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| SEC: Sr.Super60_STERLING BT | JEE-MAIN | Date: 05-07-2025 |
| Time: 09:00AM to 12:00PM | QMT-12 | Max. Marks: 300 |

# KEY SHEET

## MATHEMATICS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | **1** | 2 | **3** | 3 | **1** | 4 | **3** | 5 | **4** |
| 6 | **1** | 7 | **3** | 8 | **2** | 9 | **3** | 10 | **2** |
| 11 | **3** | 12 | **1** | 13 | **3** | 14 | **1** | 15 | **2** |
| 16 | **1** | 17 | **4** | 18 | **1** | 19 | **2** | 20 | **2** |
| 21 | **238** | 22 | **16** | 23 | **54** | 24 | **80** | 25 | **7** |

## PHYSICS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 26 | **1** | 27 | **1** | 28 | **4** | 29 | **3** | 30 | **3** |
| 31 | **1** | 32 | **1** | 33 | **2** | 34 | **4** | 35 | **1** |
| 36 | **3** | 37 | **1** | 38 | **1** | 39 | **1** | 40 | **2** |
| 41 | **3** | 42 | **3** | 43 | **1** | 44 | **1** | 45 | **1** |
| 46 | **1** | 47 | **130** | 48 | **34** | 49 | **120** | 50 | **10** |

## CHEMISTRY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 51 | **3** | 52 | **3** | 53 | **3** | 54 | **2** | 55 | **2** |
| 56 | **2** | 57 | **3** | 58 | **2** | 59 | **2** | 60 | **4** |
| 61 | **2** | 62 | **3** | 63 | **4** | 64 | **4** | 65 | **2** |
| 66 | **1** | 67 | **1** | 68 | **1** | 69 | **4** | 70 | **4** |
| 71 | **69** | 72 | **7** | 73 | **0** | 74 | **2** | 75 | **7** |

# SOLUTIONS
# MATHEMATICS

**1.** $f^{'}(x)=16x-\frac{1}{x}$

$f^{'}(x)=0 \Rightarrow x=\frac{1}{4}$

$\therefore a=\frac{1}{4}$

$$\begin{array}{ccc} & - \quad + & \\ \hline 0 & 1/4 & 4 \end{array}$$

Let $(x_1, y_1)$ be any point on parabola $y^2=2x$ diff.
w.r.t. x

$y^{'}=\frac{1}{y_1}=m_T$

$\therefore \frac{1}{y_1}=\frac{3-y_1}{4-x_1} \Rightarrow \frac{1}{y_1}=\frac{3-y_1}{4-\frac{y_1^2}{2}} \Rightarrow 8-y_1^2=6y_1-2y_1^2 \Rightarrow y_1^2-6y_1+8=0 \Rightarrow y_1=2,4$

Point is P (2, 2) or (8, 4)
Tangent at (2, 2) is

$y-2=\frac{1}{2}(x-2)$

As $(-2,0)$ satisfies $\Rightarrow$ Reject
P (8, 4)
Normal at P (8, 4) is
$y-4=-4(x-8)=-4x+32 \Rightarrow 4x+y=36$

**2.** P) If the required image is (x, y, z) then

$\frac{x-3}{2}=\frac{y-5}{1}=\frac{z-7}{1}=\frac{-2(6+5+7+18)}{2^2+1^2+1^2}=-12$

Or $(x,y,z)\equiv(-21,-7,-5)$

Q) point on line is of the form $(2-3\lambda, 1-2\lambda, 3+2\lambda)$

$\Rightarrow 2(2-3\lambda)+(1-2\lambda)-(3+2\lambda)-3=0 \Rightarrow \lambda=-\frac{1}{10}$

$\Rightarrow$ required point is $\left(\frac{23}{10},\frac{6}{5},\frac{14}{5}\right)$

R) If $(x,y,z)$ is the required foot of the perpendicular, then

$\frac{x-1}{2}=\frac{y-1}{-2}=\frac{z-2}{4}=\frac{-(2-2+8+5)}{2^2+(-2)^2+4^2}$

Or $(x,y,z)\equiv\frac{-1}{12},\frac{25}{12},\frac{-2}{12}$

S) Any point on the line

$$\frac{x-1}{2}=\frac{y-2}{3}=\frac{z-3}{4}=\lambda$$

Is $P(2\lambda+1, 3\lambda+2, 4\lambda+3)$ which satisfies the line

$$\frac{x-4}{5}=\frac{y-1}{2}=\frac{z}{1}$$

Or $\dfrac{2\lambda+1-4}{5}=\dfrac{3\lambda+2-1}{2}=\dfrac{4\lambda+3}{1}$

Or $\lambda=-1$

The required point is $(-1,-1,-1)$

**3.** Eccentricity of ellipse $e_1=\sqrt{1-\frac{16}{25}}=\frac{3}{5}$

Foci $=(\pm ae,0)=(\pm 3,0)$

For hyperbola

Ecentricity $e_2=\frac{5}{3}$

Semi-transverse axis $\rightarrow a=3$

$$b^2=a^2(e^2-1)=9\left(\frac{25}{9}-1\right)=16$$

Equation of hyperbola

$$\frac{x^2}{9}-\frac{y^2}{16}=1$$

**4.** Differentiate w.r.t x

$$f'(x)+\frac{f(x)}{x}=\frac{1}{2\sqrt{x+1}}$$

$$I.E.=e^{\int\frac{1}{x}dx}=e^{\ln x}=x$$

$$xf(x)=\int\frac{x}{2\sqrt{x+1}}dx$$

$$x+1=t^2$$

$$=\int\frac{t^2-1}{2t}2tdt$$

$$xf(x)=\frac{t^3}{3}-t+c$$

$$xf(x)=\frac{(x+1)^{3/2}}{3}-\sqrt{x+1}+c$$

Also putting x = 3 in given equation $f(3)+0=\sqrt{4}$

$$f(3)=2\Rightarrow C=8-\frac{8}{3}=\frac{16}{3}$$

$$f(x)=\frac{\frac{(x+1)^{\frac{3}{2}}}{3}-\sqrt{x+1}+\frac{16}{3}}{x}$$

$$f(8)=\frac{9-3+\frac{16}{3}}{8}=\frac{34}{24}\Rightarrow 12f(8)=17$$

**5.** $3-x=\frac{x^2+3}{2}\Rightarrow x=1,-3$

$-x+1=\frac{x^2+3}{2}\Rightarrow x=-1$

Area $A=2\sqrt{2}\times\sqrt{2}-2\left(\int_0^1\left((3-x)-\left(\frac{x^2+3}{2}\right)\right)dx\right)$

$A=\frac{7}{3}$

**6.** $=24\int_0^{\frac{\pi}{48}}-\sin\left(4x-\frac{\pi}{12}\right)+\int_{\pi/48}^{\pi/4}\sin\left(4x-\frac{\pi}{12}\right)dx$

$+\int_0^{\frac{\pi}{6}}[0]dx+\int_{\pi/6}^{\pi/4}[2\sin x]dx=24\left[\frac{\left(1-\cos\frac{\pi}{2}\right)}{4}-\frac{\left(-\cos\frac{\pi}{12}-1\right)}{4}\right]+\frac{\pi}{4}-\frac{\pi}{6}$

$=24\left(\frac{1}{2}+\frac{\pi}{12}\right)=2\pi+12=$ $\alpha=12$

**7.** $y=mx+\frac{2}{m}\Rightarrow m^2x-my+2=0$

Centre of circles is (6, 0), $r=\sqrt{32}$

$\left|\frac{6m^2+2}{r1+m^4}\right|=\sqrt{32}\Rightarrow 4(3m^2+1)^2=32(1+m^4)\Rightarrow m=\pm1$

Perpendicular tangent meet on directrix

Equation of directrix is $x=-2\therefore P(-2,0)$

Ans. = 4

**8.** $x_1x_2x_3x_4x_5=1050=2\times3\times5^2\times7$

Thus $5^2$ can assign in ${}^5C_1+{}^5C_2=15$ *ways*

We can assign 2, 3 or 7 to any of 5 variables

Hence req. number of solutions $=5\times5\times5\times15=1875$

**9.** 210 can be factorized as $210=2\times3\times5\times7$. All the factors are primes. Clearly any number can be assigned to $x_1$'s in 4 ways. Hence total ways of assigning the factors to $x_1$ 's are $4^4$ Now for a particular positive integral solution, we have ${}^4C_2$ solution when any two $x_1$'s become negative, and all the four solutions can be negative in ${}^4C_4$ ways.

Hence total number of integral solutions $2\cos^{-1}x-\sin^{-1}(2x+1)=\frac{3\pi}{2}$

**10**. $2\cos^{-1}x-\sin^{-1}(2x+1)=\frac{3\pi}{2}$

$\cos^{-1}x=\alpha,\ \sin^{-1}(2x+1)=\beta$

$2\alpha=\frac{3\pi}{2}+\beta$

$\cos 2\alpha=\sin\beta$

$2x^2-1=2x+1$

$x^2-x-1=0$

$x=\frac{1-\sqrt{5}}{2}$

$4x^2-4x=4$

**11.** $|[\vec{a}\ \ \vec{b}\ \ \vec{c}\ ]|=30$

$|abc\sin\theta\cos\phi|=30\Rightarrow\theta=\frac{\pi}{2},\phi=0\Rightarrow\vec{a},\vec{b},\vec{c}$ are mutually perpendicular

$(2\vec{a}+\vec{b}+\vec{c}).[(\vec{a}\times\vec{c})\times(\vec{a}-\vec{c})+\vec{b}]=(2\vec{a}+\vec{b}+\vec{c}).[a^2\vec{c}+c^2\vec{a}+\vec{b}]$

$=50a^2+b^2+4c^2=200+9+100=309$

$\frac{k}{103}=\frac{309}{103}=3$

**12.** **ASSASSINATIOIN** contains 4S, 3A, 2I, 2N, and one each of T and O. Four letters can be selected in following ways 1) all four identical in 1 ways.

2) Three identical and one different letter (e.g. AAAN) in ${}^2C_1\times{}^5C_1=10\ ways$

3) Two identical of one kind and two identical of another kind (eg. SSNN) in ${}^4C_2=6\,ways$

4) Two identical and other two different (e.g IINT) in ${}^4C_1\times{}^5C_2=40\,ways$

Total number of ways = 1 + 10 + 6 + 40 + 15 = 72

5) All four different letters is ${}^6C_4=15$ ways

**13.** $x_1+x_2+x_3+x_4+x_5+x_6+x_7=12, x_i\in\{1,2,3,4\}$

Number of solutions

$=$ coefficient of $x^{12}$ in $\left(x+x^2+x^3+x^4\right)^7$

$=$ coefficient of $x^{12}$ in $x^7\left(1+x+x^2+x^3\right)^7$

$=$ coefficient of $x^5$ in $\left(\frac{1-x^4}{1-x}\right)^7$

=coefficient of $x^5$ in $\left(1-x^4\right)^7\left(1-x\right)^{-7}$

=coefficient of $x^5$ in $\left(1-7x^4\right)\left(1+{}^7c_1x+{}^8c_2x^2+...+{}^{11}c_5x^5+...\right)$

$= {}^{11}c_5x^5-7x\,{}^7c_1=462-49=413$

**14.** Number of quadrilaterals having no side is common with the sides of the polygon.

$={}^nC_4-n({}^{n-5}C_2)-\frac{3}{2}n(n-5)-n.$ Substitute n = 10.

**15.** Each group contains 5 teams

In the first round the number of matches $={}^5C_2+{}^5C_2=10+10=20$

The number of matches in quarterfinals $={}^6C_2=\frac{6\times5}{2}=15$

The number of matches in semifinals $={}^4C_2=\frac{4\times3}{2}=6$

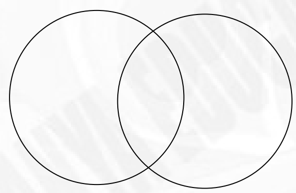
In finals, the minimum number of matches = 2

So, required ways = 20 + 15 + 6 + 2 = 43

**16.** Given circles = 6, straight lines = 6

$\xrightarrow{Case(i)}$ for circles

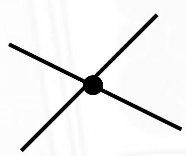
Two circles intersect at two different points



For 6 circle we have ${}^6C_2\times2=\frac{6\times5}{2\times1}\times2=30$

$\xrightarrow{Case(ii)}$ for straight lines

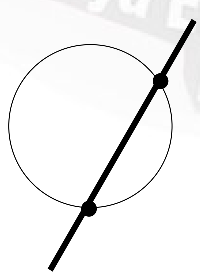
Two straight lines intersect at one point



For 6 straight lines ${}^6C_2\times1=15$

$\xrightarrow{Case(iii)}$ one circle & one straight lines

One circle & one line intersect at two different points



So we have ${}^6C_1\times{}^6C_1\times2=6\times6\times2=72$

**17.** $x+y+z+w=15,\ x\ge 0,\ \ y>5,\ z\ge 2,\ w\ge 1$

$x+y-6+z-2+w-1=6,\ y\ge 6$

$N={}^{6+4-1}C_{4-1}$

**18.** Given y+z = 5 …. (i)

and $\frac{1}{y}+\frac{1}{z}=\frac{5}{6}, y>z$ …. (ii)

Solving (i) and (ii), we get y=3, z=2⇒ $n=2^x.3^3.5^2=(2.2.2....)\ (3.3.3)(5.5)$

∴ Number of odd divisors

= (3+1(2+1) = 4x3 = 12

**19.** $(b)|A|=m-n$

And $4m+n=22 \Rightarrow n=22-4m$

Also, $17m+4n=93$

$\Rightarrow m=5$

$\therefore n=22-4\times 5=2$

$|A|=m-n=5-2=3$

$\operatorname{Det}\det(n\,adj(adj(mA))=3^a5^b6^c$

$=n^m[\det(mA)]^{(m-1)^2}\quad =n^m(m^m\det(A))^{(m-1)^2}=n^m.m^{m(m-1)^2}(|A|)^{(m-1)^2}$

$\therefore n=2, m=5\ and\ |A|=3$

$\therefore 2^5.5^{5(5-1)^2}(3)^{(5-1)^2}=2^5.5^{5\times 4^2}(3)^{4^2}\quad =2^5.5^{80}.3^{16}=2^5\times 3^5\times 3^{11}\times 5^{80}=3^{11}\times 5^{80}\times 6^5=3^a5^b6^c$

**20.** $\frac{1}{x}+\frac{1}{y}=\frac{1}{n}\Rightarrow (x-n)(y-n)=n^2$

No. of divisors of $n^2$ is equal to number of pairs but if n is prime then no of divisors of $n^2$ is 3

**21.** Conceptual

**22.** $(1+\sin^4 x)(2+\cot^2 y)(4+\sin 4z)\le 12\sin^2 x$

$\Rightarrow (\sin^2 x+\cos ec^2 x)(2+\cot^2 y)(4+\sin 4z)\le 12$

Now, $\sin^2 x+\cos c^2 x\ge 2,\ 2+\cot^2 y\ge 2,\ 4+\sin 4z\ge 3$

$\Rightarrow \sin^2 x=1, \cot^2 y=0, \sin 4z=-1\Rightarrow x=\frac{\pi}{2},\frac{3\pi}{2},\ y=\frac{\pi}{2},\frac{3\pi}{2}$

$z=\frac{3\pi}{8},\frac{11\pi}{8},\frac{15\pi}{8},\frac{7\pi}{8}$

Number of triplets $=2\times 2\times 4=16$

**23.** $(1+2x-3x^2)\left(\frac{3}{2}x^2-\frac{1}{3x}\right)^9$

General term$=\left(\frac{3}{2}x^2-\frac{1}{3x}\right)^9={}^9C_r.\frac{3^{9-2r}}{2^{9-r}}(-1)^r.x^{18-3r}$

Put r = 6 to get coef. Of $x^0 = {}^9C_6.\frac{1}{6^3}.x^0 = \frac{7}{18}x^0$

Put r = 7 to get coeff. Of $x^{-3} = {}^9C_r.\frac{3^{-5}}{2^2}(-1)^7.x^{-3} = -{}^9C_7.\frac{1}{3^5.2^2}.x^{-3} = \frac{-1}{27}x^{-3}$

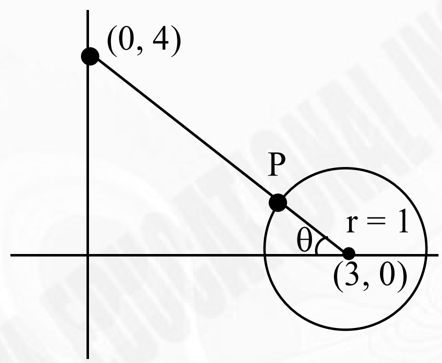
$$\frac{7}{18}+\frac{3}{27}=\frac{7}{18}+\frac{1}{9}=\frac{7+2}{18}=\frac{9}{18}=\frac{1}{2}$$

$$108.\frac{1}{2}=54$$

**24.** Here $|z-3|<1 \Rightarrow (x-3)^2+y^2<1$

And $z=(4+3i)+\bar{z}(4-3i)\le 24 \Rightarrow 4x-3y\le 12$

$$\tan\theta=\frac{4}{3}$$




Coordinate of $P=(3-\cos\theta, sin\theta)=\left(3-\frac{3}{5},\frac{4}{5}\right)$

$$\alpha+i\beta=\frac{12}{5}+\frac{4}{5}i$$

$$25(\alpha+\beta)=80$$

**25.** $\int\frac{1}{\sqrt[5]{(x-1)^4(x+3)^6}}dx=A\left(\frac{\alpha x-1}{\beta x+3}\right)^B+C$

$I=\int\frac{1}{(x-1)^{4/5}(x+3)^{6/5}}dx=$ $\quad I=\int\frac{1}{\left(\frac{x-1}{x+3}\right)^{4/5}(x+3)^2}dx$

$\left(\frac{x-1}{x+3}\right)=t\Rightarrow\frac{4}{(x+3)^2}dx=dt\ t^{-4/5+1}$

$I=\frac{1}{4}\int\frac{1}{t^{4/5}}dt=\frac{1}{4}\frac{t^{1/5}}{1/5}+c=$ $I=\frac{5}{4}\left(\frac{x-1}{x+3}\right)^{1/5}+C$

$A=\frac{5}{4}\alpha=\beta=1\ B=\frac{1}{5}$

$$\alpha+\beta+20AB=2+20\times\frac{5}{4}\times\frac{1}{5}=7$$

# PHYSICS

**26.**

$$\lambda^1 = \frac{C - V_w}{f_o} \Rightarrow \lambda^1 < \frac{C}{f_0}$$

$$n^1 = f_o\left(\frac{C}{C - V_o - V_w}\right) \Rightarrow n^1 > f_o$$

$$\lambda^1 = \frac{C + V_w}{f_o} \Rightarrow \lambda^1 > \frac{C}{f_0}$$

$$n^1 = f_o\left(\frac{C}{C + V_w}\right) \Rightarrow n^1 < f_o$$

$$\lambda^1 = \left(\frac{C + V_o + V_w}{f_o}\right) \Rightarrow \lambda^1 > \frac{C}{f_0}$$

$$n^1 = f_o$$

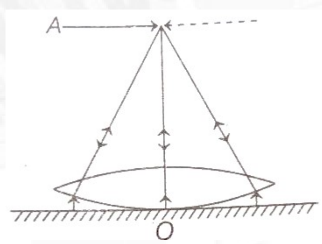
$$\lambda^1 = \frac{C - (V_o + V_w)}{f_o} \Rightarrow \lambda^1 < \frac{c}{f_o}$$

$$n^1 = f_o$$

**27.** Conceptual

**28.** Conceptual

**29.** Light from plane mirror is reflected back on it's path, so that image of A coincides with A itself.




This would happen when rays refracted by the convex lens falls normally on the plane mirror, i.e. the refracted rays from a beam parallel to principal axis of the lens. Hence, the object would then be considered at the focus of convex lens.

$\therefore$ Focal length of curvature of convex lens is $f_1 = 18\,cm$

With liquid between lens and mirror, image is again coincides with object, so the second measurement is focal length of combination of liquid lens and convex lens.

$$\therefore \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f_{eq}} \Rightarrow \frac{1}{18} + \frac{1}{f_2} = \frac{1}{27} \Rightarrow f_2 = -54\,cm$$

For convex lens by lens maker's formula, we have

$$\frac{1}{f} = (\mu - 1)\left(\frac{2}{R}\right) \Rightarrow \frac{1}{18} = 0.5 \times \frac{2}{R}$$

And for plano=convex liquid lens, we have

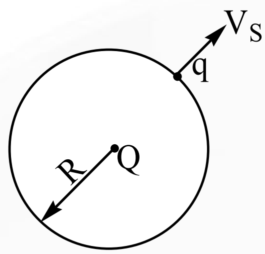
$$\frac{1}{f} = (\mu - 1)\left(\frac{-1}{R}\right) \Rightarrow -\frac{1}{54} = (\mu_1 - 1)\left(\frac{-1}{18}\right) \Rightarrow \mu_1 = 1 + \frac{1}{3} = \frac{4}{3}$$

**30.** Let q be positive

If it escapes then, from energy conservation principle

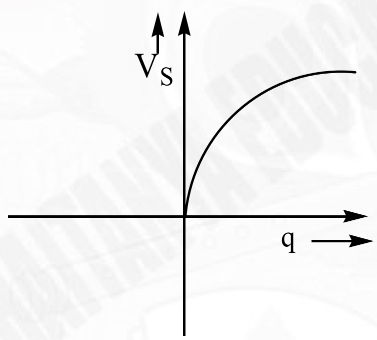
$$\frac{1}{2}mv_s^2+\frac{KQq}{R}=0$$

$$v=\sqrt{\frac{-2KQq}{Rm}}$$




{Note that Q is negative, therefore the quantity within the root is positive} $v \propto \sqrt{q}$

When q is negative, escape velocity will be zero due to electrostatic repulsion from negative Q $v \propto \sqrt{q}$




**31.** $$\vec{v}_{cm}=\frac{m_1\vec{v}_1+m_2\vec{v}_2}{m_1+m_2}$$

$$\vec{v}_{cm}=\frac{nmv\hat{i}+mnv\cos\theta\hat{i}+nmv\sin\theta\hat{j}}{m+nm}$$

$$v_{cm}=\frac{\sqrt{(nmv+mnv\cos\theta)^2+(nmv\sin\theta)^2}}{m(1+n)}$$

$$v_{cm}=\frac{nmv\sqrt{(1+c\,os\theta)^2+(s\,in\theta)^2}}{m(1+n)}$$

$$=\frac{nv\sqrt{1+\cos^2\theta+2\cos\theta+\sin^2\theta}}{(1+n)}=\left(\frac{nv}{n+1}\right)\sqrt{2^2\cos^2\frac{\theta}{2}}$$

$$v_{cm}=\frac{2nv\cos\frac{\theta}{2}}{n+1}=\frac{nv\sqrt{3}}{(n+1)}=\frac{3n}{n+1}$$

**32.** The graph of current is given by

$$i = i_0(1-e^{-t/\tau}) \Rightarrow \frac{di}{dt} = \frac{i_0}{\tau}e^{-t/\tau}$$

Energy stored in the form of magnetic field energy is

$$U_B = \frac{1}{2}Li^2$$

Rate of increase of magnetic field energy is

$$R = \frac{dU_B}{dt} = Li\frac{di}{dt}$$

$$= \frac{Li_0^2}{\tau}(1-e^{-t/\tau})e^{-t/\tau}$$

This will be maximum when $\frac{dR}{dt} = 0 \Rightarrow e^{-t/\tau} = 1/2$

Substituting

$$R_{\max} = \frac{Li_0^2}{\tau} = \frac{Li_0^2}{\tau}\left(1-\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{Li_0^2}{4\tau} = \left[\frac{L(E/R)}{4(L/R)}\right] = \frac{E^2}{4R}$$

**33.** The focal length of combination is given by

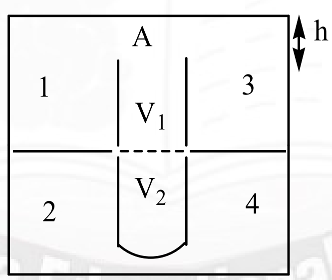
$$\frac{1}{F} = \frac{1}{40} - \frac{1}{25}\left(\frac{1}{F} = \frac{1}{F_1} + \frac{1}{F_2}\right)$$

or $\quad f = -\frac{200}{3}cm = -\frac{2}{3}m$

$\therefore$ Power of the combination in diopters,

$p = -\frac{3}{2} \quad \left[p = -\frac{1}{F(m)}\right] \quad$ =-1.5

**34.**

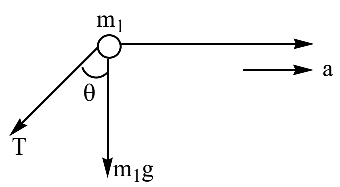


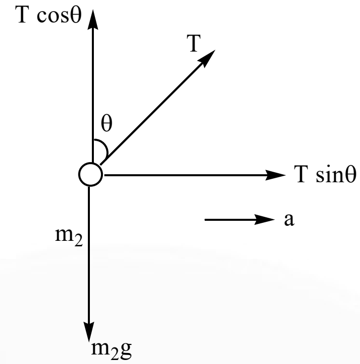

$\rho_1 v_1 g$ is not the force applied by liquid 1 on body, it is $\rho_1 gh \times A$, although net force (buoyant) comes out to be $\rho_1 v_1 g + \rho_2 v_2 g$

**35.** $1 \rightarrow d; ii \rightarrow c; iii \rightarrow b; iv \rightarrow a$

$F = (m_1 + m_2)a$

$T\sin\theta = m_2 a$




$T\cos\theta = m_2 g \Rightarrow T = m_2 g \sec\theta$

From (ii) and (iii) $a = g\tan\theta$

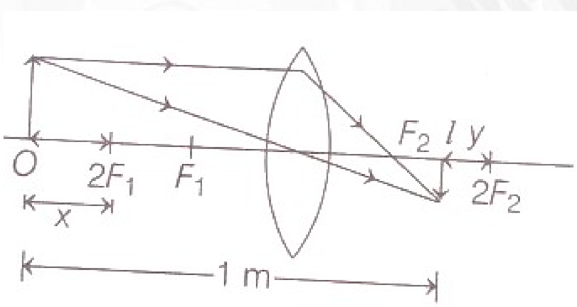
Put in (i), $F = (m_1 + m_2) g \tan\theta$

Net force acting on $m_2 = m_2 a = \dfrac{m_2 F}{m_1 + m_2}$

Force acting on $m_1$ by wire:

$m_1 g + T\cos\theta = m_1 g + m_2 g$

**36.** Image can be formed on the screen if it is real. Real image of reduced size can be formed by a concave mirror or a convex lens.




A diminished real images is formed by a convex lens when the object is placed beyond 2f and the image of such objecdt is formed between f and 2f on other side

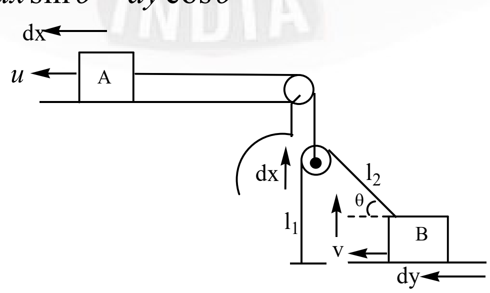
Thus, $d > (2f + 2f)$ $(x > y)$

or $4f < 0.1m$

or $f < 0.25m$

**37.** Let in a small time dt, displacement of A is dx and displacement of B id dy. Increase in length $l_1 = dx$

Increase in the length $l_2 = dx\sin\theta - dy\cos\theta$

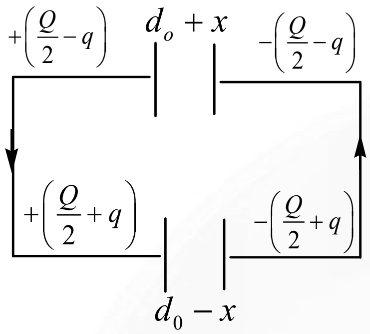



But net increase in the length should be zero, so

$$dx + dx\sin\theta - dy\cos\theta = 0$$

$$\Rightarrow dy = \frac{(1+\sin\theta)dx}{\cos\theta} \Rightarrow \frac{dy}{dx} = \left(\frac{1+\sin\theta}{\cos\theta}\right)\frac{dx}{dt} \Rightarrow v = \left(\frac{1+\sin\theta}{\cos\theta}\right)u$$

**38.** Let each plate moves a distance ‘x’ from its initial position



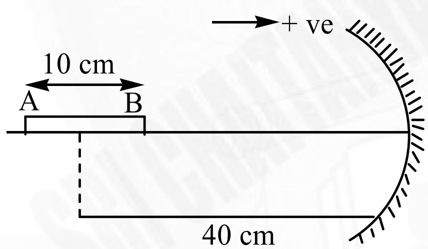

Let q charge flows in the loop using KVL

$$\frac{\left(\frac{Q}{2}-q\right)(d_0+x)}{\varepsilon_0 A} - \frac{\left(\frac{Q}{2}+q\right)(d_0-x)}{\varepsilon_0 A} = 0$$

$$q = \frac{Qx}{2d_0}; I = \frac{dq}{dt} = \frac{Q}{2d_0}\left(\frac{dx}{dt}\right);$$

$$I = \frac{Qu_0}{2d_0}$$

**39.**




$$u_A = -45cm,\ f = -20cm$$

$$\frac{1}{v_A} + \frac{1}{u_A} = \frac{1}{f} \Rightarrow \frac{1}{v_A} - \frac{1}{45} = \frac{-1}{20}$$

$$\frac{1}{v_A} = \frac{1}{45} - \frac{1}{20} \Rightarrow v_A = -36cm\ and\ u_B = -35cm$$

$$\frac{1}{v_B} + \frac{1}{u_B} = \frac{1}{f} \Rightarrow \frac{1}{v_B} - \frac{1}{35} = \frac{-1}{20}$$

$$\frac{1}{v_B} = \frac{1}{35} - \frac{1}{20} \Rightarrow v_B = -\frac{700}{15} = -\frac{140}{3}cm$$

$$v_A - v_B = length\ of\ image$$

$$= \left(-36 + \frac{140}{3}\right)cm = \frac{-108+140}{3}cm = \frac{32}{3}cm \therefore x = 32$$

**40.** Let focal length of convex lens is +f, then focal length of concave lens would be $-\frac{3}{2}f$

From the given condition, $\frac{1}{30}=\frac{1}{f}-\frac{2}{3f}=\frac{1}{3f}$

Therefore, focal length of convex lens= +10 cm and that of concave lens = -15 cm.

**41.** $\mu=\frac{\lambda_{air}}{\lambda_{medium}}=\frac{3}{2}$

Further $|m|=\frac{1}{3}=\left|\frac{v}{u}\right|$ $\Rightarrow u=-24m$ and v=+8 m

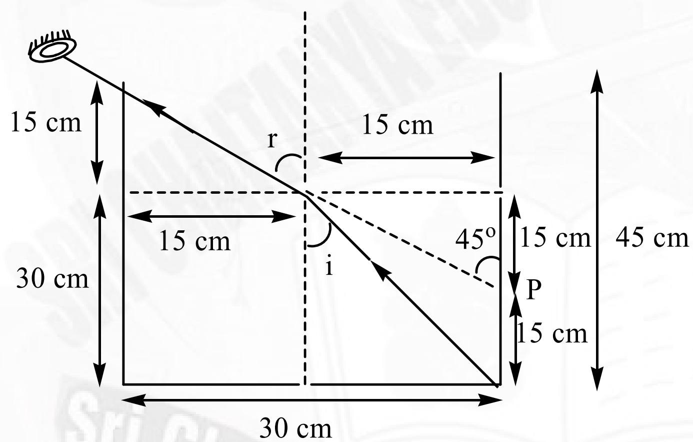
$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}=(\mu-1)\left(\frac{1}{R}-\frac{1}{\infty}\right)$

$\therefore$ R=3 m

**42.** From figure, $\sin i=\frac{15}{\sqrt{15^2+30^2}}$

$\sin r=\frac{15}{15}=1\Rightarrow r=45°$

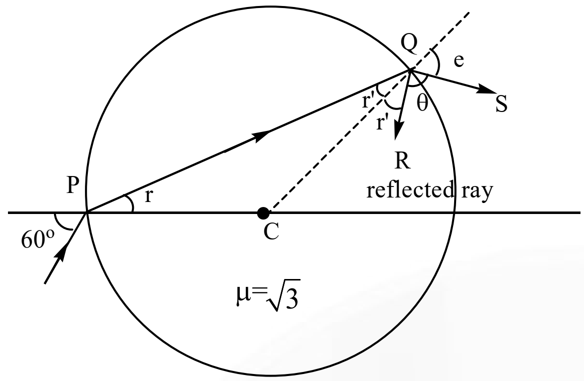
From Snell's law, $\mu\times\sin i=1\times\sin r\Rightarrow\mu\times\frac{15}{\sqrt{15^2+30^2}}=1\times\sin 45°=\frac{1}{\sqrt{2}}$




$$\mu=\frac{\frac{1}{\sqrt{2}}}{\frac{15}{\sqrt{1125}}}=158\times10^{-2}=\frac{N}{100}$$

Hence value of N = 158

**43.** In the figure, QR is the reflected ray and QS is refracted ray. CQ is normal.
Apply Snell's law at P




$$1\sin 60° = \sqrt{3}\sin r \Rightarrow \sin r = \frac{1}{2} \Rightarrow r = 30°$$

From geometry,

CP = CQ = radius

$r' = 30°$

Again apply snell's law at Q

$$\sqrt{3}\sin r' = 1\sin e \Rightarrow \frac{\sqrt{3}}{2} = \sin e \Rightarrow e = 60°$$

From geometry

$r' + \theta + e = 180°$ (*As angle lines on a straight line*) $\Rightarrow 30° + \theta + 60° = 180° \Rightarrow \theta = 90°$

**44.** Using lens formula

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{V_1} - \frac{1}{-30} = \frac{1}{+10} \Rightarrow V_1 = 15cm$$

So, $u_2 = (15-5)cm = 10cm$

$$\frac{1}{V_2} - \frac{1}{+10} = \frac{1}{-10} \Rightarrow \frac{1}{V_2} = 0 \Rightarrow V_2 = \infty$$

So, $u_3 = \infty$

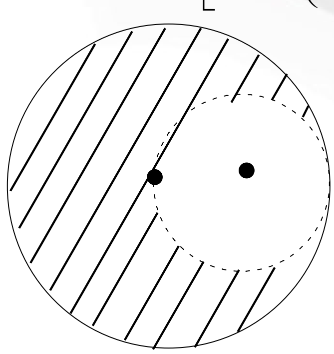
Then, $V_3 = 30cm$

$OV_3 = 75cm$

**45.** Conceptual.

**46.** Due to complete solid sphere, potential at point P

$$V_{sphere} = \frac{-GM}{2R^3}\left[3R^2 - \left(\frac{R^2}{2}\right)\right] = \frac{-GM}{2R^3}\left(\frac{11R^2}{4}\right) = -11\frac{GM}{8R}$$



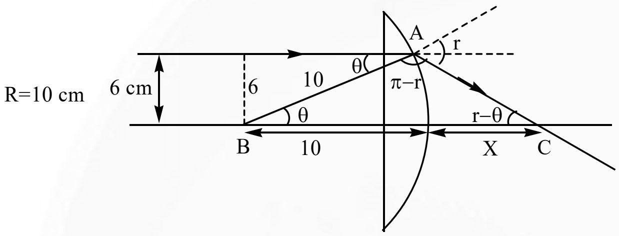
Due to cavity part potential at point P

$$V_{cavity} = -\frac{3}{2}\frac{\frac{GM}{8}}{\frac{R}{2}} = -\frac{3GM}{8R}$$

So potential at the centre of cavity

$$= V_{sphere} - V_{cavity} = -\frac{11GM}{8R} - \left(\frac{-3}{8}\frac{GM}{R}\right) = \frac{-GM}{R}$$

**47.**




Applying Snell's law $\frac{\sin\theta}{\sin r} = \frac{3}{4} \Rightarrow r = 53°$

By sine law in $\Delta ABC \frac{\sin(r-\theta)}{10} = \frac{\sin(\pi - r)}{(10+x)}$

$$\frac{10+x}{10} = \frac{4}{5(\sin r\cos\theta - \cos r\sin\theta)} = \frac{4}{5\left(\frac{4}{5}\times\frac{4}{5} - \frac{3}{5}\times\frac{3}{5}\right)}$$

$$10 + x = \frac{200}{7}$$

(note : $f = 30cm\ for\ paraxial\ rays)(f_m < f_p) \Rightarrow x = \frac{200-70}{7} = \frac{130}{7} = 18.5cm$

**48.** Given focal length of $L_1 = 24m$

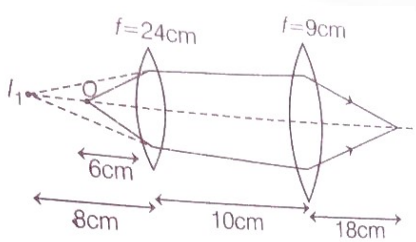
Focal length of $L_2 = 9cm$ distance b/w two lenses =10 cm

According to question, for $L_1$

$$\frac{1}{v} + \frac{1}{6} = \frac{1}{24} \Rightarrow v = -8cm$$

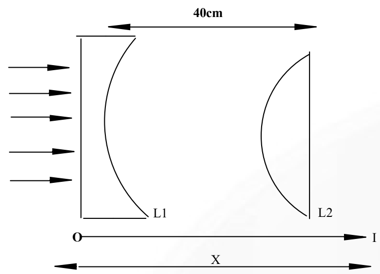
For $L_2 \frac{1}{v} + \frac{1}{18} = \frac{1}{9} \Rightarrow \frac{1}{v} = \frac{1}{18}$

$\Rightarrow$ v=18 cm



**49.** Using lens maker's formula,

$$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$



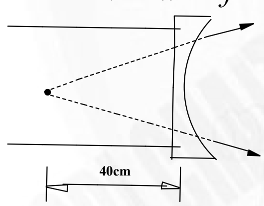

For lens, $L_1 \Rightarrow R_1=\infty, R_2=30cm$ and $\mu=175$

So, $\frac{1}{f_2}=0.75\left(\frac{1}{30}\right)=40cm$

Now, in given situation for lens $L_1$

$\mu=\infty, f_1=-40cm, v=?$

Using, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$ We have $\frac{1}{v}=\frac{1}{-40}\Rightarrow v=-40cm$




Now lens $L_2$, $\mu=-80cm, v=?, f=40cm$ So $\frac{1}{v}-\frac{1}{-80}=\frac{1}{40}$

or $\frac{1}{v}=\frac{1}{40}-\frac{1}{80}=\frac{1}{80}$

or v=80 cm

So, distance of image from plano concave $(L_1)$ is 80 + 40 = 120 cm.

**50.** $\frac{1}{10}=\left(\frac{3}{2}-1\right)\left(\frac{1}{R}-\frac{1}{\infty}\right)\Rightarrow\frac{1}{2R}=\frac{1}{10}\Rightarrow R=5cm$

Rays should retrace the path $\Rightarrow$ incident rays on mirror should be normal

$\Rightarrow\frac{3/2}{\infty}-\frac{1}{-d}=\left(\frac{1/2}{5}\right)$ [u = -d, as lens is their]$\Rightarrow\frac{1}{d}=\frac{1}{10}\Rightarrow d=10cm$

# CHEMISTRY

**51.** Friedel craft's benzoylation

**52.** $6\,CaO + P_4O_{10} \rightarrow 2\,Ca_3(PO_4)_2$

Base Acid Salt

Mole ratio of reactant = $\frac{CaO}{P_4O_{10}} = \frac{6}{1}$

Mol. wt of $P_4O_{10}$ = 284

Mole of CaO required = 6 × Mole of $P_4O_{10}$ = $6 \times \frac{852}{284}$

Weight of CaO required = $\frac{6\times 852}{284} \times 56$ = **1008 g**

**53.** Basic hydrolysis of gem dihalide

**54.** Both are Correct but **STATEMENT –II** not the correct explanation for **STATEMENT-I**.

**55.** $Cu^{+2} + 2e \longrightarrow Cu$

$E_1 = E^o_{Cu^{+2}/Cu} - \frac{0.0591}{2}\log\left(\frac{1}{Cu^{2+}}\right)_1$ as $E^o_{SHE} = 0$ and ${}^aH_2(g)$ and ${}^aH_3O^+$ in SHE are 1

$E_2 = E^o_{Cu^{+2}/Cu} - \frac{0.0591}{2}\log\left(\frac{1}{Cu^{2+}}\right)_2$ as $E^o_{SHE} = 0$ and ${}^aH_2(g)$ and ${}^aH_3O^+$ in SHE are 1

$E_2 = E^o_{Cu^{+2}/Cu} - \frac{0.0591}{2}\log\frac{10}{\left(Cu^{+2}\right)_1}$

$= E^o_{Cu^{+2}/Cu} - \frac{0.0591}{2}\log\frac{1}{\left(Cu^{2+}\right)_1} - \frac{0.0591}{2}\log 10 = E_1 - 0.030$ V

**56.** $\pi_1 v_1 + \pi_2 v_2 = \pi_R\left(v_1 + v_2\right)$

$$\pi_R = \frac{\pi_1 v_1 + \pi_2 v_2}{\left(v_1 + v_2\right)} = \frac{1.2\times 100 + 2.4\times 300}{500} = 1.86\ atm$$

**57.** $\Delta S = \frac{\Delta H}{T}$

$$T = \frac{1.435\times 10^3}{5.26} = 273\ K\ \ or\ 0^o C$$

**58.** Smaller cation and high charge has more polarizing power.

**59.** +M effect of $NH_2$ >+ M of –OH group disperse the charge of carbocation, hence increase the stability $–CH_3$ group shows +I effect, so it will disperse the charge less than $–NH_2$, –OH group. Whereas $–NO_2$ group shows –M / –I effect due to which the positive charge on the carbocation increases, hence stability decreases

**60.** Friedel-Crafts alkylation

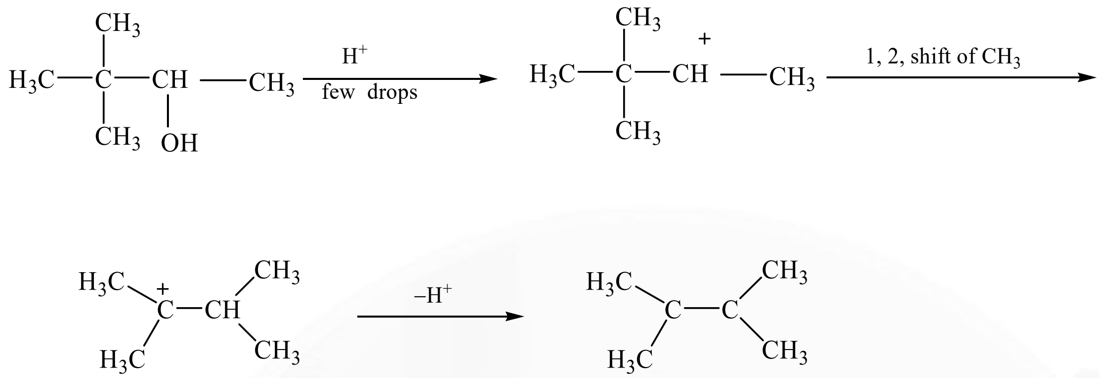
**61.** Hydrogenation followed by ozonalysis

**62.** Hydro boration followed by oxydation

**63.** Aldol condensation

**64.** Conceptual

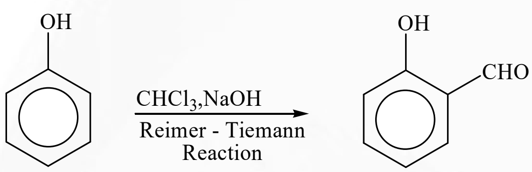
**65.**



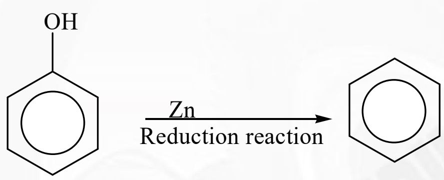

**66.** Nucleophilic addition

**67.**

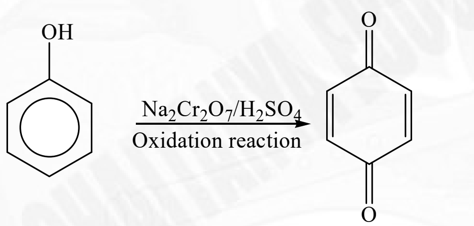
**(I)**




**(II)**

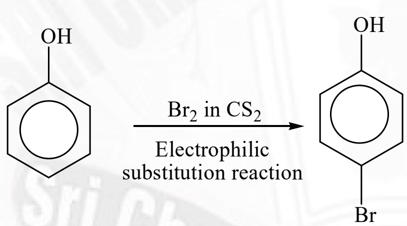



**(III)**

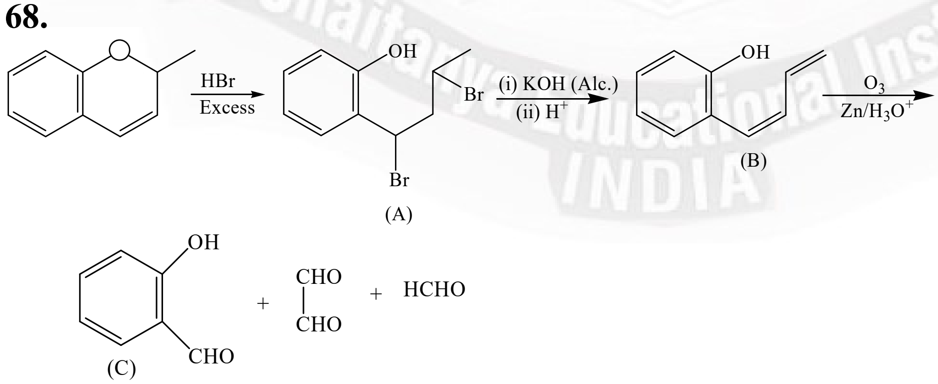



Benzoquinone

**(IV)**



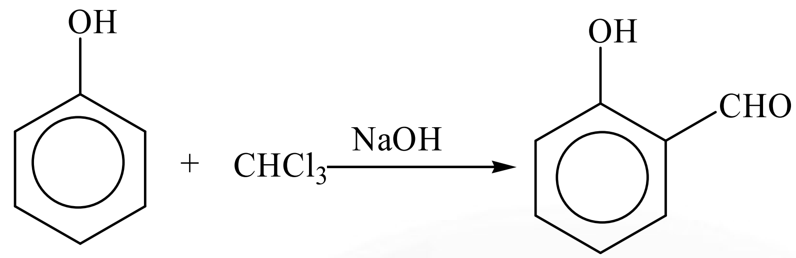

**68.**




**69.** Addition of Grignard's reagent followed by SN

**70.** Nucleophilic addition

**71.**

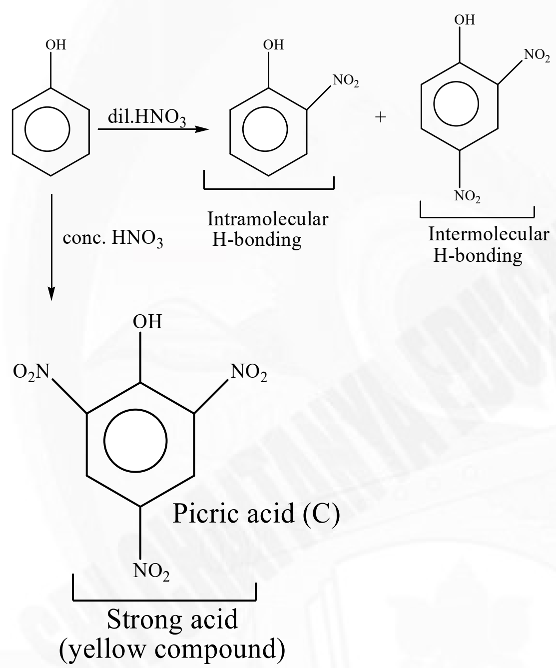



P ( Salicylaldehyde)

Molecular formula of product 'P' = $C_7H_6O_2$

So, mass % of C in 'P' = $\frac{12\times7}{84+6+32}\times100 = 68.85\% \approx 69\%$

**72.**




Number of Oxygen atoms present in compound 'C' are 7

**73.**

$$\underset{(1\text{ mole})}{[Cr(H_2O)_3(NH_3)_3]Cl_3} \longrightarrow \underset{(1\text{ mole})}{[Cr(H_2O)_3(NH_3)_3]^{3+}} + \underset{(3\text{ mole})}{3\,Cl^-} \xrightarrow{AgNO_3\text{ (Excess)}} 3\,AgCl$$

None of the chloride ion is directly bonded to metal ion. Hence, number of chloride ions satisfying the secondary valency of the metal ion is zero.

**74.** Steoreo isomerism

**75.** Polymerisation of Acetylene followed by Friedel Craft's Acylation