s_2 t_2 + m_1 s_1 t_1}{m_1 s_1 + m_2 s_2}}$$

material same $\boxed{s_1 = s_2}$

$$t = \frac{m_1 t_1 + m_2 t_2}{m_1 + m_2}$$

mass are same

$$t = \frac{t_1 + t_2}{2}$$

⇒ Regulation :-

Re solidification of ice takes place when external pressure is removed.

⇒ Super cooling :- pure water

Cooling of water below freezing point without solidification is called supercooling of water

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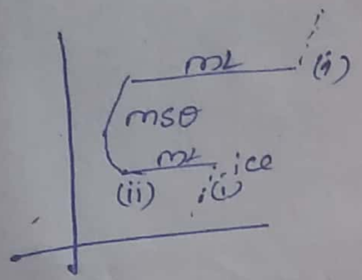
2) superheating :-
process of heating of liquid above its boilingpoint without vapourization



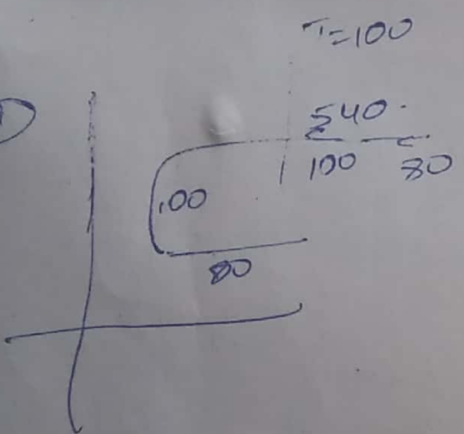
$Q_s = Q_{ab}$

$m[L + s\theta] = m_{ice} L_{ice}$

$m[540 + 100] = 1 \times 80$

$m[640] = 80$

$\boxed{m = \frac{1}{8} gm}$



$\boxed{T_{eq} = 100}$

Given

$Q = 2 kcal$

$U = 5030 J$

$W = 3350 J$

$dQ = dU + dW$

$2000 = 5030 + 3350$

$\frac{cal}{2000 J} = 8380$

$J = \frac{8380}{2000}$

$\boxed{J = 4.2 J}$

(12) $P = 200\,N/m^2$
$dQ = 1000J$
$V_2 - V_1 = 3m^3$
$dU = ?$

$dW = P(V_2 - V_1)$
$= 200 \times 3$
$= 600$

$dQ = dU + dW$
$dQ - dW$
$dU = 1000 - 600$
$\boxed{dU = 400J}$

(13). Given.

$T = 10^\circ C$
$Q = 500J$
$dW = ?$

(14) $dQ = 35J$
$dW = -15J$
$dU = ?$

$dQ = dU + dW$
$dU = dQ - dW$
$= 35 - (-15)$
$= 45J$

(15) $dQ = (U_2 - U_1) + dW$
$-20 = U_2 - 30 - 8$
$\boxed{U_2 = 18J}$

(16) Adiabatic. $dQ = 0$
$dU = -dW$
$= -(-144)$
$= 144J$

(17) $S_1 : S_2 = 2:3$ $d_1 : d_2 = 3:5$

thermal capacity $= \frac{d_1}{d_2} \times \frac{S_1}{S_2}$
$= \frac{3}{5} \times \frac{2}{3} = 2:5$

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(20) fraction of heat for internal energy in const pressure

$$\frac{dU}{dQ} = \frac{mC_v dT}{mC_p dT} = \frac{1}{\gamma}$$

* fraction of heat used for external energy $dQ = dU + dW$

$$\frac{dW}{dQ} = \frac{dQ - dU}{dQ} = 1 - \frac{dU}{dQ} = 1 - \frac{1}{\gamma}$$

---

(21) monoatomic gas

$$\frac{dU}{dQ} = \frac{1}{\gamma} \qquad \gamma = \frac{\frac{5\cancel{R}}{\cancel{2}}}{\frac{3\cancel{R}}{\cancel{2}}} = \frac{5}{3}$$

$$= \frac{1}{\frac{5}{3}}$$

$$= \frac{3}{5} = 0.6$$

(22) diatomic gas

$$\frac{dW}{dQ} = 1 - \frac{1}{\gamma} \qquad \gamma = \frac{\frac{7\cancel{R}}{\cancel{2}}}{\frac{5\cancel{R}}{\cancel{2}}}$$

$$\gamma = \frac{7}{5}$$

$$= 1 - \frac{5}{7}$$

$$= \frac{2}{7}$$

(23) $dQ = 140J.$

$$\frac{dW}{dQ} = \frac{2}{7}$$

$$dW = \frac{2}{\cancel{7}} \times \cancel{140}^{20}$$

$$= 40J.$$

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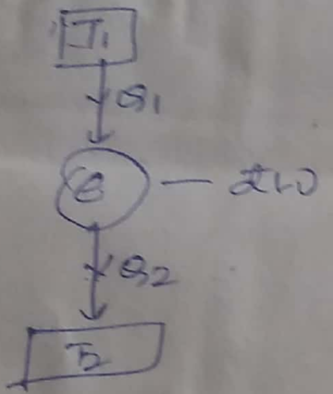
Second Law of Thermodynamics:

Kelvin plank's statement :

It is impossible to construct a device operating in a cycle to produce work continiously while exchanging heat with single reservior.



$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$$

Carnot ideal $\longrightarrow$ $\boxed{Q = KT}$

$$\eta = \frac{K(T_1 - T_2)}{KT_1} \Rightarrow 1 - \frac{T_2}{T_1}$$

Q η Carnot max when

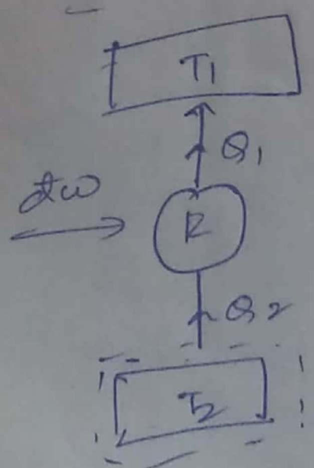
(a) T_1 max

(b) T_1 min

(c) T_2 max

✓ (d) T_2 min

⇒ clausis statement :-



COP = coefficient of performance.

$$W + Q = Q_1$$

$$\boxed{W = Q_1 - Q_2}$$

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$$\frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$$

$$COP_{\text{Carnot Ref}} = \frac{T_2}{T_1 - T_2}$$

$$COP_{\text{Heat pu}} = \frac{T_1}{T_1 - T_2}$$

Relation

$$\boxed{COP_{H.P} - COP_{ref} = 1}$$

$$\boxed{COP_{H.P} = \frac{1}{\eta_{engine}}}$$

Note: $S_{isothermal} = \frac{Q}{m(\cancel{\Delta T})} = \infty$

$S_{adiabatic} = \frac{\cancel{Q}}{m(\Delta T)} = 0$

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