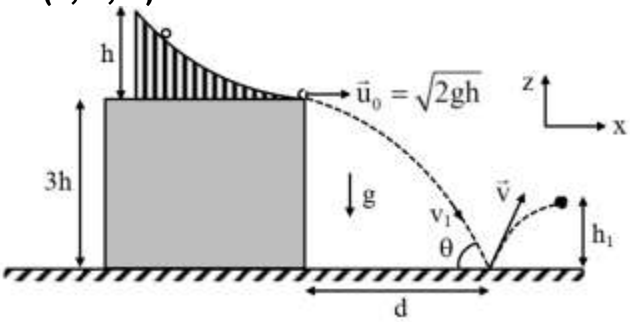
**1. (a, c, d)**




$$\vec{v}_1 = \sqrt{2gh}\hat{i} - \sqrt{2\,g3\,h}\hat{k}$$

$$\vec{v} = \sqrt{2gh}\hat{i} + \sqrt{2\,g3\,h} \times \frac{1}{\sqrt{3}}\hat{k}$$

$$= \sqrt{2gh}\hat{i} + \sqrt{2gh}\hat{k}$$

$$\tan\theta = \frac{\sqrt{2\,g3\,h}}{\sqrt{2gh}} = \sqrt{3}\;\theta = 60^\circ$$

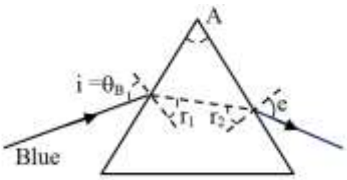
$$h_1 = \frac{v_{1y}^2}{2\,g} = \frac{2gh}{2\,g} = h$$

$$d = v_x t = \sqrt{2gh} \times \sqrt{\frac{2 \times 3\,h}{g}}$$

$$= \sqrt{2gh}\sqrt{\frac{6\,h}{g}} = 2\sqrt{3}\,h$$

$$= \frac{d}{h_1} = 2\sqrt{3}$$

**2. (a, c, d)**
**Sol.**




$\tan\theta_B = \mu_B = \sqrt{3}$
$i = \theta_B = 60^\circ$
$1\sin 60^\circ = \sqrt{3}\sin r_1$
$r_1 = 30^\circ$
$r_1 + r_2 = A$
$\delta = (i + e) - A$
$60^\circ = 60^\circ + e - A$
$e = A$
$\sqrt{3}\sin r_2 = 1\sin e$
$\sqrt{3}\sin(A - 30) = \sin A$

Solving

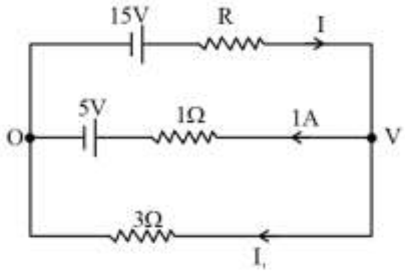
$A = 60^\circ$
$\therefore e = 60^\circ$

For red light

$$\mu = \frac{\sin\left(\frac{A+\delta_{\min}}{2}\right)}{\sin\frac{A}{2}} = \sqrt{2}$$

**3. (a,b,c,d)**

**Sol.**




By writing voltage drop across $1\Omega$

$\Rightarrow$ 0+5+1x1=V

V=6

$\Rightarrow$ Similarly across R

0+ 15-IxR = 6

IR = 9

$\Rightarrow$ across $3\Omega$

6 - 3 $I_1$ = 0

$I_1$ = 2A

Hence option (b) is correct

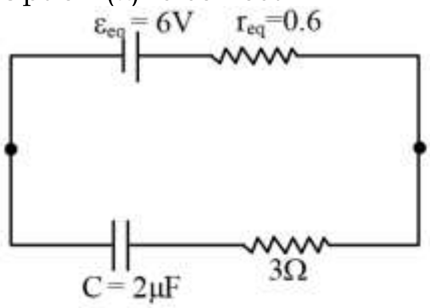
$\Rightarrow$ 1=1+2 (by KCL)

I = 3

IR = 9

R = $3\Omega$

Option (a) is correct



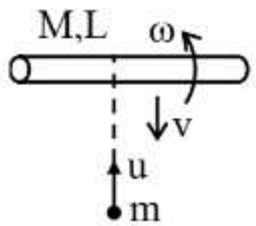

$$\varepsilon = \frac{\frac{15}{3}+\frac{5}{1}+\frac{0}{3}}{\frac{1}{3}+\frac{1}{1}+\frac{1}{3}} = 10\times\frac{3}{5} = 6V$$

$$q_{\max} = 2\times 6 = 12\mu C$$

$$i = \frac{6}{3.6}e^{-\frac{t}{\tau}}$$

$$= \frac{5}{3}e - \frac{7.2}{7.2} = \frac{5}{3}e^{-1} \approx 0.6A$$

**4. (a)**




Applying angular momentum conservation about hinge

$$mv\frac{L}{2}+0=-mv\frac{L}{2}+\frac{ML^2}{3}\omega \quad \ldots.(i)$$

Also from eq. of restitution

$$e=1=\frac{\omega\frac{L}{2}+V}{u} \Rightarrow u=\omega\frac{L}{2}+V \quad \ldots.(ii)$$

Solving (i) & (ii)

$\omega \approx$ 6.98 rad/sec & v = 4.30 m/s

**5. (b)**

In t = 10 sec volume of liquid is

V = 2500 cc

$$h=\frac{2500}{50\times 5}=10cm$$

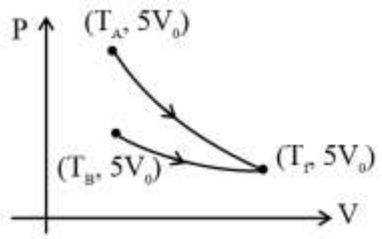
$$C_d=\frac{A_d\varepsilon_0 k}{d}$$

$$=\frac{50\times10^{-2}\times10\times10^{-2}\varepsilon_0\times3}{5\times10^{-2}}=3\varepsilon_0$$

$$C_a=\frac{A_a\varepsilon_0}{d}=\frac{50\times10^{-2}\times40\times10^{-2}\varepsilon_0}{5\times10^{-2}}=4\varepsilon_0$$

$$C=C_a+C_d=7\varepsilon_0$$

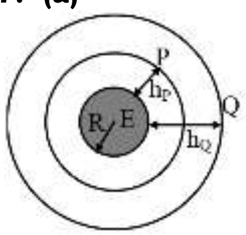
**6. (a)**




$$T_AV_0^{\gamma-1}=T_f\left(5V_0\right)^{\gamma-1}$$

$$\frac{T_A}{T_f}=5^{\gamma-1}=\frac{T_A}{T_B}$$

**7. (a)**




$$\frac{g_P}{g_Q}=\frac{\frac{GM}{r_P^2}}{\frac{GM}{r_Q^2}}=\left(\frac{r_Q}{r_P}\right)^2$$

$$\frac{36}{25} = \left(\frac{r_Q}{r_P}\right)^2$$

$$\frac{r_Q}{r_P} = \frac{6}{5}$$

$$r_Q = \frac{6}{5} r_P$$

$$R + h_Q = \frac{6}{5}\left(R + \frac{R}{3}\right) \; h_Q = \frac{24}{15}R - R = \frac{9}{15}R = \frac{3}{5}R$$

**8. (3)**

n = 4      n = 3

$-1.51Z^2eV$      $-0.85\ Z^2$ eV

$E = E_4 - E_3 = 0.66\ Z^2$ eV

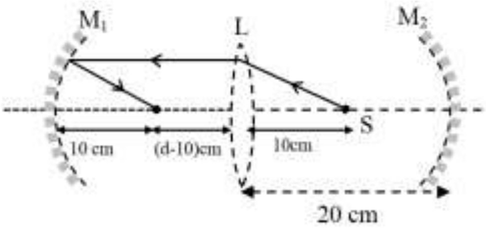
$K_{max} = E - W$

$0.66\ Z^2\ 1.95 + 4 = 5.95$

$W = 0.66Z^2 - 1.95 = \frac{hc}{\lambda} = \frac{1240}{310}$

$\therefore Z = 3$

**9. (80 or 150 or 220)**




Two cases are possible if Ist refraction on lens :
Since object is at focus $\Rightarrow$ light will become parallel.
Ist reflection at $M_1$ :-
Light is parallel $\Rightarrow$ Image will be at focus.
IInd refraction from L :-
u = -(d-10)
f= 10cm

$$\frac{1}{v} - \frac{1}{\mu} = \frac{1}{f}$$

$$\frac{1}{v} + \frac{1}{d-10} = \frac{1}{10}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{(d-10)} \qquad \ldots (i)$$

This v will be object for $M_2$, and image should be at 10 cm

$$\frac{1}{\mu} + \frac{1}{v_1} = \frac{1}{f}$$

$$-\frac{1}{(20-v)} - \frac{1}{10} = -\frac{1}{12}$$

$$\frac{1}{12} - \frac{1}{10} = \frac{1}{20-v}$$

$$-\frac{2}{120} = \frac{1}{20-v}$$

$$20 - v = -60$$

$$v = 80 \text{ cm}$$

From equation (i)

$$\frac{1}{80}=\frac{1}{10}-\frac{1}{d-10}$$

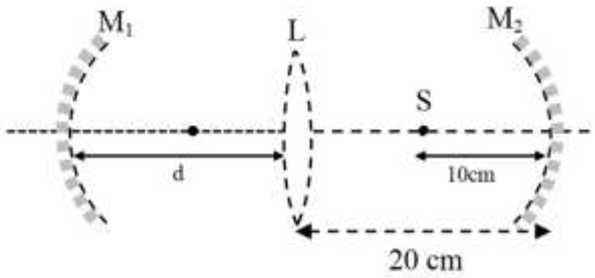
$$\frac{1}{d-10}=\frac{1}{10}-\frac{1}{80}$$

$$\frac{1}{d-10}=\frac{80-10}{800}=\frac{70}{800}$$

$$d-10=\frac{80}{7}\Rightarrow d=10+\frac{80}{7}=\frac{150}{7}$$

$$\boxed{n=150}$$

Case-2: If 1st reflection on mirror ni2




For $m_2$

$$\frac{1}{V_1}+\frac{1}{-10}=\frac{1}{-12}$$

$V_1$ = 60 cm

Then refraction on lens L

$u_2$=-80 cm

$$\frac{1}{V_2}-\frac{1}{-60}=\frac{1}{10}$$

$$V_2=\frac{80}{7}$$

Then reflection on $m_2$

Either $V_2$ is at centre (normal incidence)

$$d-\frac{80}{7}=20$$

$$d=\frac{220}{7}$$

$$\frac{n}{7}=\frac{220}{7},$$

n=220

$V_2$ is at pole of $m_2$

$$d-\frac{80}{7}=0$$

$$d=\frac{80}{7}$$

$$\frac{n}{7}=\frac{80}{7}$$

$$n=80$$

**10. (1)**

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\Rightarrow\frac{1}{v^2}dv+\frac{1}{u^2}du=-\frac{1}{f^2}df$$

$$\frac{1}{20}+\frac{1}{10}=\frac{1}{f}\Rightarrow\frac{1}{f}=\frac{3}{20}\Rightarrow f=\frac{20}{3}cm$$

$$\Rightarrow\frac{1}{(20)^2}(0.2)+\frac{1}{(10)^2}(0.1)=\frac{9}{400}df$$

$$df=\frac{1}{9}\left(\frac{400}{400}\times0.2+\frac{400}{100}\times0.1\right)$$

$$df=\frac{1}{9}(0.2+0.4)\Rightarrow df=\frac{0.6}{9}$$

$$\frac{df}{f}=\frac{0.6}{9}\times\frac{3}{20}=\frac{1}{100}$$

% error = 1 %

Sol.

$$\frac{1}{V}-\frac{1}{U}=\frac{1}{f};\qquad +\frac{1}{20}+\frac{1}{10}=\frac{1}{f}$$

$$-\frac{1}{V^2}dv+\frac{dU}{u^2}=-\frac{df}{f^2}\qquad \frac{1+2}{20}=\frac{1}{f};\ f=\frac{20}{3}$$

$$\frac{0.1}{100}+\frac{0.2}{400}=\frac{f\%}{f}$$

$$\frac{0.4+0.2}{400}=\frac{\Delta f}{f\left(\frac{20}{3}\right)}$$

$$\frac{0.6\times20}{400\times3}=\frac{\Delta f}{f}$$

$$\frac{1}{100}=\frac{\Delta f}{f}$$

% change in f is 1%

**11. (121)**

At constant pressure

$W=nR\Delta T=66$

$$\Delta U=n(C_V)_{mix}\Delta T$$

$$(C_V)_{mix}=\frac{n_1C_{V_1}+n_2C_{V_2}}{n_1+n_2}$$

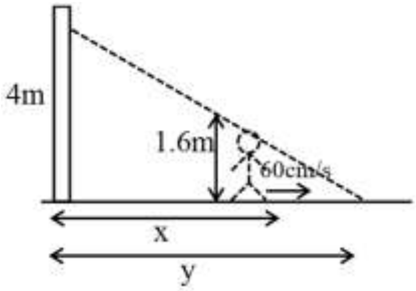
$$(C_V)_{mix}=\frac{2\times\frac{3}{2}R+1\times\frac{5}{2}R}{3}$$

$$(C_V)_{mix}=\frac{11}{6}R$$

$$\Delta U=\frac{11}{6}(nR\Delta T)$$

$$\Delta U=\frac{11}{6}\times66=121J$$

**12. (40)**




Sol.

$$\frac{4}{y}=\frac{1.6}{y-x}$$

$$4y-4x=1.6y$$

$$2.4y=4x$$

$$X=0.6y$$

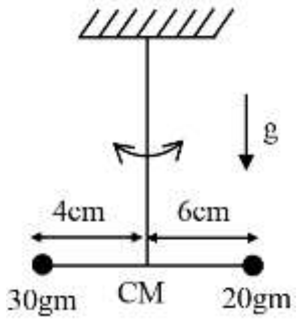
$$\frac{dx}{dt}=0.6\times\frac{dy}{dt}$$

$$60=0.6\times\frac{dy}{dt}$$

$$\therefore\frac{dy}{dt}=100cm/s$$

Speed of tip of person's
Shadow w.r.t person = 100 - 60 = 40 cm/s

**13. (10)**




$$T=\frac{2\pi}{\omega}=2\pi\sqrt{\frac{I}{C}}$$

$$\Rightarrow\omega=\sqrt{\frac{C}{I}}$$

Where I = moment of inertia
$I = (30)(4)^2 + (20)(6)^2$
$= 1200$ gm-cm$^2$
$= 1.2\times 10^{-4}$kg-m$^2$

$$\Rightarrow\omega=\sqrt{\frac{1.2\times10^{-8}}{1.2\times10^{-4}}}$$

$$\Rightarrow\omega=\sqrt{10^{-4}}$$

$$\omega=\left(10^{-2}\right)$$

$$n\times10^{-3}=10^{-2}\Rightarrow n=10$$

**14. (a)**

$$_{Z_1}Z^{A_1}\rightarrow{}_{Z_2}Y^{A_2}+N_1\,{}_2He^4+N_2\,{}_1e^0+N_3\,{}_{-1}e^0$$

Conservation of charge
$Z_1=Z_2 + 2N_1+N_2-N_3$ ... (i)
Conservation of nucleons.

$A_1 = A_2 + 4N_1$

$N_1 = \dfrac{A_1 - A_2}{4}$ …(ii)

From (i) and (ii)

$$N_2 - N_3 = Z_1 - Z_2 - \left(\frac{A_1 - A_2}{2}\right)$$

(P) ${}_{92}U^{238} \rightarrow {}_{91}Pa^{234}$

$$N_1 = \frac{238-234}{4} = 1 \rightarrow 1\alpha$$

$$N_2 - N_3 = (92-91) - \left(\frac{4}{2}\right) = -1 \rightarrow 1\beta^-$$

(Q) ${}_{82}Pb^{214} \rightarrow {}_{82}Pb^{210}$

$$N_1 = \frac{214-210}{4} = 1 \rightarrow 1\alpha$$

$$N_2 - N_3 = (82-82) - \left(\frac{4}{2}\right) = -2 \rightarrow 2\beta^-$$

(R) ${}_{81}T\ell^{210} \rightarrow {}_{82}Pb^{206}$

$$N_1 = \frac{210-206}{4} = 1 \rightarrow 1\alpha$$

$$N_2 - N_3 = (81-83) - \frac{4}{2} = -3 \rightarrow 3\beta^-$$

(S) ${}_{91}Pa^{228} \rightarrow {}_{88}Ra^{224}$

$$N_1 = \frac{228-224}{4} = 1\alpha$$

$$N_2 - N_3 = (91-88) - \frac{4}{2} = 1\beta^+$$

**15. (c)**

Sol. $\Rightarrow$ For option (P) temperature is minimum hence $\lambda$m will be maximum $\beta = \dfrac{\lambda D}{d} \Rightarrow \beta$ will also be maximum

$\Rightarrow$ For option (Q) T = 3000

$$\lambda m = \frac{b}{T} = \frac{2.9\times10^{-3}}{30000}$$

$$\lambda m = \frac{2.9}{3}\times10^{-6}$$

$= 0.96 \times 10^{-6}$

$= 966.6$ nm

$P_{3000} = 6A\,(3000)^4$

$P_{6000} = 6A\,(6000)^4$

$$\frac{P_{3000}}{P_{6000}} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

$$P_{3000} = \frac{1}{16}P_{6000}$$

Q – 4

⇒ For (R) T = 5000 K

$$\lambda m = \frac{2.9\times10^{-3}}{5\times10^{3}} = 0.58\times10^{-6}$$

= 580 nm

Visible to human eyes

R – 2

⇒ For (S) T = 10,000 → maximum

Hence (3) is wrong as it has minimum (λm)

**16. (b)**

Sol. V = 45 sin $\omega$t, L = 50 mH

$$\omega_0 = 10^5 \text{rad/s} = \frac{1}{\sqrt{LC}} \Rightarrow C = \frac{1}{L\omega_0^2} = \frac{1}{5\times10^{-2}\times10^{10}}$$

$$= 2\times10^{-9}\text{ F}$$

$$I_0 = \frac{45}{R}$$

$$\omega = 8\times10^4 \text{ rad/s} = 0.8\ \omega_0$$

$$I = 0.05I_0 = \frac{I_0}{20} \Rightarrow Z = 20R$$

$$X_L = 8\times10^4\times5\times10^{-2}\Omega = 4k\Omega$$

$$X_C = \frac{1}{8\times10^4\times2\times10^{-9}} = \frac{1}{16}\times10^5\Omega = \frac{25}{4}k\Omega$$

$$Z^2 = R^2 + (X_C - X_L)^2$$

$$400R^2 = R^2 + \left(\frac{9}{4}k\Omega\right)^2$$

$$R = \frac{\frac{9}{4}k\Omega}{\sqrt{399}} \approx \frac{9}{80}k\Omega = \frac{900}{8}\Omega$$

$$I_0 = \frac{V_0}{R} = \frac{45\times8}{900} = \frac{8}{20}A \approx 0.4A = 400mA$$

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{8}{900}\sqrt{\frac{5\times10^{-2}}{2\times10^{-9}}} = \frac{8}{900}\sqrt{25\times10^6}$$

$$Q = \frac{8}{900}\times5000 = 44.4$$

$$Q = \frac{\omega_0}{\Delta\omega} \Rightarrow \Delta\omega = \frac{\omega_0}{Q} = \frac{10^5}{44.4} = 2250.0$$

$$P_{max} = I_0^2R = \frac{45^2}{R^2}\times R = \frac{45^2}{R} = \frac{45^2}{900}\times8 = 18.4W$$

**17. (d)**

From force equation

$$mg - Bi\ell = \frac{mdv}{dt}$$

$$mg - \frac{BBi\ell}{R} \times \ell = \frac{mdv}{dt}$$

$$\frac{mgR}{B^2\ell^2} - v = \frac{mR}{B^2\ell^2}\frac{dv}{dt}$$

$$\frac{B^2\ell^2}{mR}\int_{t=0}^{t} dt = \int_0^v \frac{dv}{\left(\frac{mgR}{B^2\ell^2} - v\right)}$$

Now

$$\frac{mgR}{B^2\ell^2} = \frac{20\times10^{-3}\times10\times10}{16\times\frac{1}{16}} = 2$$

And

$$\frac{B^2\ell^2}{mR} = \frac{16\times\frac{1}{16}}{20\times10^{-3}\times10} = \frac{1}{0.2} = 5$$

$$\therefore 5t = \left[-\ell n(2-v)\right]_0^v$$

$$-5t = \ell n\left[\frac{2-v}{v}\right]$$

$$\therefore v = 2\left(1 - e^{-5t}\right)$$

At $t = 0.2$ sec $\quad v = 2\left(1 - e^{-5\times0.2}\right)$

$v = 2(1 - 0.4)$

$v = 1.2$ m/s

(P) Now at t = 0.2 sec

The magnitude of the induced emf = E = B$v l$

$= 4\text{x}1.2\text{x}\frac{1}{4}$ = 1.2Volt

(Q) At t = 0.2 sec, the magnitude of magnetic force = $BIl\sin\theta$

$$= B \times \frac{BlV}{R} \times l \times \sin 90^0$$

$$= \frac{4\times4\times\frac{1}{4}\times1.3\times\frac{1}{4}}{10} = 0.12 \text{ Newton}$$

(R) At t = 0.2 sec, the power dissipated as heat

$$P = i^2R = \frac{v^2}{R} = \frac{1.2\times1.2}{10}$$

p = 0.144 watt

(S) Magnitude of terminal velocity

At terminal velocity, the net force become zero

$$\therefore mg = Bil$$

$$mg = B \times \frac{Blv_t}{R} \times l$$

$$\therefore v_T = \frac{mgR}{B^2l^2} = \frac{20\times10^{-3}\times10\times10}{16\times\frac{1}{16}}$$

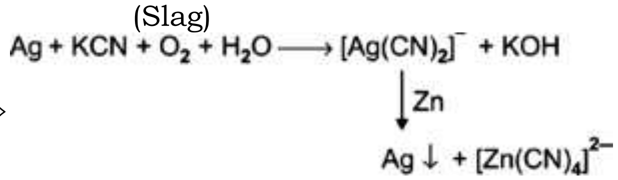
$V_T$ = 2 m/s

**18. (b, c, d)**

$\Rightarrow$ Under roasting condition, the malachite will be converted into $CuCO_3.Cu(OH)_2 \rightarrow 2CuO + CO_2 + H_2O$

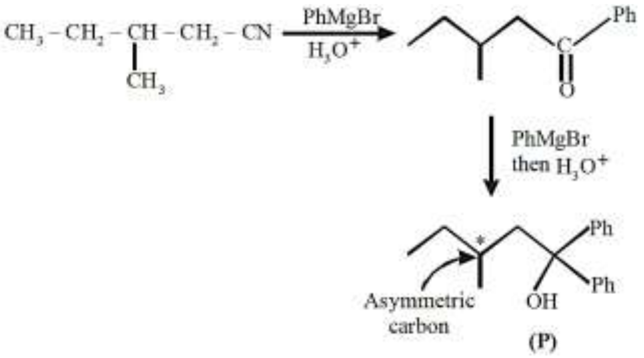
⇒ $ZnCO_3 \rightarrow ZnO + CO_2 \uparrow$
(Calamine) (Zincite)
⇒ Copper pyrites is heated in a reverberatory furnace after mixing with silica. In the furnace, iron oxide 'slag of' as iron silicate and copper is produced in the form of copper matte. $FeO + SiO_2 \rightarrow FeSiO_3$
(Slag)

⇒

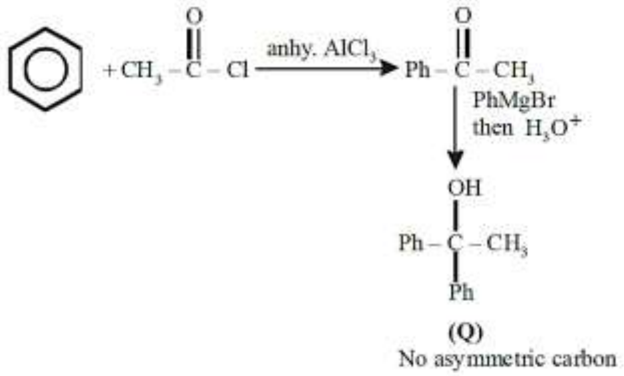


**19. (c, d)**

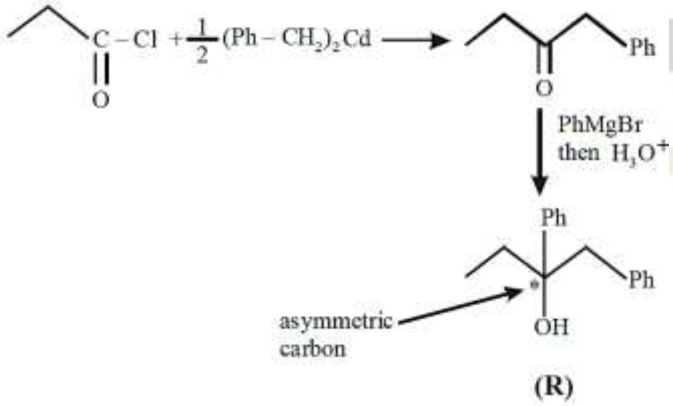
Formation of P



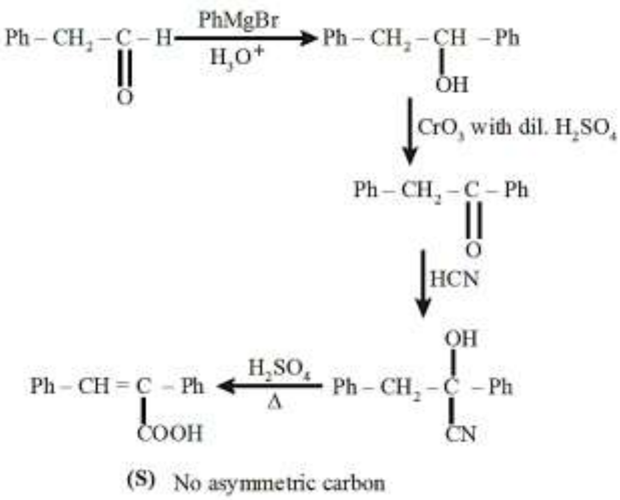
Formation of Q



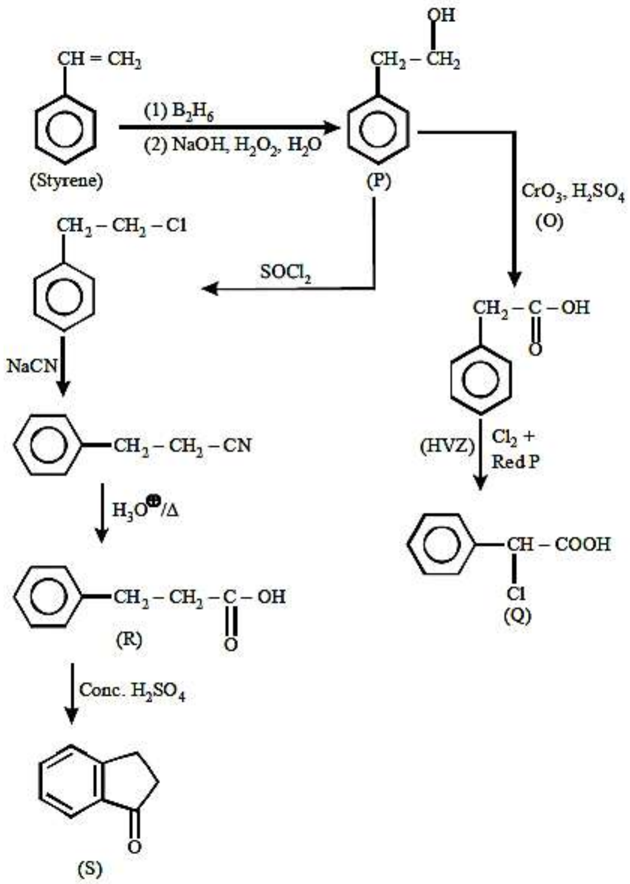
Formation of R



Formation of S




**20. (b)**




**21. (c)** MnCl$_2$+NaOH-»Mn(OH)$_2$↓ + NaCl

$$Mn(OH)_2 \xrightarrow[\text{heat}]{PbO_2+H^+(H_2SO_4)} \underset{\text{Purple}}{MnO_4^-} + Pb^{2+}$$

$$Cl^- \xrightarrow{MnO(OH)_2/\text{conc. } H_2SO_4/\square} Cl_2 \xrightarrow{2I^-} \underbrace{(\text{Starch} + I_2)}_{\text{blue coloration}} + 2Cl^-$$

**22. (a)**

For weak acid, $\alpha = \frac{\wedge_m}{\wedge_0}$

$$K_a = \frac{C\alpha^2}{1-\alpha} \Rightarrow K_a(1-\alpha) = C\alpha^2$$

$$\Rightarrow K_a\left(1-\frac{\wedge_m}{\wedge_0}\right) = C\left(\frac{\wedge_m}{\wedge_0}\right)^2$$

$$\Rightarrow K_a - \frac{\wedge_m K_a}{\wedge_0} = \frac{C\wedge_m^2}{(\wedge_0)^2}$$

Divide by '$\wedge_m$'

$$\Rightarrow \frac{K_a}{\wedge_m} = \frac{C\wedge_m}{(\wedge_0)^2} + \frac{K_a}{\wedge_0}$$

$$\Rightarrow \frac{1}{\wedge_m} = \frac{C\wedge_m}{K_a(\wedge_0)^2} + \frac{1}{\wedge_0}$$

Plot $\frac{1}{\wedge_m}$ vs $C\wedge_m$ has

Slope = $\frac{1}{K_a(\wedge_0)^2}$ = S

y-intercept = $\frac{1}{\wedge_0}$ = P

Then, $\frac{P}{S} = \frac{\frac{1}{\wedge_0}}{\frac{1}{K_a(\wedge_0)^2}} = K_a\wedge_0$

**23.** **(b)** At pH = 7 $\Rightarrow$ pure water

solubility = $S_1 = \sqrt{K_{sp}}$

At pH = 2

$$\Rightarrow \underset{}{MX(s)} + aq \xrightleftharpoons{K_{sp}} \underset{s}{M^+(aq)} + \underset{s-x}{X^-(aq)}$$

$$\underset{s-x}{X^-(aq)} + \underset{10^{-2}}{H^+(aq)} \xrightleftharpoons{1/K_a} \underset{x\,=\,s}{HX(aq)}$$

Approximation: s - x $\approx$ 0 [X- is limiting reagent]

$\Rightarrow s \approx x$

$\Rightarrow$ s(s-x) = $K_{sp}$ ......(1)

$\frac{s}{(s-x)(10^{-2})} = \frac{1}{K_a}$ ....(2)

Multiply (1) x (2) $\Rightarrow \frac{s^2}{10^{-2}} = \frac{K_{sp}}{K_a}$

$$\Rightarrow s = \frac{\sqrt{K_{sp}}}{10\sqrt{K_a}}$$

Now given: $\frac{s}{s_1} = \frac{10^{-3}}{10^{-4}}$

$$\Rightarrow \frac{\frac{\sqrt{K_{sp}}}{10\sqrt{K_a}}}{\sqrt{K_{sp}}} = 10 \Rightarrow \frac{1}{10\sqrt{K_a}} = 10$$

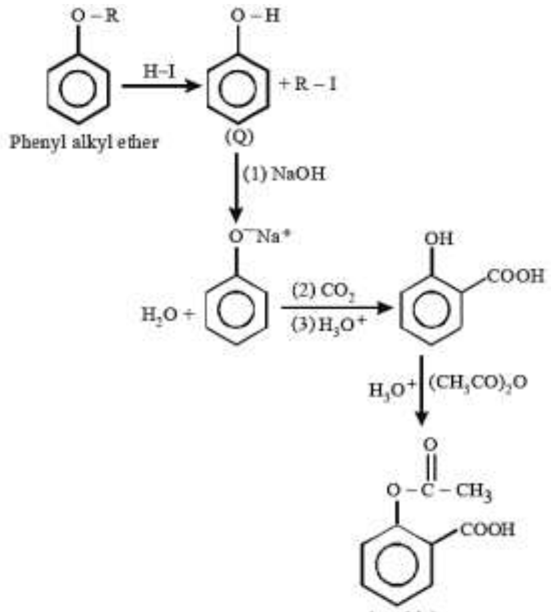
$$\Rightarrow \sqrt{K_a} = 10^{-2}$$

$$\Rightarrow K_a = 10^{-4}$$

$$\Rightarrow pK_a = 4$$

**24. (b)**

P is phenyl alkyl ether
Q is aromatic compound
R and S are the major product
i.e.




(Aspirin)
Pain killer
Acetyl salicylic acid
(Non-narcotic analgesic)

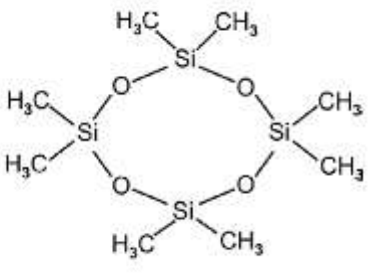
Correct ans is (b)
Aspirin inhibits the synthesis of chemicals known as prostaglandins.

**25. (222)**

$$4(CH_3)_2SiCl_2 + 4H_2O \xrightarrow{75\%} \underset{(X)}{(CH_3)_8Si_4O_4} + 8HCl$$

w = 516g

$$\underset{(moles)}{n} = \frac{516}{129} = 4$$




weight = 296 g

%yield=75

The weight of X (in gram) = 296 x $\frac{75}{100}$ = 222 g

**26. (100)**

For gas : Z = 0.5, $V_m$ = 0.4 L/mol

T = 800 K, P = X atm.

$$\Rightarrow Z = \frac{PV_m}{RT}$$

$$\Rightarrow \frac{X(0.4)}{0.08 \times 800} = 0.5$$

$\Rightarrow$ X=80

For ideal gas, $PV_m = RT$

$$\Rightarrow V_m = \frac{RT}{P} = \frac{0.08 \times 800}{80} = 0.8 L\,mol^{-1} = y$$

Then, $\frac{x}{y} = \frac{80}{0.8} = 100$

**27. (5)**

For reaction A(g) ⇌ P(g)

$\log k_f = \frac{-E_f}{2.303RT} + \log A_f$ [Arrhenius equation for forward reaction]

From plot when, $\frac{1}{T}$ = 0.002, log $k_f$ = 9

$$\Rightarrow 9 = \frac{-E_f}{2.303R}(0.002) + \log(A_f)$$

Given: $A_f = 10^{15} s^{-1}$

$$\Rightarrow 9 = \frac{-E_f}{2.303R}(0.002) + 15$$

$$\Rightarrow \frac{E_f}{2.303}R = \frac{6}{0.002} = 3000$$

Now, $K = \frac{k_f}{k_b} = \frac{A_f}{A_b} e^{-(E_f - E_b)/RT}$

$$\log K = -\frac{1}{2.303}\frac{(E_f - E_b)}{RT} + \log\left(\frac{10^{15}}{10^{11}}\right)$$

At 500 K

$$\Rightarrow 6 = \frac{-(E_f - E_b)}{500R(2.303)} + 4$$

$\Rightarrow$ (1000 R) (2.303) = $E_b$-Ef

$\Rightarrow$ (1000 R) (2.303) = $E_b$-3000 (2.303 R)

$\Rightarrow$ $E_b$ = 4000 R (2.303) .........(1)

Now $k_b = A_b e^{-Eb/RT}$

$$\Rightarrow \log k_b = \frac{-E_b}{2.303RT} + \log A_b$$

At 250 K

$\Rightarrow \log k_b = -\frac{4000}{250} + \log(10^{11})$ [From equation (1)]

$|\log k_b|$ = 5

**28. (7)**

For $A \rightarrow B$ $600V_1^{\gamma-1} = 60V_2^{\gamma-1} (\gamma = 5/3)$

(Reversible adiabatic)

$\Rightarrow$ 600 $(V_1)^{2/3}$ = 60 $(V_2)^{2/3}$

$\Rightarrow 10 = \left(\frac{V_2}{V_1}\right)^{2/3}$

$\Rightarrow 10 = \left(\frac{V_2}{10}\right)^{2/3}$

$\Rightarrow V_2 = 10(10)^{3/2} = 10^{5/2}$

Now, $q_{net} = RT_2 \ln 10 = 60 R \ln 10 = q_{AB} + q_{BC}$

$\Rightarrow q_{BC} = 60R\ln 10 = 60R\ln\frac{V_3}{V_2}$ [ $\because$ B $\rightarrow$ C is reversible isothermal]

$\Rightarrow 60R\ln 10 = 60R\ln\left(\frac{V_3}{10^{5/2}}\right)$

$\Rightarrow \log 10 = \log V_3 - \frac{5}{2}$

$\Rightarrow \log V_3 = \frac{7}{2} \Rightarrow 2\log V_3 = 7$

**29. (8)**

At $T_1$ K : A(g) ⇌ P(g)

t = 0 6

t = ∞ 6 - x x = 4 (from plot)

$\Rightarrow$ At $T_1$ K: $K_{P_1} = \frac{4}{2} = 2$

$\Rightarrow$ At $T_2$ K : A(g) ⇌ P(g)

t = 0 6

t = ∞ 6-y y = 2 (from plot)

$\Rightarrow$ At $T_2$ K: $K_{P_2} = \frac{2}{4} = \frac{1}{2}$

Now, $\Delta G_2^0 = -RT_2 \ln K_{P_2} = -RT\ln\frac{1}{2}$

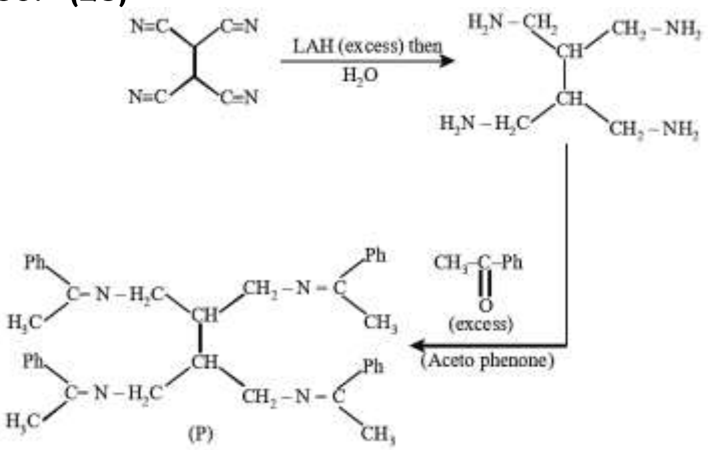
$\Rightarrow \Delta G_2^0 = RT_2 \ln 2$

$\Delta G_1^0 = -RT_1 \ln K_{P_1} = -RT_1 \ln 2 = -2RT_2 \ln 2$

Given: $\Delta G_2^0 - \Delta G_2^0 = RT_2 \ln 2 + 2RT_2 \ln 2 = 3RT_2 \ln 2 = RT_2 \ln x$

$\Rightarrow x = 2^3 = 8$

**30. (28)**




Total number of $sp^2$ hybridized C-atom in P = 28

**31. (d)**

(P) $P_2O_3 + 3H_2O \rightarrow \underline{2H_3PO_3}$

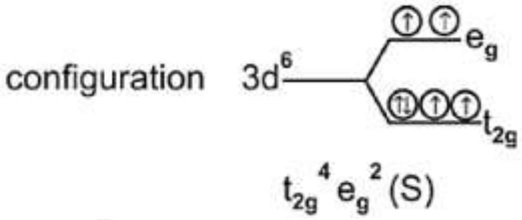
(Q) $P_4 + 3NaOH + 3H_2O \rightarrow 3NaH_2PO_2 + \underline{PH_3}$

(R) $PCl_5 + CH_3COOH \rightarrow CH_3COCl + \underline{POCl_3} + HCl$

(S) $H_3PO_2 + 2H_2O + 4AgNO_3 \rightarrow 4Ag + 4HNO_3 + \underline{H_3PO_4}$

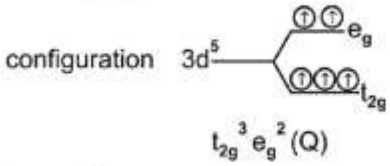
**32. (d)**

. $\underset{\text{WFL}}{\overset{\text{II}}{[Fe(H_2O)_6]^{+2}}}$



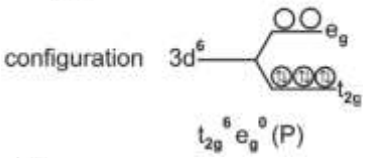

$\underset{\text{WFL}}{\overset{\text{II}}{[Mn(H_2O)_6]^{+2}}}$

2.



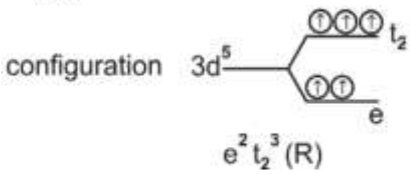

$\underset{\text{SFL}}{\overset{\text{III}}{[Co(NH_3)_6]^{+3}}}$

3.



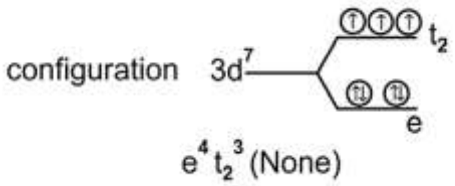

$\underset{\text{WFL}}{\overset{\text{III}}{[FeCl_4]^{\ominus}}}$

4.

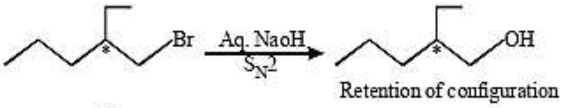


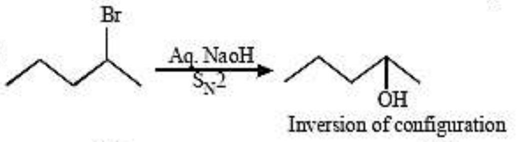

5.

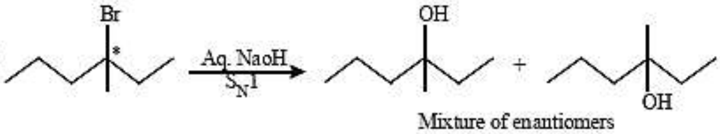
$\underset{\text{WFL}}{\overset{\text{II}}{[CoCl_4]^{-2}}}$

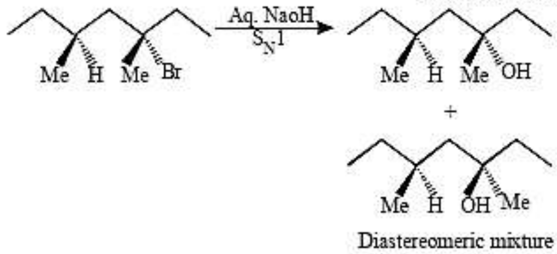



**33. (b) P$\rightarrow$2, Q$\rightarrow$1,R$\rightarrow$3,S$\rightarrow$5**

(P) 

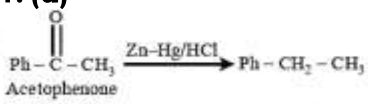

(Q) 

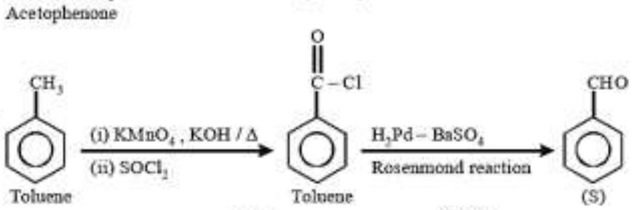

(R) 

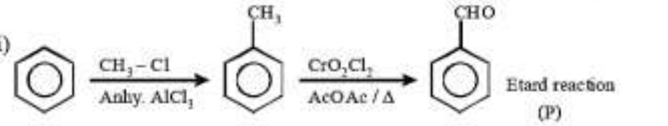



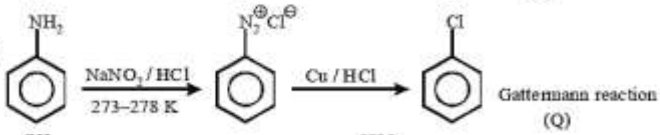

(S)

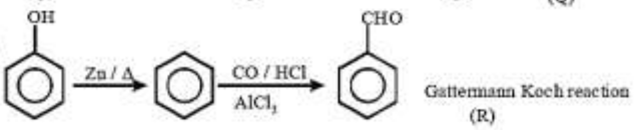
**34. (d)**

(i) 


(ii) 


(iii) 


(iv) 


(v) 


**35. (a c d)**

Sol. S = (0, l)u(l,2)u(3,4)

T= {0,1,2,3}

Number of functions:

Each element of S have 4 choice

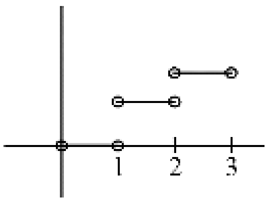
Let n be the number of element in set S.

Number of function = $4^n$

Here $n \to \infty$

$\Rightarrow$ Option (a) is correct.

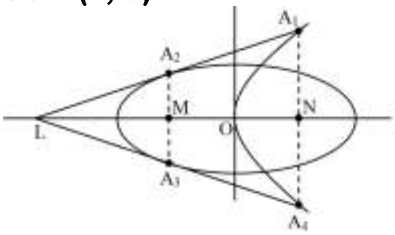
Option (b) is incorrect (obvious)

(c) 


For continuous function

Each interval will have 4 choices.
$\Rightarrow$ Number of continuous functions
= 4x4x4 = 64
$\Rightarrow$ Option (c) is correct.
(d) Every continuous function is piecewise constant functions
$\Rightarrow$ Differentiable.

**36. (a, c)**




$y = mx + \frac{3}{m}$

$C^2 = a^2m^2 + b^2$

$\frac{9}{m^2} = 6m^2 + 3 \Rightarrow m^2 = 1$

$T_1$&$T_2$
y = x + 3,y = -x-3
Cuts x-axis at (-3, 0)
$A_1(3, 6)$ $A_4(3, -6)$
$A_2(-2, 1)$ $A_3(-2, -1)$
$A_1A_4$=12, $A_2A_3$ = 2, MN = 5

Area= $\frac{1}{2}$ (12 + 2)x5 = 35sq.unit

**37. (b, c, d)**

$f(x) = \frac{x^3}{3} - x^2 + \frac{5x}{9} + \frac{17}{36}$

f'(x) = $x^2$-2x + $\frac{5}{9}$

f'(x) = 0 at x= $\frac{1}{3}$ in [0,1]

$A_R$ = Area of Red region
$A_G$ = Area of Green region

$A_R = \int_0^1 f(x)dx = \frac{1}{2}$

Total area = 1

$\Rightarrow A_G = \frac{1}{2}$

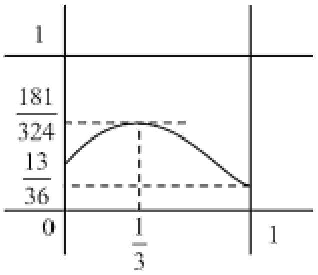
$\int_0^1 f(x)dx = \frac{1}{2}$

$A_G = A_R$

$f(0) = \frac{17}{36}$

$f(1) = \frac{13}{36} \approx 0.36$

$f\left(\frac{1}{3}\right) = \frac{181}{324} \approx 0.558$




(a) Correct when h = $\frac{3}{4}$ but $h \in \left[\frac{1}{4}, \frac{2}{3}\right]$

$\Rightarrow$ (a) is incorrect

(b) Correct when h = $\frac{1}{4}$

$\Rightarrow$ (b) is correct

(c) When $h = \frac{181}{324}, A_R = \frac{1}{2}, A_G < \frac{1}{2}$

$h = \frac{13}{36}, A_R < \frac{1}{2}, A_G = \frac{1}{2}$

$\Rightarrow A_R = A_G$ for some $h \in \left(\frac{13}{36}, \frac{181}{324}\right)$

$\Rightarrow$ (c) is correct

(d) Option (d) is remaining coloured part of option (c), hence option (d) is also correct.

**38. (c)**

$$\int_{x^2}^{x} \sqrt{\frac{1-t}{t}} dt . \sqrt{n} \le f(x) g(x) \le 2\sqrt{x}\sqrt{n}$$

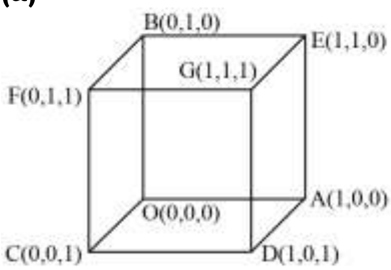
$$\because \int_{x^2}^{x} \sqrt{\frac{1-t}{t}} dt = \sin^{-1}\sqrt{x} + \sqrt{x}\sqrt{1-x} - \sin^{-1} x - x\sqrt{1-x^2}$$

$$\Rightarrow \lim_{x \to 0}\left(\frac{\sin^{-1}\sqrt{x} + \sqrt{x}\sqrt{1-x} - \sin^{-1} x - x\sqrt{1-x^2}}{\sqrt{x}} \le f(x) g(x) \le \frac{2\sqrt{x}}{\sqrt{x}}\right)$$

$$\Rightarrow 2 \le \lim_{x \to 0} f(x) g(x) \le 2$$

$$\Rightarrow \lim_{x \to 0} f(x) g(x) = 2$$

**39. (a)**




DR'S of OG=l, 1, 1
DR'S of AF = -l, 1, 1
DR'S of CE=l, 1,-1
DRS of BD =1,-1,1

Equation of OG $\Rightarrow \frac{x}{1} = \frac{y}{1} = \frac{z}{1}$

Equation of AB $\Rightarrow \frac{x-1}{1} = \frac{y}{-1} = \frac{z}{0}$

Normal to both the line's

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 1 & -1 & 0 \end{vmatrix} = \hat{i} + \hat{j} - 2\hat{k}$$

$$\overrightarrow{OA} = \hat{i}$$

$$\text{S.D.} = \frac{\left|\hat{i}.(\hat{i}+\hat{j}-2\hat{k})\right|}{\left|\hat{i}+\hat{j}-2\hat{k}\right|} = \frac{1}{\sqrt{6}}$$

**40. (b)**

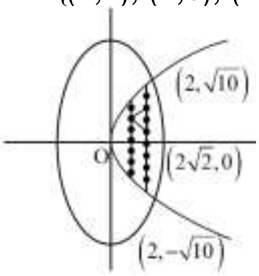
$$\frac{x^2}{8} + \frac{y^2}{20} < 1 \;\&\; y^2 < 5x$$

Solving corresponding equations

$$\frac{x^2}{8} + \frac{y^2}{20} = 1 \;\&\; y^2 = 5x$$

$$\Rightarrow \begin{Bmatrix} x = 2 \\ y = \pm\sqrt{10} \end{Bmatrix}$$

X = {(1,1), (1,0), (1-1), (1,2), (1-2), (2, 3), (2,2), (2,1), (2,0), (2-1), (2-2), (2-3)}




Let S be the sample space & E be the event n(S) = ${}^{12}C_3$

<u>For E</u>

Selecting 3 points in which 2 points are either or x=l & x = 2 but distance b/w then is even

Triangles with base 2:

= 3x7 + 5x5 = 46

Triangles with base 4:

= 1x7 + 3x5 = 22

Triangles with base 6:

= 1x5 = 5

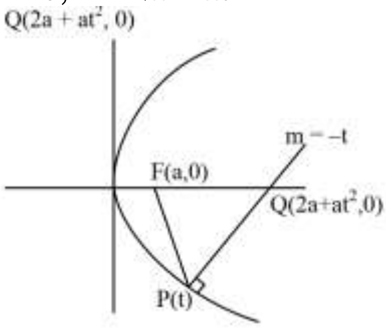
$$P(E) = \frac{46+22+5}{{}^{12}C_3} = \frac{73}{220}$$

**41. (a)**

Let point P ($at^2$, $2at$)

normal at P is $y = -tx + 2at + at^3$

$y = 0$, $x = 2a + at^2$




Area of $\Delta PFQ = \left|\frac{1}{2}\left(a + at^2\right)\left(2at\right)\right| = 120$

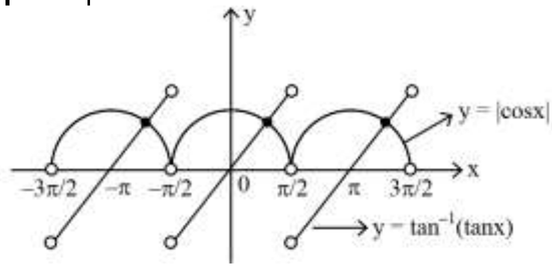
$\because$ m = -t

$\because$ $a^2[1+m^2]m = 120$
(a, m) = (2, 3) will satisfy

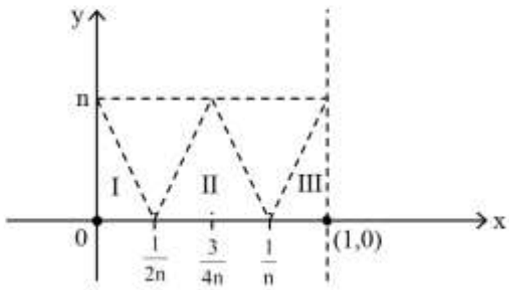
**42. (3)**

$\sqrt{2}\,|\cos x| = \sqrt{2}.\tan^{-1}(\tan x)$

$|\cos x| = \tan^{-1} \tan x$




**43. (8)**




Area = Area of (I + II + III) = 4

$= \frac{1}{2}\times\frac{1}{2n}\times n + \frac{1}{2}\times\frac{1}{2n}\times n + \frac{1}{2}\left(1-\frac{1}{n}\right)\times n$

$= \frac{1}{4}+\frac{1}{4}+\frac{n-1}{2} = 4$

n=8

$\therefore$ maximum value of f(x) = 8

**44. (1219)**

$$S = 77 + 757 + 7557 + \ldots + 7\underbrace{5\ldots\ldots5}_{98}7$$

$$10S = \qquad 770 + 7570 + \ldots + 75\ldots570 + 755\ldots\ldots570$$

$$9S = -77 + \underbrace{13+13+\ldots\ldots+13}_{98\text{ times}} + 7\underbrace{5\ldots\ldots5}_{98}70$$

$$= -77 + 13\times 98 + 7\underbrace{5\ldots\ldots5}_{99}7 + 13$$

$$S = \frac{7\overbrace{5\ldots\ldots5}^{99}7+1210}{9}$$

m= 1210
n = 9
m + n= 1219

**45.** $A = \dfrac{1967+1686i\sin\theta}{7-3i\cos\theta}$

$= \dfrac{281(7+6i\sin\theta)}{7-3i\cos\theta}\times\dfrac{7+3i\cos\theta}{7+3i\cos\theta}$

$= \dfrac{281(49-18\sin\theta\cos\theta)+i(21\cos\theta+42\sin\theta)}{49+9\cos^2\theta}$

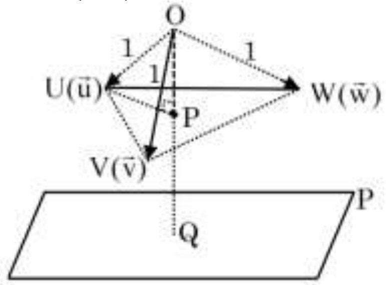
for positive integer
Im(a) = 0

$21\cos\theta + 42\sin\theta = 0$

$\tan\theta = \frac{-1}{2}; \sin 2\theta = \frac{-4}{5}, \cos^2\theta = \frac{4}{5}$

$$= \frac{281\left(49 - 9 \times \frac{-4}{5}\right)}{49 + 9 \times \frac{4}{5}} = 281 \text{ (+ve integer)}$$

**46. (45)**




Given $|\vec{u} - \vec{v}| = |\vec{v} - \vec{w}| = |\vec{w} - \vec{u}|$

$\Rightarrow \Delta UVW$ is an equilateral $\Delta$

Now distances of U, V, W from P = $\frac{7}{2}$

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

Also, Distance of plane P from origin

$\Rightarrow$OQ = 4

$\therefore$ OP = OQ - PQ $\Rightarrow$ OP = $\frac{1}{2}$

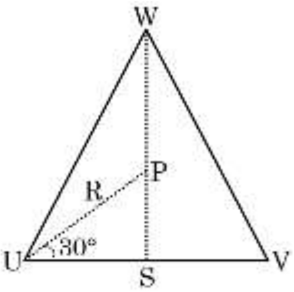
Hence, $PU = \sqrt{OU^2 - OP^2} \Rightarrow PU = \frac{\sqrt{3}}{2} = R$

Also, for $\Delta$UVW, P is circumcenter

$\therefore$ for $\Delta$UVW: US = Rcos30°

$\Rightarrow$ UV = 2Rcos30°

$\Rightarrow UV = \frac{3}{2}$




$\therefore Ar(\Delta UVW) = \frac{\sqrt{3}}{4}\left(\frac{3}{2}\right)^2 = \frac{9\sqrt{3}}{16}$

$\therefore$ Volume of tetrahedron with coterminous edges $\vec{u}, \vec{v}, \vec{w}$

$= \frac{1}{3}(Ar.\Delta UVW) \times OP = \frac{1}{3} \times \frac{9\sqrt{3}}{16} \times \frac{1}{2} = \frac{3\sqrt{3}}{32}$

$\therefore$ parallelopiped with coterminous edges

$\vec{u}, \vec{v}, \vec{w} = 6 \times \frac{3\sqrt{3}}{32} = \frac{9\sqrt{3}}{16} = V$

$\therefore \frac{80}{\sqrt{3}} V = 45$

**47. (3)**

$T_{r+1} = {}^4C_r \left(a.x^2\right)^{4-r} . \left(\frac{70}{27bx}\right)^r$

$= {}^4C_r . a^{4-r} . \frac{70^r}{(27b)^r} . x^{8-3r}$

Here 8-3r=5

$8-5=3r \Rightarrow r=1$

$\therefore coeff. = 4.a^3 . \frac{70}{27b}$

$T_{r+1} = {}^7C_r (ax)^{7-r} \left(\frac{-1}{bx^2}\right)^r$

$= {}^7C_r . a^{7-r} \left(\frac{-1}{b}\right)^r . x^{7-3r}$

$7-3r=-5 \Rightarrow 12=3r \Rightarrow r=4$

Coeff.: ${}^7C_4 . a^3 . \left(\frac{-1}{b}\right)^4 = \frac{35a^3}{b^4}$

Now $\frac{35a^3}{b^4} = \frac{280a^3}{27b}$

$b^3 = \frac{35 \times 27}{280} = b = \frac{3}{2} \Rightarrow 2b = 3$

**48. (a)**

Given x + 2y + z = 7 ....(1)

x + $\alpha$ z=11 ....(2)

2x-3y+ $\beta$ z = $\gamma$ ....(3)

Now, $\Delta = \begin{vmatrix} 1 & 2 & 1 \\ 1 & 0 & \alpha \\ 2 & -3 & \beta \end{vmatrix} = 7\alpha - 2\beta - 3$

$\therefore$ if $\beta = \frac{1}{2}(7\alpha - 3)$

$\Rightarrow \boxed{\Delta = 0}$

Now, $\Delta_x = \begin{vmatrix} 7 & 2 & 1 \\ 11 & 0 & \alpha \\ \gamma & -3 & \beta \end{vmatrix}$

$= 21\alpha - 22\beta + 2\alpha\gamma - 33$

$\therefore$ if $\gamma = 28$

$\Rightarrow \Delta_x = 0$

$\Delta_y = \begin{vmatrix} 1 & 7 & 1 \\ 1 & 11 & \alpha \\ 2 & \gamma & \beta \end{vmatrix}$

$\Delta_y = 4\beta + 14\alpha - \alpha\gamma + \gamma - 22$

$\therefore$ if $\gamma = 28$

$\Rightarrow \Delta_y = 0$

Now, $\Delta_z = \begin{vmatrix} 1 & 2 & 7 \\ 1 & 0 & 11 \\ 2 & -3 & \gamma \end{vmatrix} = 56 - 2\gamma$

If $\gamma = 28$

$\Rightarrow \boxed{\Delta_z = 0}$

$\therefore$ if $\gamma = 28$ and $\beta = \frac{1}{2}(7\alpha - 3)$

$\Rightarrow$ system has infinite solution

and if $\gamma \neq 28$

$\Rightarrow$ system has no solution

$\Rightarrow P \to (3)$ ; $Q \to (2)$

Now if $\beta \neq \frac{1}{2}(7\alpha - 3)$

$\Rightarrow \Delta \neq 0$

and for $\alpha = 1$ clearly

$y = -2$ is always be the solution

$\therefore$ if $\gamma \neq 28$

System has a unique solution

if $\gamma = 28$

$\Rightarrow x = 11$, $y = -2$ and $z = 0$ will be one of the solution

$\therefore R \to 1$ ; $S \to 4$

$\therefore$ option 'A' is correct

**49. (a)**

Sol. $x_i$ 3 4 5 8 10 11

$f_i$ 5 4 4 2 2 3

(P) Mean

(Q) Median

(R) Mean deviation about mean

(S) Mean deviation about median

| $x_i$ | $f_i$ | $x_i f_i$ | C.F. | $\lvert x_i - \text{Mean}\rvert$ | $f_i\lvert x_i - \text{Mean}\rvert$ | $\lvert x_i - \text{Median}\rvert$ | $f_i\lvert x_i - \text{Median}\rvert$ |
|---|---|---|---|---|---|---|---|
| 3 | 5 | 15 | 5 | 3 | 15 | 2 | 10 |
| 4 | 4 | 16 | 9 | 2 | 8 | 1 | 4 |
| 5 | 4 | 20 | 13 | 1 | 4 | 0 | 0 |
| 8 | 2 | 16 | 15 | 2 | 4 | 3 | 6 |
| 10 | 2 | 20 | 17 | 4 | 8 | 5 | 10 |
| 11 | 3 | 33 | 20 | 5 | 15 | 6 | 18 |
| | $\Sigma f_i = 20$ | $\Sigma x_i f_i = 120$ | | | $\Sigma f_i\lvert x_i - \text{Mean}\rvert = 54$ | | $\Sigma f_i\lvert x_i - \text{Median}\rvert = 48$ |

(P) Mean $= \frac{\Sigma x_i f_i}{\Sigma f_i} = \frac{120}{20} = 6$

(Q) Median $= \left(\frac{20}{2}\right)^{th}$ observation $= 10^{th}$ observation $= 5$

(R) Mean deviation about mean $= \frac{\Sigma f_i \lvert x_i - \text{Mean}\rvert}{\Sigma f_i} = \frac{54}{20} = 2.70$

(S) mean deviation about median $= \frac{\Sigma f_i \lvert x_i - \text{Median}\rvert}{\Sigma f_i} = \frac{48}{20} = 2.40$

**50. (b)**

$L_1 : \vec{r_1} = \lambda\left(\hat{i} + j + k\right)$

$L_2 : \vec{r_2} = j - k + \mu\left(\hat{i} + k\right)$

Let system of planes are

ax + by + cz = 0 ----(1)

$\because$ It contain $L_1$

$\because$ a + b + c = 0 …. (2)

For largest possible distance between plane (1) and $L_2$ the line $L_2$ must be parallel to plane (1)
∴ a + c = 0 …. (3)
$\Rightarrow b = 0$
∴ Plane $H_0$: x-z = 0
Now $d(H_0)$ = ⊥ distance from point (0, 1, -1) on $L_2$ to plane.
$\Rightarrow d(H_0) = \left|\frac{0+1}{\sqrt{2}}\right| = \frac{1}{\sqrt{2}}$
$\therefore P \to 5$
for 'Q' distance $= \left|\frac{2}{\sqrt{2}}\right| = \sqrt{2}$
$\therefore Q \to 4$
∴ (0, 0, 0) lies on plane
∴ R → 3
For 'S' x = z ; y = z ; x = 1
∴ point of intersection p(l, 1, 1).
$\therefore OP = \sqrt{1+1+1} = \sqrt{3}$
$\therefore S \to 2$

**51. (b)**

∵ $|z|^3 + 2z^2 + 4\bar{z} - 8 = 0$ ….(1)
Take conjugate both sides
$\Rightarrow |z|^3 + 2\bar{z}^2 + 4z - 8 = 0$ ….(2)
By(l)-(2)
$\Rightarrow 2(z^2 - \bar{z}^2) + 4(\bar{z} - z) = 0$
$\Rightarrow \boxed{z + \bar{z} = 2}$ …. (3)
$\Rightarrow |z + \bar{z}| = 2$ …. (4)
Let z = x + iy
$\therefore \boxed{x = 1}$ $\therefore z = 1 + iy$
Put in (1)
$\Rightarrow (1 + y^2)^{3/2} + 2(1 - y^2 + 2iy) + 4(1 - iy) - 8 = 0$
$\Rightarrow (1 + y^2)^{3/2} = 2(1 + y^2)$
$\Rightarrow \sqrt{1 + y^2} = 2 = |z|$
Also $\boxed{y = \pm\sqrt{3}}$
$\therefore z = 1 \pm i\sqrt{3}$
$\Rightarrow z - \bar{z} = \pm 2i\sqrt{3}$
$\Rightarrow |z - \bar{z}| = 2\sqrt{3}$
$\Rightarrow |z - \bar{z}|^2 = 12$
Now $z + 1 = 2 + i\sqrt{3}$
$|z + 1|^2 = 4 + 3 = 7$
$\therefore P \to 2 ; Q \to 1 ; R \to 3 ; S \to 5$
∴ Option [B] is correct.