PACE-IIT & MEDICAL
MUMBAI / DELHI-NCR / PUNE / HYDERABAD / AKOLA / GOA / JALGOAN / BOKARO / AMRAVATI / PATNA / BARAMATI

IIT – JEE: 2026 **MAJOR TEST - 2** **DATE: 20/10/24**

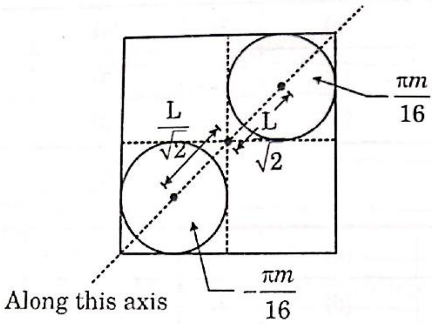
ADVANCED **ANSWER KEY**

PAPER – 1 (Code – 11)

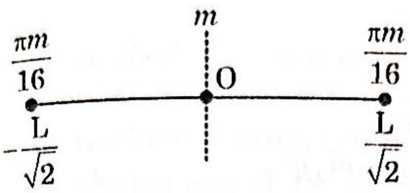
PHYSICS		CHEMISTRY		MATHEMATICS	
1.	D	**18.**	A or B or D	**35.**	C
2.	D	**19.**	C	**36.**	B
3.	B	**20.**	B	**37.**	B
4.	A	**21.**	A	**38.**	C
5.	BC	**22.**	ABD	**39.**	AC
6.	AC	**23.**	ABC	**40.**	ABC
7.	AB	**24.**	ABC	**41.**	BC
8.	6	**25.**	7	**42.**	4
9.	8	**26.**	9	**43.**	7
10.	8	**27.**	255	**44.**	3
11.	7	**28.**	7	**45.**	2
12.	5	**29.**	11	**46.**	7
13.	2	**30.**	4	**47.**	3
14.	C	**31.**	C	**48.**	B
15.	A	**32.**	D	**49.**	C
16.	A	**33.**	A	**50.**	C
17.	D	**34.**	C	**51.**	A

PART (A) : PHYSICS

1. (D)

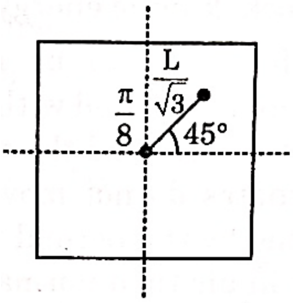


Let mass of square $= m$ then mass of disc $= \frac{\pi m}{16}$



$$\vec{r}_{CM} = \frac{\left(\frac{\pi m}{16}\right)\frac{L}{\sqrt{2}} - \frac{\pi m}{16}\left(-\frac{L}{\sqrt{2}}\right) + m \times 0}{m}$$

$$= \frac{\pi}{8}\left(\frac{L}{\sqrt{2}}\right) \qquad \text{[From origin]}$$



$$\vec{r} = \frac{\pi}{8}\left(\frac{L}{\sqrt{2}}\right)\left(\cos 45\hat{i} + \sin 45\hat{j}\right)$$

$$= \frac{\pi L}{16}\left(\hat{i} + \hat{j}\right)$$

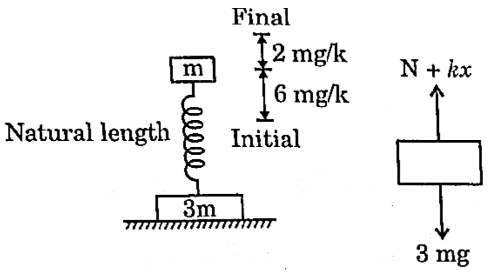
2. (D)

For $3m$ block

$N = mg$

$N + kx = 3mg$

$mg + kx = 3mg$



Extension in spring when $N = mg$ is $x = \frac{2mg}{k}$

Applying *WET* at initial and final position

$$\frac{1}{2}k\left(\frac{6mg}{k}\right)^2 - \frac{1}{2}k\left(\frac{2mg}{k}\right)^2 - \left(\frac{8mg}{k}\right)mg = \frac{1}{2}m\upsilon^2$$

$$\frac{36m^2g^2}{k} - \frac{4m^2g^2}{k} - \frac{16m^2g^2}{k} = m\upsilon^2$$

$$\frac{16m^2g^2}{k} = m\upsilon^2$$

$$\upsilon = 4g\left(\frac{m}{k}\right)^{1/2}$$

3. (B)

As $F = -\frac{dU}{dx}$

For *O* to P part, *F* is constant and has a – ve value while for rest part it is zero as *U* becomes constant.

4. (A)

$$\frac{1}{2}m\upsilon^2 = 18$$

$$m\upsilon^2 = 36$$

$$\Rightarrow \quad F = \frac{m\upsilon^2}{R} = 36N$$

5. (BC)

Work done by the spring on block
= loss in spring P.E.

$$= \frac{1}{2}ka^2 - \frac{1}{2}kb^2$$

$$= \frac{1}{2}k\left(a^2 - b^2\right)$$

This is also work done against friction $= \mu mg\left(a+b\right)$

$$\therefore \ \mu = \frac{\frac{1}{2}k\left(a^2-b^2\right)}{mg\left(a+b\right)} = \frac{k}{2mg}\left(a-b\right)$$

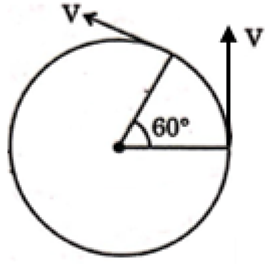
6. (AC)

Let υ_0 is velocity of train

W_F (w.r.t. girl) $= F_0 \cdot \frac{1}{2}\left(\frac{F_0}{m}\right)t_0^2$

W_F (w.r.t. boy) $= F_0\left[\frac{1}{2}\left(\frac{F_0}{m}\right)t_0^2 + \upsilon_0 t\right]$

7. (AB)

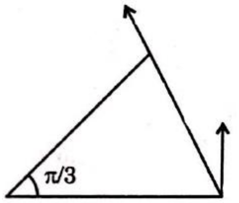


$T = \frac{2\pi l}{\upsilon}$

$t = \frac{T}{6}$

$\theta = \frac{\pi}{3}$

$\Delta V = \sqrt{2\upsilon^2 - 2\upsilon^2 \cos\frac{\pi}{3}}$



$= \upsilon$

$a_{avg} = \frac{\upsilon}{T} = \frac{6\upsilon^2}{2\pi R} = \frac{3\upsilon^2}{\pi R}$

$\upsilon_{avg} = \frac{\text{Displacement}}{\text{Time}} = \frac{R}{\frac{T}{6}} = \frac{6R\upsilon}{2\pi R} = \frac{3\upsilon}{\pi}$

8. (6)

$\frac{R}{3(4\pi - 1)}$

Here $\alpha = 3$ and $\beta = 4$

$$\frac{(\pi R^2\sigma)\times 0 - \frac{1}{2}\left(\frac{R^2}{2}\right)\sigma\left(-\frac{2R}{6}\right)}{\pi R^2\sigma - \frac{1}{2}\left(\frac{R^2}{2}\right)\sigma} = \frac{R}{3(4\pi - 1)}$$

9. (8)

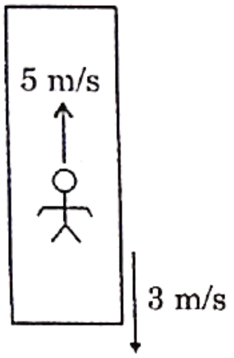
$f = 2N$

$a_{1kg} = 2\ m/s^2$

$S = \frac{1}{2} \times 2 \times 4 = 4\ m$

$W = 8J$

10. (8)



Work done by gravity on boy in 2 sec.

$W_2 = 50 \times 10 \times -2 \times 2 = -2000\,\text{J} = -2\,\text{kJ}$

Work done by gravity on ladder in 2 sec.

$W_1 = 100 \times 10 \times 6 = 6\ kJ$

$W_1 - W_2 = 8\ kJ$

11. (7)

It can be observed that power delivered to particle by force F is

$P = F\upsilon = K$

The power is constant. Hence work done by force in time t is

$\Delta W = Pt = Kt = 7$

12. (5)

Tangential acceleration, $a_t = r\alpha = 4\,\text{m/s}^2$

Radial acceleration, $a_C = \frac{\upsilon^2}{r} = \frac{60 \times 60}{1200} = 3\,\text{m/s}^2$

Hence, resultant acceleration of the car

$a = \sqrt{a_t^2 + a_C^2} = \sqrt{4^2 + 3^2} = 5\,\text{m/s}^2$

13. (2)

$u = 18\ \text{km/hr} = 5\ \text{m/s}$

$$\omega = \frac{\upsilon_1}{r} = \frac{u\sin\theta}{R} = \frac{u\sin\theta}{\frac{2(u\cos\theta)(u\sin\theta)}{g}} = \frac{g}{2u\cos\theta}$$

$$= \frac{10}{2 \times 5 \times \frac{1}{2}} = 2\ \text{rad/s}$$

14. (C)

$$R = \frac{u^2 \sin 2\theta}{g},$$

$$T = \frac{2u \sin\theta}{g},$$

$$H = \frac{u^2 \sin^2\theta}{g}$$

(P) If $H_{\max}$ is same for two projectile, time of flight will also be same.

(Q) $\frac{u_y}{u_x} = \tan\theta$

So, it is greatest when angle is greatest.

(R) $u_x = u\cos\theta$

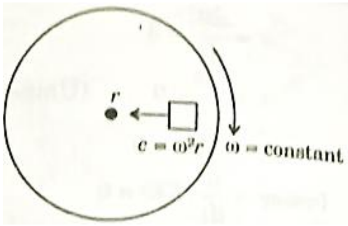
As θ decreases, $\cos\theta$ increases. So, u_x is greatest for C only

(S) $u_x u_y = u^2 \sin\theta\cos\theta = \left(u^2 \sin 2\theta\right)/2$

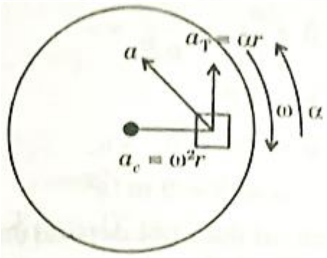
So, if range is equal then $u_x u_y$ is also equal.

15. (A)

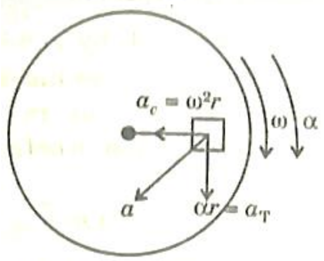
Case-A



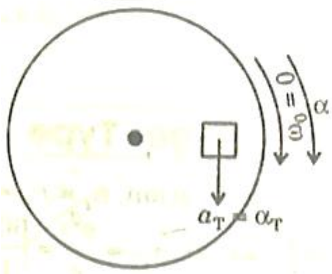
Case-B



Case-C



Case-D



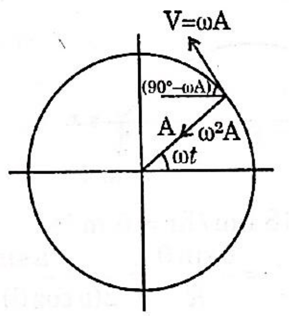
16. (A)

$V_x = \omega A\cos(90° - \omega t)$

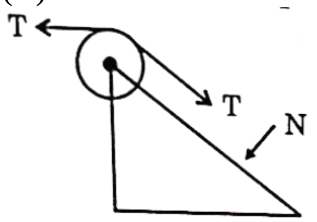
$V_x = -\omega A\sin\omega t$

$F_y = -m\omega^2 A\sin\omega t$

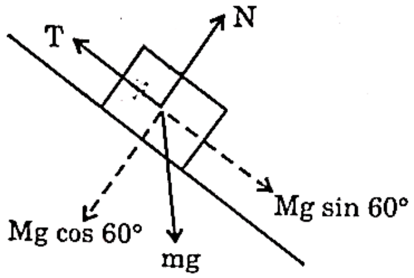
$x = A\cos\omega t$

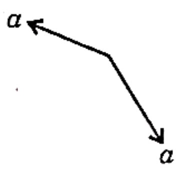


17. (D)



$T + N\sin 60° - T\cos 60° = ma$ ...(i)





$b = \sqrt{a^2 + a^2 + 2a^2\cos 120°}$ ...(ii)

$mg\sin 60 - T = ma(1 - \cos 60°)$ ...(iii)

$mg\cos 60 - N = ma\sin 60°$ ...(iv)

BY eqs. (i), (ii), (iii), (iv)

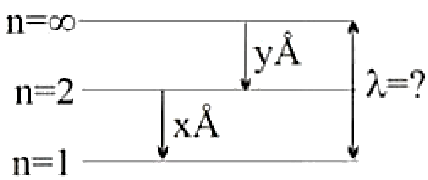
PART (B) : CHEMISTRY

18. (A or B or D)

19. (C)

$$\frac{1}{\lambda}=\frac{1}{x\text{Å}}+\frac{1}{y\text{Å}}$$

$$\therefore\ \lambda=\frac{xy}{x+y}\text{Å}$$



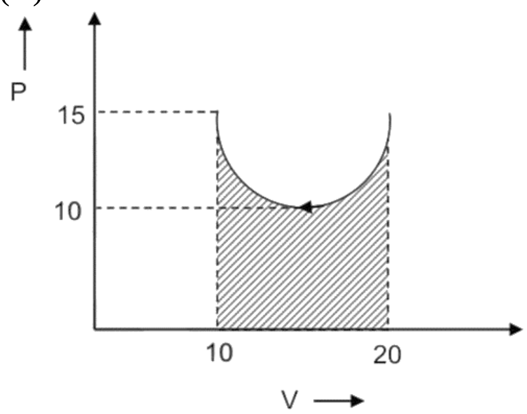
20. (B)

At Boyle's temperature Z = 1

$$0.4P=\frac{200P}{T}$$

$$T_b=500\,K$$

21. (A)



Work done = + (Area of shaded region)

$$=+\left(15\times10-\frac{\pi5^2}{2}\right)$$

$$=\left[150-\frac{25\pi}{2}\right]\text{L-atm}$$

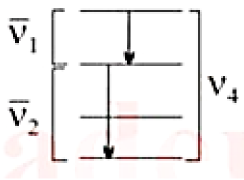
22. (ABD)

$$\frac{n(n-1)}{2}=6\ \Rightarrow n=4$$

(A) $E_4=E_1+E_2$

$$\frac{hc}{\lambda_4}=\frac{hc}{\lambda_1}+\frac{hc}{\lambda_2}$$

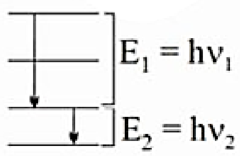
$$\nu_4=\nu_1+\nu_2$$



(B) $E=E_1+E_2$

$$h\nu=h\nu_1+h\nu_2$$

$$\nu=\nu_1+\nu_2$$



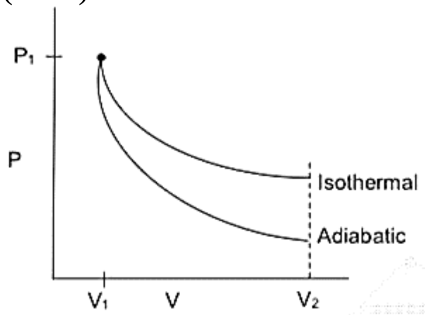
(D) Longest wavelength $= \frac{1}{\lambda_{long}} = R_H\left[\frac{1}{3^2}-\frac{1}{4^2}\right]$ ...(i)

Shortest wavelength $= \frac{1}{\lambda_{short}} = R_H\left[\frac{1}{1^2}-\frac{1}{4^2}\right]$ ...(ii)

$$\frac{\lambda_{long}}{\lambda_{short}} = \frac{\left[1-\frac{1}{16}\right]}{\left[\frac{1}{9}-\frac{1}{16}\right]} = \frac{\frac{15}{6}}{\left(\frac{7}{9\times16}\right)}$$

$$= \frac{15}{16}\times\frac{9\times16}{7} = \frac{135}{7}$$

23. (ABC)



Area under PV came of isothermal is greater than adiabatic.
(B): Factual
(C) As no work is done, W = 0 in isothermal $\Delta U = 0$ so, Q = 0
(D) x

24. (ABC)
Chlorine due to large size than fluorine has highest electron gain enthalpy.

25. (7)

$$q = q_{AB} + q_{BC} + q_{CD} + q_{DA}$$

$$= nRT_B \cdot \ln\frac{2V_0}{V_0+n} \cdot C_{v,m}\cdot(T_C - T_B) + nRT_C \ln\frac{V_0}{2V_0} + n\cdot C_{v,m}(T_A - T_D)$$

$$= nR\ln 2(T_B - T_C) = 1\times2\times0.7\times200$$

$$= 280\ \text{cal/mol}$$

26. (9)

$$\Psi = \left[2/\left(\pi C^2\right)\right]^{3/4} e^{-(x^2+y^2+z^2)/C^2}$$

$$(\Psi)^2\,dx\,dy\,dx = \left(2/\pi C^2\right)^{3/2} e^{-2}\left(x^2+y^2+z^2\right)/C^2 dxdydz$$

$$= \left[2/\left(4\pi nm^2\right)\right]^{3/2} e^{-2}\left[(1.2)^2+(-1)^2+(0)^2\right]/4\times(0.004\ nm)^3$$

$$= 1.2\times10^{-9} \qquad \therefore\ Y = 9$$

27. (255)

$$1\times\frac{3}{2}R(T_2-300)=-P_{ext}\left(\frac{nRT_2}{P_2}-\frac{nRT_1}{P_1}\right)$$

$$1.5(T_2-300)=-1\left(\frac{T_2}{2}-\frac{300}{5}\right)$$

$$1.5T_2-450=-0.5T_2+60$$

$$2T_2=510$$

$$T_2=255\,K$$

28. (7)

$CO_2, N_3^-, C_2H_2, I_3^-, XeF_2, BeCl_2, CS_2$ are linear.

29. (11)

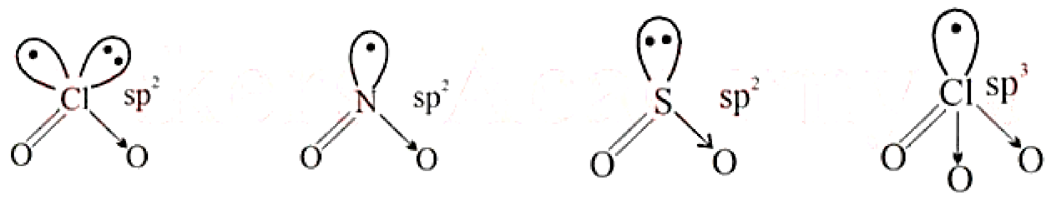
Total line in H atom $=\frac{4(4-1)}{2}=6$

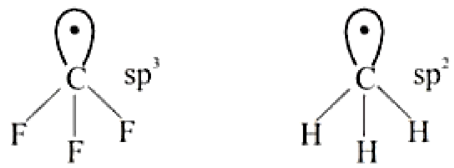
Total line in He^+ $=\frac{4(4-1)}{2}=6$

But the line $2\rightarrow1$ in H & $4\rightarrow2$ in He^+ have same wavelength, so total different line = 11

30. (4)

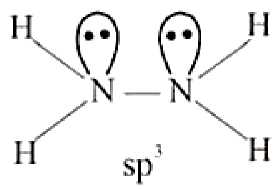
$ClO_2, NO_2, SO_2, \bullet CH_3$ are sp^2 hybridised.





$O=C=C=C=O$ (sp)

$N\equiv C-C\equiv N$ (sp)



31. (C)

K.E. $=\frac{1}{2}$P.E. & Total energy = –K.E.

Total energy = K.E + P.E

(A) $\frac{V_n}{K_n}=-2(Q)$

(B) $\frac{V_n}{E_n} = 2(S)$

(C) $\frac{K_n}{E_n} = -1(P)$

32. (D)

(A) [Ar] $3d^{10}\,4s^2\,4p^2$: Fourth shell contains two electron in 4p-sub shell i.e., $4p^2$.
Therefore, group number = 10 + 4 = 14.

(B) Halogens (i.e. group number 17) have valence shell electronic configuration ns^2np^5 and there is one unpaired electron in p-subshell i.e., ⇅ ⇅ ↑

(C) The element in which last electron enters in d-subshell belongs to d-block. For d-block elements the group number = number of electrons in valence shell + number of electrons in (n – 1) d-subshell. Group number 8. Valence shell electronic configuration is $ns^2(n-1)d^6$. Therefore, group number = 2 + 6 = 8.
Like wise, group is $ns^2(n-1)d^{10}$. Therefore, group number = 2 + 10 = 12.
So in group 8 and 12 last electron enters in d-subshell.

(D) For electronic configuration. $[Ar]4s^2 3d^{10}$ the group number = 2 + 10 = 12.

33. (A)

$P \to (4);\ Q \to (3);\ R \to (2);\ S \to (1)$

Apply $PV^{1+2/3} =$ constant for F to H.

$(32P_0)V_0^{5/3} = P_0V_H^{5/3} \Rightarrow V_H = 8V_0$

For path FG PV = constant

$\Rightarrow (32P_0)V_0 = P_0V_G \Rightarrow V_G = 32V_0$

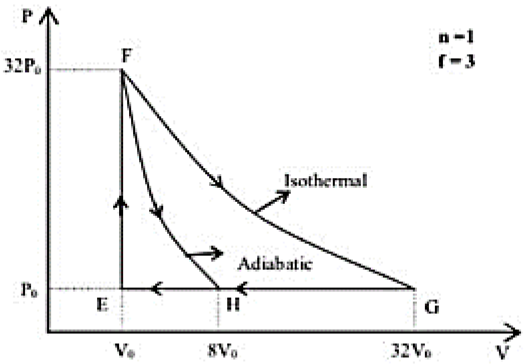
Work done in GE = $31\,P_0V_0$

Work done in FH $= 24\,P_0V_0$

Work done in $FH = \frac{P_HV_H - P_FV_F}{(-2/F)} = 36\,P_0V_0$

Work done in $FG = RT\ln\left(\frac{V_G}{V_F}\right)$

$= 160\,P_0V_0\ln 2$.



34. (C)

PART (C) : MATHEMATICS

35. (C)

$$\frac{\left(1-\frac{1}{3}\right)\left(1+\frac{1}{3}\right)\left(1+\frac{1}{3^2}\right)....\text{n term}}{\left(1-\frac{1}{3}\right)}=\frac{3}{2}\left[1-\frac{1}{3^{2^n}}\right]=\frac{3}{2} \text{ as } n\to\infty$$

36. (B)

$$\left(1+\sqrt{x}+\frac{1}{\sqrt{x}-1}\right)^{-30}=\left(\frac{\sqrt{x}-1}{x}\right)^{30}=\frac{\left(\sqrt{x}-1\right)^{30}}{x^{30}} \Rightarrow \text{ there is no constant term}$$

37. (B)

$$\frac{(\alpha+1)^2}{(\alpha+1)^2-(1-c)}+\frac{(\beta+1)^2}{(\beta+1)^2-(1-c)}$$

$$\frac{(\alpha+1)^2}{(\alpha+1)^2-(\alpha+1)(\beta+1)}+\frac{(\beta+1)^2}{(\beta+1)^2-(\alpha+1)(\beta+1)}$$

$$=\frac{\alpha+1}{\alpha-\beta}+\frac{\beta+1}{\beta-\alpha}$$

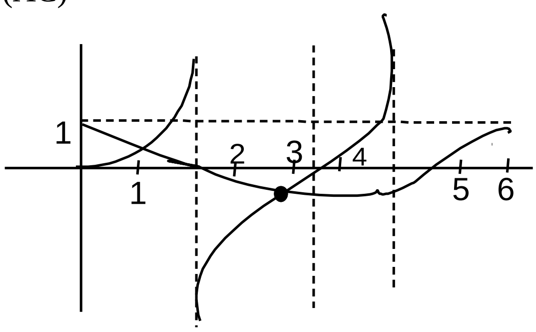
$$=\frac{\alpha-\beta}{\alpha-\beta}=1$$

38. (C)

$$\sum\frac{1}{\sqrt{r}\sqrt{r+1}\left(\sqrt{r+1}+\sqrt{r}\right)}=\sum\frac{\sqrt{r+1}-\sqrt{r}}{\sqrt{r}\sqrt{r+1}}$$

$$\sum_{r=1}^{15}\frac{1}{\sqrt{r}}-\frac{1}{\sqrt{r+1}}=1-\frac{1}{4}=\frac{3}{4}$$

39. (AC)



40. (ABC)

$$\sin^4 x+\cos^4 x=\left(\sin^2 x\right)^2+\left(\cos^2 x\right)^2=1-\frac{1}{2}\sin^2 2x$$

So, the equation becomes

$1-\frac{1}{2}\sin^2 2x+\sin 2x+k=0$

$\Rightarrow\ 2k+2=\sin^2 2x-2\sin 2x$

$\Rightarrow\ 2k+3=(\sin 2x-1)^2$

Range of $(\sin 2x-1)^2$ is [0, 4]

For the equation to have solution,

$0\le 2k+3\le 4$

$\Rightarrow\ -\frac{3}{2}\le k\le\frac{1}{2}$

41. (BC)

Coefficient of $x^{19}=1+2+3.......20=\frac{20\times 21}{2}=210$

Coefficient of

$x^{18}=1\times 2+1\times 3+1\times 4.........+2\times 3+2\times 4......=\frac{(1+2+3......20)^2-(1^2+2^2+.....20^2)}{2}=20615$

42. (4)

$t_n=\frac{6n-1}{(3n-2)^2(3n+1)^2}$

$=\frac{1}{3}\left[\frac{1}{(3n-2)^2}-\frac{1}{(3n+1)^2}\right]$

Taking a telescopic sum

We get

$S_n=\frac{1}{3}\left[1-\frac{1}{(3n+1)^2}\right]$

43. (7)

$\frac{1}{2}\left[(1+\cos 20^\circ)\right]-(\cos 60^\circ+\cos 40^\circ)+(1+\cos 100^\circ)$

$=\frac{1}{2}\left[\frac{3}{2}+\cos 20^\circ-(\cos 40^\circ+\cos 80^\circ)\right]$

$=\frac{1}{2}\left[\frac{3}{2}+\cos 20^\circ-2\cos 60^\circ.\cos 20^\circ\right]$

$=\frac{3}{4}$

44. (3)

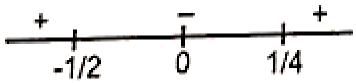
Case-I:

$ax^2+2(a+1)x+9a+4>0$ & $(-a)x^2-(3-2a)x-a<0$

$a>0$ | $-a<0$

$D<0$ | $a>0$

$$2^2(a+1)^2 - 4.a.(9a+4) < 0$$
$$4\left[a^2+2a+1\right] - 4\left[9a^2+4a\right] < 0$$
$$-8a^2 - 2a + 1 < 0$$
$$8a^2 + 2a - 1 > 0$$
$$8a^2 + 4a - 2a - 1 > 0$$
$$4a(2a+1) - 1(2a+1) > 0$$
$$(4a-1)(2a+1) > 0$$



$$a \in \left(\frac{1}{4}, \infty\right)$$
$$a \in \left(\frac{3}{4}, \infty\right)$$

$$D < 0$$
$$(3-2a)^2 - 4\left(a^2\right) < 0$$
$$9 + 4a^2 - 12a - 4a^2 < 0$$
$$3(3-4a) < 0$$
$$a > 3/4$$
$$a \in \left(\frac{3}{4}, \infty\right)$$

45. (2)

$$x^2 - 2^{2010}x + \left|x - 2^{2009}\right| + 2.2^{4017} - 2 = 0$$
$$\Rightarrow \left(x^2 - 2.2^{2009}x + 2^{4018}\right) + \left|x - 2^{2009}\right| - 2 = 0$$
$$\Rightarrow \left(x - 2^{2009}\right)^2 + \left|x - 2^{2009}\right| - 2 = 0$$

Put $\left|x - 2^{2009}\right| = t \geq 0$

$$\Rightarrow t^2 + t - 2 = 0$$
$$\Rightarrow (t-1)(t+2) = 0$$
$$\Rightarrow t = 1 \text{ or } t = -2$$
$$\Rightarrow \left|x - 2^{2009}\right| = 1 \text{ or } x - 2^{2009} = -2 \text{ but } \left|x - 2^{2009}\right| = -2 \text{ is impossible}$$
$$\Rightarrow x - 2^{2009} = \pm 1$$
$$\Rightarrow x = 2^{2009} + 1 \text{ or } x = 2^{2009} - 1.$$

Absolute value of difference of roots = 2

46. (7)

Equation reduces to

$$\sin x\left(6\cos^2 x + 2\cos x - 1\right) = 0$$
$$x = n\pi \text{ or } \cos x = \frac{-1 \pm \sqrt{7}}{6}$$

47. (3)

Eliminating b we get

$$a^2 - ak + k = 0$$
$$D < 0$$

$\Rightarrow \quad 0 < k < 4$

48. (B)

49. (C)

$P \rightarrow 3$

We have, $7^{103} = 7(49)^{51} = 7(50-1)^{51}$

$= 7\left(50^{51} - {}^{51}C_1 50^{50} + {}^{51}C_2 50^{49} - ..... - 1\right)$

$= 7\left(50^{51} - {}^{51}C_1 50^{50} + {}^{51}C_2 50^{49} - .....\right) - 7 + 18 - 18$

$= 7\left(50^{51} - {}^{51}C_1 50^{50} + {}^{51}C_2 50^{49} - .....\right) - 25 + 18$

$= k + 18 (\text{say})$

$\because$ k is divisible by 25,

$\therefore$ remainder is 18.

$Q \rightarrow 4$

$(r+1)$th term in the given expansion is given by

$t_{r+1} = {}^{10}C_r 2^{\frac{10-r}{2}} 3^{\frac{r}{5}}$, where $r = 0, 1, 2, ..., 10$

For rational terms

$r = \text{a multiple of } 5 = 0, 5, 10 \quad ....(1)$

$10 - r = \text{a multiple of } 2 = 0, 2, 4, 6, 8, 10 \quad ....(2)$

From (1) and (2), possible values of r are: 0 and 10

$\therefore$ sum of rational terms

$= t_1 + t_{11} = {}^{10}C_0 \left(\sqrt{2}\right)^{10} \left(3^{1/5}\right)^0 + {}^{10}C_{10} \left(\sqrt{2}\right)^0 \left(3^{1/5}\right)^{10}$

$= 2^5 + 3^2 = 32 + 9 = 41$

$R \rightarrow 2$

We have, $2^{4n} = \left(2^4\right)^n = (16)^n = (1+15)^n$

$\therefore \quad 2^{4n} = 1 + {}^nC_1 . 15 + {}^nC_2 \, 15^2 + {}^nC_3 \, 15^3 + ...]$

$= 225\,k$, where k is an integer.

Hence, $2^{4n} - 15n - 1$ is divisible by 225.

$S \rightarrow 1$

We have,

$5^{99} = 5^3 . 5^{96} = (125)(625)^{24}$

$= [13 \times 9 + 8](1 + 48 \times 13)^{24}$

$= (13 \times 9 + 8)\left[1 + {}^{24}C_1 \times (48 \times 13) + {}^{24}C_2 (48 \times 13)^2 + ... + (48 \times 13)^{24}\right]$

$= 8 + \text{terms containing power of } 13$

50. (C)

51. (A)

$P \rightarrow 3$

Since the roots of given equation are real, therefore the discriminant ≥ 0

$\Rightarrow \quad 4(bc+ad)^2 - 4(a^2+b^2)(c^2+d^2) \geq 0$

$\Rightarrow \quad b^2c^2 + a^2d^2 + 2abcd - a^2c^2 - a^2d^2 - b^2c^2 - b^2d^2 \geq 0$

$\Rightarrow \quad (ac-bd)^2 \leq 0$

But $(ac-bd)^2$ cannot be negative as it is a square of real number

$\therefore \quad ac - bd = 0$; or $b^2d^2 = a^2c^2$

Hence, a^2, bd, c^2 are in G.P.

$Q \rightarrow 2$

Since the roots are equal,

$\therefore \quad B^2 - 4AC = 0$

$\Rightarrow \quad b^2(c-a)^2 - 4ac(b-c)(a-b) = 0$

$\Rightarrow \quad b^2(c^2+a^2-2ac) - 4ac[ab - ac - b^2 + bc] = 0$

$\Rightarrow \quad b^2(c^2+a^2-2ac+4ac) + 4a^2c^2 - 4abc(c+a) = 0$

$\Rightarrow \quad [b(c+a)]^2 + (2ac)^2 - 2.\ 2ac.\ b(c+a) = 0$

$\Rightarrow \quad [b(c+a) - 2ac]^2 = 0 \ \Rightarrow \ b(c+a) = 2ac$

$\Rightarrow \quad b = \dfrac{2ac}{a+c}$

$\therefore \quad$ b is H.M. of a and c, i.e. a, b, c are in H.P.

$R \rightarrow 1$

Let α and β be the roots of the given equation;

Then, $\alpha + \beta = -\dfrac{b}{a}$ and $\alpha\beta = \dfrac{c}{a}$

Given, $\alpha + \beta = \dfrac{1}{\alpha^2} + \dfrac{1}{\beta^2} = \dfrac{\alpha^2+\beta^2}{(\alpha\beta)^2} = \dfrac{(\alpha+\beta)^2 - 2\alpha\beta}{(\alpha\beta)^2}$

$$\Rightarrow \quad -\frac{b}{a} = \frac{\frac{b^2}{a^2} - \frac{2c}{a}}{\frac{c^2}{a^2}} = \frac{b^2 - 2ca}{c^2}$$

$\Rightarrow \quad 2ca^2 = bc^2 + ab^2$

Hence, bc^2, ca^2 and ab^2 are in A.P.

$S \rightarrow 3$

We have, $(a^2+b^2+c^2)p^2 - 2(ab+bc+cd)p$

$\Rightarrow \quad (ap-b)^2+(bp-c)^2+(cp-d)^2 \le 0$

$\Rightarrow \quad (ap-b)^2+(bp-c)^2+(cp-d)^2 = 0 \qquad (\because a, b, c, d, p \in R)$

$\Rightarrow \quad ap-b=0,\ bp-c=0,\ cp-d=0$

$\Rightarrow \quad \frac{b}{a}=\frac{c}{b}=\frac{d}{c}=p \Rightarrow$ a, b, c, d are in G.P.