Test Date: 04/08/2020

B
CODE

Aakash
Medical | IIT-JEE | Foundations
(Divisions of Aakash Educational Services Limited)

Regd. Office: Aakash Tower, 8, Pusa Road, New Delhi-110005, Ph.011-47623456

Mock Test
for JEE (Advanced) - 2021
Test – 4A (Paper – II)

ANSWERS

Physics	CHEMISTRY	MATHEMATICS
1. (A, B, D)	19. (A, B, D)	37. (A, C)
2. (A, B, C, D)	20. (A, B, C)	38. (B, C, D)
3. (A, B, C, D)	21. (A, B, D)	39. (A, B, C, D)
4. (A, D)	22. (B, D)	40. (A, B, C, D)
5. (A, B, C, D)	23. (A, C)	41. (A, B, C, D)
6. (A, B, C)	24. (A)	42. (A, B, D)
7. (32)	25. (39)	43. (45)
8. (10)	26. (18)	44. (37)
9. (20)	27. (05)	45. (17)
10. (12)	28. (08)	46. (01)
11. (12)	29. (10)	47. (18)
12. (04)	30. (06)	48. (02)
13. (10)	31. (10)	49. (02)
14. (40)	32. (04)	50. (12)
15. (C)	33. (C)	51. (D)
16. (B)	34. (B)	52. (B)
17. (D)	35. (A)	53. (B)
18. (C)	36. (D)	54. (C)

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ANSWERS & SOLUTIONS

PART – I : PHYSICS

1. Answer (A, B, D)

$$\frac{MR^2}{2}\times\omega_0=\left(\frac{3}{2}MR^2\right)\times\left(\frac{V_C}{R}\right)$$

$$\Rightarrow V_c=\frac{\omega_0 R}{3}$$

$$KE_f=\frac{1}{2}\left(\frac{3}{2}MR^2\right)\times\left(\frac{\omega_0}{3}\right)^2=\frac{M\omega_0^2R^2}{12}$$

$$\therefore W_f=\frac{M\omega_0^2R^2}{12}-\frac{M\omega_0^2R^2}{4}=-\frac{M\omega_0^2R^2}{6}$$

2. Answer (A, B, C, D)

T_A = 300 K, T_C = 900 K, T_B = 100K

$\therefore$ W_{BC} = nRΔT = 1 × R × 800 = 800R

$$\Delta U_{CA}=n\times\frac{3R}{2}\times\Delta T=1\times\frac{3R}{2}\times(-600)=-900R$$

For A $\rightarrow$ B, P × (PV) = constant

$\Rightarrow PV^{\frac{1}{2}}$ = const.

$$\therefore W_{AB}=\frac{1\times R\times(200)}{\left(\frac{1}{2}-1\right)}$$

= – 400R

3. Answer (A, B, C, D)

$$V_{C_1}=\frac{KQ}{3R}=\frac{Q}{12\pi\epsilon_0 R}$$

$$V_{C_2}=\frac{KQ}{3R}-\frac{KQ}{R}+\frac{KQ}{R/2}=\frac{Q}{3\pi\epsilon_0 R}$$

Surface charge density on outer surface is uniform

4. Answer (A,D)

$$\frac{1.5}{V_1}+\frac{1}{30}=\frac{1.5-1}{10}$$

$\Rightarrow V_1$ = 90 cm

$\therefore$ u_2 = 90 – 20 = 70 cm

$$\therefore\frac{1}{V}-\frac{1.5}{70}=\frac{1-1.5}{-10}$$

$\Rightarrow V=14$ cm

$\therefore$ from O, $d_{image}=10+14=24$ cm

5. Answer (A, B, C, D)

$$\frac{1}{2}kx^2=Ax^2\Rightarrow k=2A$$

$$\frac{1}{2}mv^2=Bv^2\Rightarrow m=2B$$

$$\therefore T=2\pi\sqrt{\frac{m}{K}}=2\pi\sqrt{\frac{B}{A}}$$

At x = 0, V = V_{max}, $\therefore$ $V_{max}=\sqrt{\frac{E}{B}}$

At V = 0, x = Amp

$$\therefore \text{Amp}=\sqrt{\frac{E}{A}}$$

6. Answer (A, B, C)

From max. power theorem $R=\frac{3\times6}{3+2}$

$\Rightarrow R=2\Omega$

$\therefore i_R=\frac{3}{2}=1.5$ A, $\therefore P_R=(1.5)^2\times2=4.5$ W

$$i_6=\frac{7}{6}A,\ P_6=\left(\frac{7}{6}\right)^2\times6=8.17\ W$$

7. Answer (32)

y^2 = 2 × 2 $\Rightarrow$ y = 2 m

$\therefore l_{ef}$ = 2 × 2 = 4 m

$\therefore F_m$ = 2 × 4 × 4 = 32 N

8. Answer (10)

$$mV_A=(2m)V_B$$

$$\Rightarrow V_B=\frac{V_A}{2}$$

$$\therefore \frac{1}{2}mV_A^2 + \frac{1}{2}(2m)\left(\frac{V_A}{2}\right)^2 = \frac{-Q^2}{4\pi \in_0 (5R)} + \frac{Q^2}{4\pi \in_0 (2R)}$$

$$\Rightarrow V_A = \sqrt{\frac{Q^2}{10\pi \in_0 mR}}$$

9. Answer (20)

$$\frac{dN_y}{dt} = \lambda_x N_x - \lambda_y N_y$$

$$\lambda_x = \frac{\ln 2}{T_1}, \lambda_y \frac{\ln 2}{T_2} = 2\lambda_x$$

$$\Rightarrow N_y(+) = \frac{\lambda_x N_0}{(\lambda_y - \lambda_x)}\left(e^{-\lambda_x t} - e^{-\lambda_y t}\right)$$

For max, $\frac{dN_y}{dt} = 0 \Rightarrow t_0 = \frac{\ln\left(\frac{\lambda_y}{\lambda_x}\right)}{(\lambda_y - \lambda_x)}$

$$\Rightarrow t_0 = \frac{\ln(2)}{\lambda_x} = T_1$$

$\therefore$ t_0 = 20 years

10. Answer (12)

$T_1 = 2 \times 10 = 20$ N

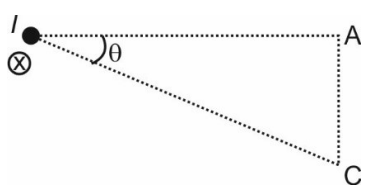
$T_2 = 8 \times 10 = 80$ N

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

$$\Rightarrow \frac{\nu\lambda_1}{\nu\lambda_2} = \sqrt{\frac{20}{80}} \Rightarrow \frac{6}{\lambda_2} = \frac{1}{2}$$

$\Rightarrow \lambda_2 = 12$ cm

11. Answer (12)



$$\tan\theta = \frac{1}{\sqrt{3}}$$

$$\Rightarrow \theta = \frac{\pi}{6}$$

$$\therefore \int \vec{B}.\vec{dl} = (\mu_0 I) \times \left(\frac{\pi/6}{2\pi}\right)$$

$$= \frac{\mu_0 I}{12}$$

12. Answer (04)

$$\beta = \frac{\lambda_0 D}{d}, y_p = 10 \times \beta = 10\left(\frac{\lambda_0 D}{d}\right)$$

Now $\lambda' = \frac{\lambda_0}{4/3} = \left(\frac{3\lambda_0}{4}\right)$

$$\therefore \Delta x = \mu x\left(y\frac{d}{D}\right) = \frac{4}{3} \times \left(10\lambda_0 \frac{D}{d}\right) \times \frac{d}{D} = \frac{40}{3}\lambda_0$$

$$\therefore \Delta\phi = \frac{2\pi}{\lambda_0} \times \left(\frac{40\lambda_0}{3}\right) = \frac{80}{3}\pi = 26\pi + \frac{2\pi}{3}$$

$$\therefore I_P = I_m.\cos^2\left(\frac{\pi}{3}\right) = \frac{I_m}{4}$$

13. Answer (10)

$\omega_z = \omega \sin 30°$ (from rolling analysis)

$$\Rightarrow \omega_z = 20 \times \frac{1}{2}$$

= 10 rad/s

14. Answer (40)

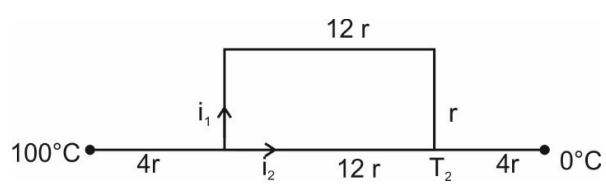
Range $= \sqrt{60^2 + 80^2} = 100$,

$$\therefore \frac{U_{min}^2}{g(1 + \sin\alpha)} = \text{Range}$$

$$\Rightarrow V_{min}^2 = 100 \times 10 \times \left(1 + \frac{3}{5}\right) = 1600$$

$\Rightarrow V_{min} = 40$ m/s

15. Answer (C)



$$i_1 \times 14r = i_2 \times 12r$$

$$\Rightarrow i_2 = \frac{7}{6}i_1$$

And $i_1 + i_2 = 130$

$$\Rightarrow i_1 + \frac{7}{6}i_1 = 130$$

$\Rightarrow i_1 = 60$ J/s, $i_2 = 70$ J/s

And $\frac{100 - T_1}{4r} = \frac{T_2 - 0}{4r} \Rightarrow T_1 + T_2 = 100$

and $\frac{T_1 - T_2}{12r} = 70, \frac{100 - T_1}{4r} = 130$

$\Rightarrow T_1 = 72.3$ °C, $T_2 = 27.7°C$

16. Answer (B)

$\Delta E_{21} = 10.2$ eV,

$$\therefore \lambda_{12} = \frac{1240}{10.2} = 121 \text{ nm}$$

$\therefore 2 \rightarrow 1$ ultroviolet

For $4 \rightarrow 2$, $\lambda = \dfrac{1240}{(3.4 - 0.85)} = 486$ nm visible

For $6 \rightarrow 3$, infrared

For $7 \rightarrow 6 \Rightarrow$ microwave

17. Answer (D)

P $\rightarrow$ Spherical wave front & convergent

Q $\rightarrow$ Spherical wave front & diverging

R $\rightarrow$ Plane wave from bent downward

S $\rightarrow$ Spherical wave front & converging

18. Answer (C)

For P, ΔW = +ve, ΔV = +ve

For Q, ΔW = +ve, ΔU = –ve

For R, ΔW = –ve, ΔU = +ve

For S, ΔW = –ve, ΔU = +ve

Draw PV diagram to analyse further

PART – II : CHEMISTRY

19. Answer (A, B, D)

HCP unit cell has 12 tetrahedral voids 8 of them are inside the unit cell, not shared by the neighbouring unit cells

Volume of unit cell = base area × height

$= 6 \times \dfrac{\sqrt{3}}{4}(2r)^3 \times 4r\sqrt{\dfrac{2}{3}}$

$= 24\sqrt{2}r^3$

5th nearest neighbour in BCC is 8 at a distance of $2\sqrt{3}$

20. Answer (A, B, C)

The oxidation reaction is B_2O_n

$B_2O_n \longrightarrow 2BO_3^-$

n-factor = 10 – 2n

5.36 (10 – 2n) = 64.4 × 0.1 × 5

10 – 2n = 6

n = 2

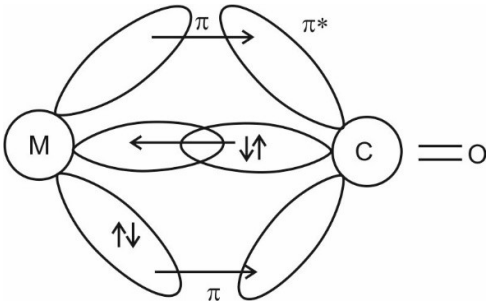
molecular formula = B_2O_2

empirical formula = BO

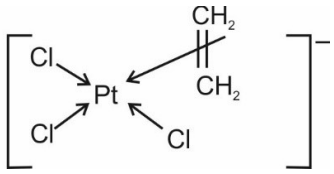
Since n-factor $\Rightarrow$ 10 – 2n = 6, which is also n-factor of $K_2Cr_2O_7$, 1 mol B_2On will be oxidized by 1 mol of acidified $K_2Cr_2O_7$ solution. B can't be a metal from II group of periodic table because it cannot undergo change in oxidation state from +2 to +5

21. Answer (A, B, D)

(A) Synergic bond will cause increase of Bond length

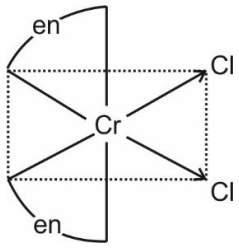


(B)



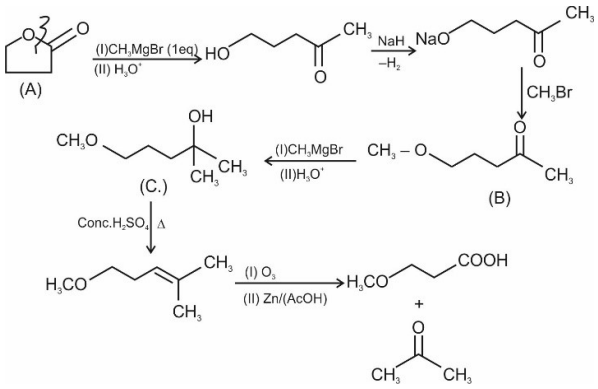
C – C bond length in the complex is more than in ethene due to back donation from the metal to the antibonding MO of ethene ligand

(C)



Has no plane of symmetry

22. Answer (B, D)



23. Answer (A, C)

(A) Boric acid is a very weak acid $(pKa \simeq 9)$

It can-not be estimated by titration with NaOH using phenolphthalein as indicator

(B) $HA + \underset{(\text{Strong Base})}{OH^-} \rightleftharpoons A^- + H_2O$

$$K_{eq} = \frac{[A^-]}{[HA][OH^-]}$$

$$\Rightarrow 10^7 = \frac{[A^-][H^+]}{[HA][OH^-][H^+]}$$

$\Rightarrow K^7 \times K_w = K_a$

$\Rightarrow K_a = 10^7 \times 10^{-14} = 10^7 \Rightarrow p^{K_a} = 7$

pH of salt weak acid and strong Base (KA) is

$$pH = \frac{p^{K_w}}{2} + \frac{1}{2}\left[p^{K_a} + \log C\right]$$

$$= 7 + \frac{1}{2}[7-1] = 10$$

(C) $AgCl(s) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq) + Cl^-(aq)$

-	0.1	0	0
-	0.1 – 2S	S	S

$$K_{eq} = K_C = K_{SP} \times K_f \Rightarrow \frac{S \times S}{(0.1-2S)^2} = 1 \times 10^{-10} \times 1.6 \times 10^9$$

$$\Rightarrow \frac{S}{0.1-2S} = \sqrt{16 \times 10^{-2}} = 0.4$$

$\Rightarrow$ S = 0.04 – 0.8S ; S = 0.022 M

(D) For the equilibrium

$$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$$

$1-\alpha \qquad \alpha \qquad \frac{\alpha}{2}$

If D is Vapour density of SO_3 and d is the vapour density of equilibrium mixture, then

$$\frac{D}{d} = \frac{1+\frac{\alpha}{2}}{1}$$

$$\alpha = 2\left(\frac{D-d}{d}\right) = 2\left(\frac{40-32}{32}\right) = 0.50$$

24. Answer (A)

E° = 1.1 – 0.00034 (T – 300)

= 1.1 – 0.00034 (T – 300)

= 1.1 + 0.102 – 0.00034T

E° = 1.202 – 0.00034T

$= -\frac{\Delta H°}{nF} + \frac{\Delta S°}{nF}T$

$\Rightarrow \Delta H° = -1.202 \times 2 \times 96500$

= –231986 J

= – 231.986 kJ

– 0.00034 × 2 × 96500 = ΔS°

ΔS° = –65.62 J

ΔG° = ΔH° – T ΔS°

= –231.986 × 10^3 – 300(–65.62)

= –231986 + 19686

= – 212.300 kJ

25. Answer (39)

Weight of NaCl solution= V × 1.2 g

Weight of NaCl = $\frac{V \times 1.2 \times 1}{100}$ g

No. of moles of NaCl = $\frac{V \times 1.2 \times 1}{100} \times \frac{1}{58.5}$

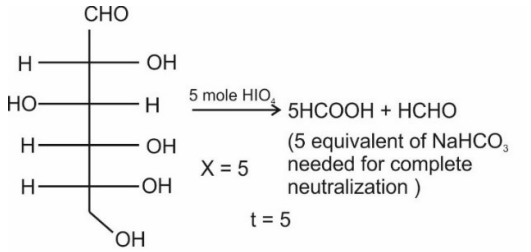
Coagulating value = $\frac{\text{no. of mili moles of NaCl}}{\text{Vol. of solution (lit)}}$

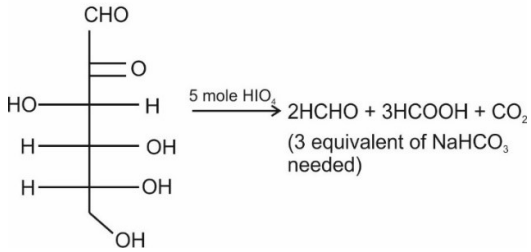
$$\Rightarrow 10 = \frac{V \times 1.2 \times 10^3}{100 \times 58.5} \times \frac{1000}{500}$$

$$\Rightarrow V = \frac{12 \times 58.5 \times 5}{1.2 \times 10^2} = 29.25$$

$$\frac{100}{75}V = 39$$

26. Answer (18)





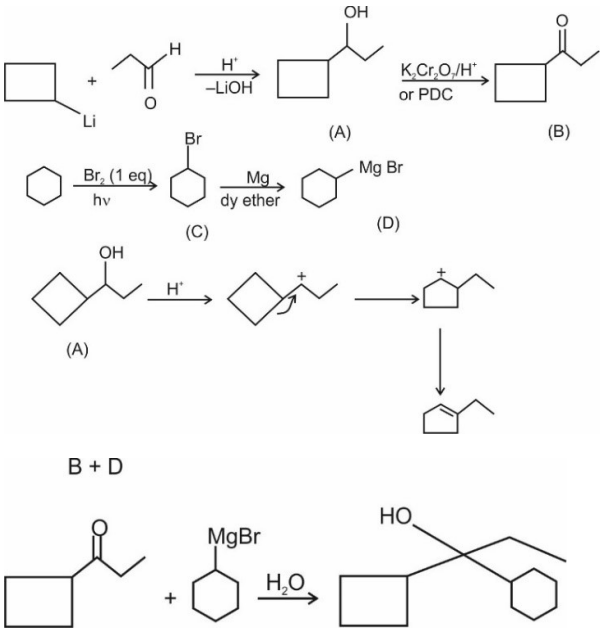
y = 5

r =3

= 5 + 5 + 5 + 3 = 18

27. Answer (05)

(iii), (iv), (v) , (vi) and (viii) are correct statement



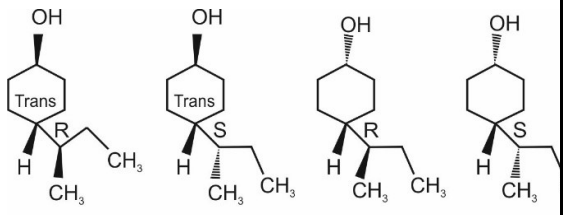
28. Answer (08)

Mabcd square planar can ecibit 3G.I and with each ambidentate ligand it exbits 2 isomers

So number of isomers for each ambidentate ligand = 2 × 3 = 6

There are 4 ambidentate ligands so total isomers = 4 × 2 × 3 = 24 = n

$$\frac{n}{6} = \frac{24}{6} = 4$$



y = 4

29. Answer (10)

(a) $q_v = \int_{290K}^{390K} C_{v,m}\, dT = C_{v,m}(100\ K)$

W = 0

(b) free expansion q = 0, w = 0

(c) $q_p = \int_{390\ K}^{290\ K} C_{p,m}\, dT$

$= -100\ C_{p,m}$

$W = -\int P\, dV = -nR\Delta T = -200\ R$

$q_{overall} = C_{v,m}(200) - 100\ C_{p,m}$

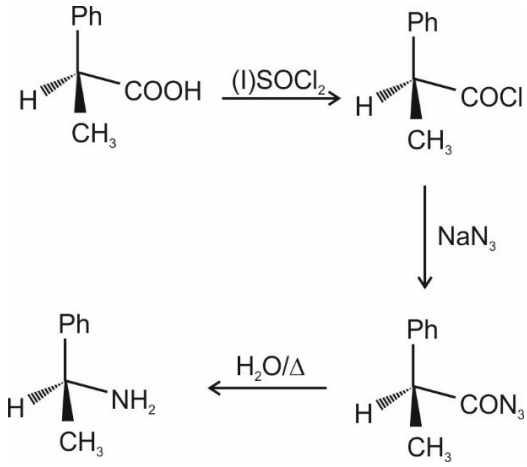
$= 100\ (C_{v,m} - C_{p,m})$

$= -100\ R$

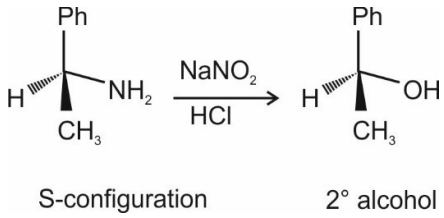
$W_{overall} = -100\ R$

$= \frac{(100+100)R}{20R} = 10$

30. Answer (06)



a, b, c, f, g, h are correct

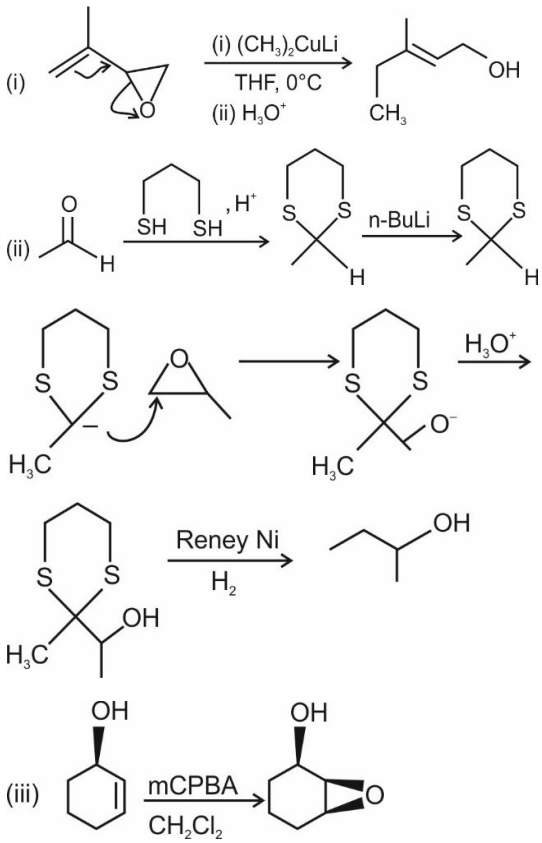


31. Answer (10)

$LiHCO_3$, SI_6, BiCl, KH_3, NH_6^-, $SiCl_6^{-2}$ and ClF_7 do not exist so x = 7

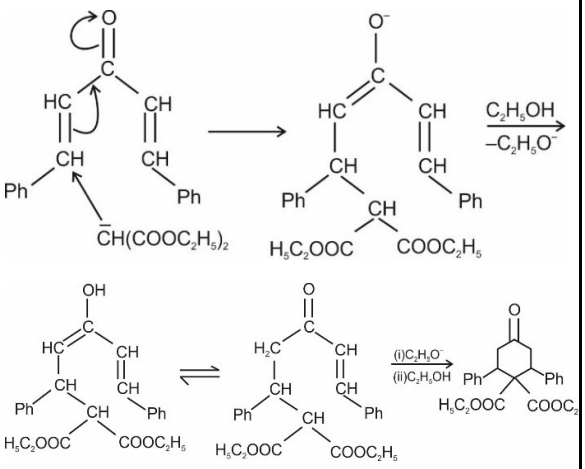
B_2^-, C_2^- and BO are paramagnetic with Bond orders 1.5, 2.5 and 2.5 respectively y = 3

32. Answer (04)

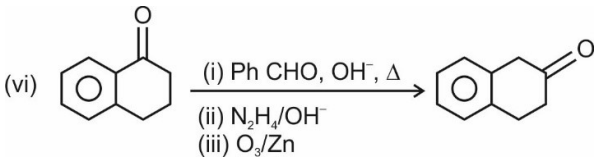


(iv) It is an example of double Michel addition for ring formation

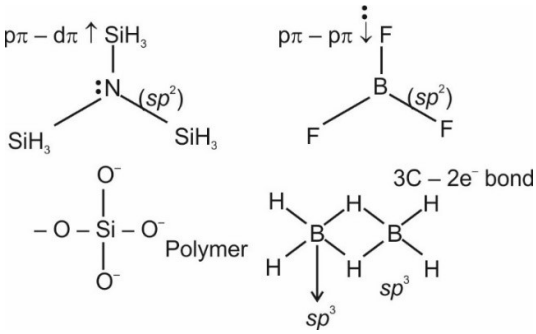
$$CH_2(COOC_2H_5)_2 \xrightarrow{C_2H_5O^-} \bar{C}H(COOC_2H_5)_2 + C_2H_5OH$$



mCPBA attack on e^- rich olifin e^- rich olifin is a good nucleophile and mCPBA is a good E^+(electrophile)



33. Answer (C)



34. Answer (B)

P – Oppenauer Oxidation

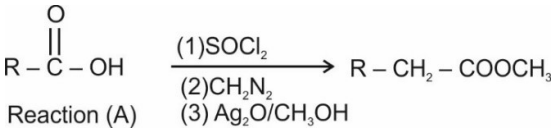
Q – Used in Etard reaction

R – Used in Wolf Kishner

S – Used in Benzoin Condensation

35. Answer (A)

Reaction A is the Arnd't. Eistert reaction where Ketene participates. Reaction C is the acyloin condensation where free radical participates

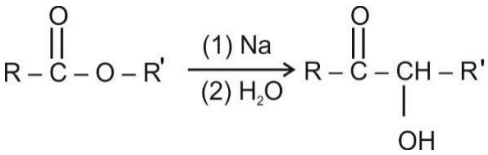


Reaction B

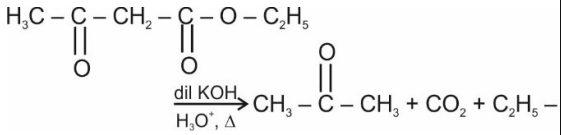
$$CH_3 - CH_2 - COOEt + EtO^- \rightarrow CH_3\bar{C}H - COOEt$$

$$CH_3 - \bar{C}H - COOEt + \underset{COOEt}{COOEt} \rightarrow CH_3 - \underset{COOEt}{CH} - CO - COOEt$$

Reaction C



Reaction D



36. Answer (D)

Fact based

PART – III : MATHEMATICS

37. Answer (A, C)

$$\frac{\left(\sin^{-1}x\right)^2}{3}+\frac{\left(\cos^{-1}x\right)^2}{2}\ge\frac{\left(\sin^{-1}x+\cos^{-1}x\right)^2}{3+2}$$

$$\frac{\left(\sin^{-1}x\right)^2}{3}+\frac{\left(\cos^{-1}x\right)^2}{2}\ge\frac{\left(\frac{\pi}{2}\right)^2}{5}$$

$$\Rightarrow\frac{\left(\sin^{-1}x\right)^2}{3}+\frac{\left(\cos^{-1}x\right)^2}{2}\ge\frac{\pi^2}{20}$$

As per question, for the equality to hold,

$$\frac{\sin^{-1}x}{3}=\frac{\cos^{-1}x}{2}$$

$$\Rightarrow\left(\frac{\sin^{-1}x}{\cos^{-1}x}\right)^2=\frac{9}{4}$$

$\Rightarrow$ Option 'a' is correct

Also

$$\because\frac{\sin^{-1}x}{3}=\frac{\cos^{-1}x}{2}$$

$\Rightarrow 2\sin^{-1}x = 3\cos^{-1}x$

$$\Rightarrow 2\sin^{-1}x=3\left(\frac{\pi}{2}-\sin^{-1}x\right)$$

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

$$\Rightarrow 5\sin^{-1}x=\frac{3\pi}{2}$$

$$\Rightarrow \sin^{-1}x=\frac{3\pi}{10}$$

$$\Rightarrow x=\sin\left(\frac{3\pi}{10}\right)$$

$$\Rightarrow x=\frac{\sqrt{5}+1}{4}$$

$\Rightarrow$ Option C is correct

38. Answer (B, C, D)

$$f(\theta)=\cos\theta$$

$$I_1=\int_{3\pi/2}^{2\pi}\ln\left(f(\theta)\right)d\theta$$

$$=\int_{3\pi/2}^{2\pi}\ln(\cos\theta)d\theta$$

$$=\int_{0}^{\pi/2}\ln(\cos\theta)d\theta$$

$$=-\frac{\pi}{2}\ln 2$$

$$I_2=\int_0^{\pi/2}\cos\left(\pi\cos^2\theta\right)d\theta$$

$$I_2=\int_0^{\pi/2}\cos\left(\pi\sin^2\theta\right)d\theta$$

$$2I_2=\int_0^{\pi/2}2\cos(\pi/2),\cos\left(\frac{\pi}{2}\cos 2x\right)dx=0$$

$I_2 = 0$

$$I_3=\int_0^{\pi/2}\cos\left(2\pi\cos^2\theta\right)d\theta$$

$$I_3=\int_0^{\pi/2}\cos\left(2\pi\sin^2\theta\right)d\theta$$

$$2I_3=\int_0^{\pi/2}2(\cos\pi).\cos(\pi\cos 2\theta)d\theta$$

$$\Rightarrow I_3=-\int_0^{\pi/2}\cos(\pi\cos 2\theta)d\theta$$

$$=-2\int_0^{\pi/4}\cos(\pi\cos 2\theta)d\theta$$

Put $2\theta = z$

$$\Rightarrow d\theta = \frac{1}{2}dz$$

$$I_3 = -\int_0^{\pi/2} \cos(\pi\cos z)\,dz$$

$$I_3 = -\int_0^{\pi/2} \cos(\pi\cos z)\,dz = -I_4$$

$$\Rightarrow I_3 + I_4 = 0$$

39. Answer (A, B, C, D)

$$A = \begin{vmatrix} 1+(2020)^2\cos^2\alpha + (2020)^2\sin^2\alpha & (2020)x(\cos\theta\cos\beta+\sin\alpha\sin\beta) & (2020)x(\cos\alpha\cos\gamma+\sin\alpha\sin\gamma) \\ (2020)\cos\alpha\cos\beta + (2020)\sin\alpha\sin\beta & 1 & \cos\beta\cos\gamma+\sin\beta\sin\gamma \\ (2020)\cos\alpha\cos\gamma + (2020)\sin\alpha\sin\gamma & \cos\beta\cos\gamma+\sin\beta\sin\gamma & 1 \end{vmatrix}$$

$$\Rightarrow A = \begin{vmatrix} 1 & (2020)\cos\alpha & (2020)\sin\alpha \\ 0 & \cos\beta & \sin\beta \\ 0 & \cos\gamma & \sin\gamma \end{vmatrix}$$

$$\Rightarrow A = (\cos\beta\sin\gamma - \sin\gamma\sin\beta)^2$$

$$= (\sin(\gamma-\beta))^2 = (\sin(\beta-\gamma))^2$$

$\Rightarrow$ A is independent of α

$\Rightarrow$ Option 'a' is correct

Now

If $\beta = \gamma + \alpha$ ($\alpha = 15°$)

$\Rightarrow \beta - \gamma = 15°$

$\Rightarrow A = \sin^2 15°$

$$\Rightarrow A = \frac{2-\sqrt{3}}{4}$$

$\Rightarrow$ Option 'b' is correct

If $\gamma = \beta + \alpha$ ($\alpha = 15°$)

$\Rightarrow \gamma - \beta = 15°$

$\Rightarrow A = \sin^2 15°$

$$\Rightarrow A = \frac{2-\sqrt{3}}{4}$$

$\Rightarrow$ Option 'c' is correct

If $\gamma = \beta + \alpha$ ($\alpha = 45°$)

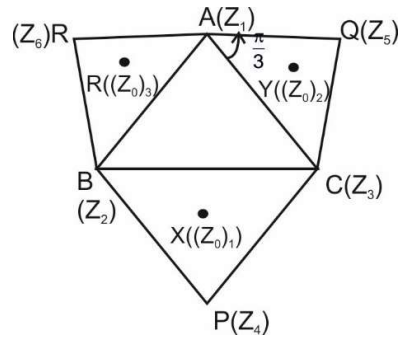
$\Rightarrow \gamma - \beta = 45°$

$\Rightarrow A = \sin^2 45°$

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

$\Rightarrow$ Option 'd' is correct

40. Answer (A, B, C, D)



$$(Z_0)_1 = \frac{Z_2+Z_3+Z_4}{3} \quad \ldots(i)$$

$$(Z_0)_2 = \frac{Z_3+Z_1+Z_5}{3} \quad \ldots(ii)$$

$$(Z_0)_3 = \frac{Z_1+Z_2+Z_6}{3} \quad \ldots(iii)$$

Now, Consider Rotation in ΔAQC

$$\Rightarrow \frac{(Z_1-Z_5)}{|Z_1-Z_5|} = \frac{(Z_1-Z_3)}{|Z_1-Z_3|}e^{in/3}$$

$$\Rightarrow (Z_1-Z_5) = (Z_1-Z_3)e^{in/3} \quad \ldots(iv)$$

($\because$ ΔAQC is equilateral)

Similarly, in ΔABR and ΔBCP

$$(Z_2-Z_6) = (Z_2-Z_1)e^{in/3} \quad \ldots(v)$$

$$(Z_3-Z_4) = (Z_3-Z_2)e^{in/3} \quad \ldots(vi)$$

adding (iv), (v) and (vi)

$$\Rightarrow (Z_1-Z_5)+(Z_2-Z_6)+(Z_3-Z_4) = 0$$

$$\Rightarrow Z_1+Z_2+Z_3 = Z_4+Z_5+Z_6 \quad \ldots(vii)$$

$$\Rightarrow \frac{Z_1+Z_2+Z_3}{3} = \frac{Z_4+Z_5+Z_6}{3}$$

$\Rightarrow$ Centroid of ΔABC co-indices with centroid of ΔPQR

Also,

$$|Z_1+Z_2+Z_3|=|Z_4+Z_5+Z_6|$$

$\Rightarrow$ Option 'a' 'c' are correct

Now adding (i), (ii), and (iii)

$$(Z_0)_1+(Z_0)_2+(Z_0)_3=\frac{2}{3}(Z_1+Z_2+Z_3)+\frac{(Z_4+Z_5+Z_6)}{3}$$

$$\Rightarrow (Z_0)_1+(Z_0)_2+(Z_0)_3=\frac{2}{3}(Z_1+Z_2+Z_3)+\frac{(Z_1+Z_2+Z_3)}{3}$$

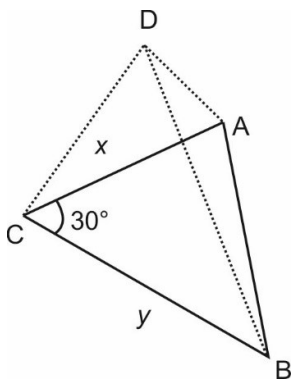
$$\Rightarrow \frac{(Z_0)_1+(Z_0)_2+(Z_0)_3}{3}=\frac{(Z_1+Z_2+Z_3)}{3}$$

$\Rightarrow$ Centroid of ΔXYZ coincides with centroid of ΔABC and ΔPQR

Also, $\left|(Z_0)_1+(Z_0)_2+(Z_0)_3\right|=|Z_1+Z_2+Z_3|$

$\Rightarrow$ Option 'c' and 'd' are also correct

41. Answer (A, B, C, D)



$\because \sqrt{2}x+\sqrt{2}y+h\le 9\sqrt{2}$ and

Volume = $\frac{xyh}{12}=9\sqrt{2}$

$$\Rightarrow x\sqrt{2}.y\sqrt{2}.h=\left(3\sqrt{2}\right)^3$$

$\because$ *G.M.* $\le$ *A.M.*

$$\Rightarrow x\sqrt{2}=y\sqrt{2}=h=3\sqrt{2}$$

42. Answer (A, B, D)

$$f'(x)=e^x\left(\ln\left(\frac{4x-3}{x^4}\right)-\frac{12}{x}\left(\frac{x-1}{4x-3}\right)\right)$$

$\Rightarrow f'(1)=0 \Rightarrow$ Option 'a' is correct

Now $f(x)=\int_1^x e^x\left(\ln\left(\frac{4x-3}{x^4}\right)-\frac{12(x-1)}{x(4x-3)}\right)$

$$=\int_1^x e^x\left(\ln\left(4x^{-3}-3x^{-4}\right)-\frac{12(x-1)}{x^5\left(4x^{-3}-3x^{-4}\right)}\right)dx$$

$$=\int_1^x e^x\left(\ln\left(4x^{-3}-3x^{-4}\right)-\frac{12\left(x^{-4}-x^{-5}\right)}{x^5\left(4x^{-3}-3x^{-4}\right)}\right)dx \quad \ldots\text{(i)}$$

Now let $g(x)=\ln(4x^{-3}-3x^{-4})$

$$\Rightarrow g'(x)=\frac{1}{4x^{-3}-3x^{-4}}\times(-12)\left(x^{-4}-x^{-5}\right)$$

$$=-12\frac{\left(x^{-4}-x^{-5}\right)}{\left(4x^{-3}-3x^{-4}\right)} \quad \ldots\text{(ii)}$$

From (i) & (ii)

$$f(x)=\int_1^x e^x\left(g(x)+g'(x)\right)dx$$

$$=e^x g(x)\Big|_1^x$$

$$=\left(e^x\ln\left(\frac{4}{x^3}-\frac{3}{x^4}\right)\right)\Bigg|_1^x$$

$$f(x)=e^x\ln\left(\frac{4x-3}{x^4}\right) \quad \ldots\text{(iii)}$$

$$\Rightarrow f(3)=e^3\ln\left(\frac{12-3}{3^4}\right)$$

$$=e^3\ln\left(\frac{3^2}{3^4}\right)$$

$$=e^3\ln\left(3^{-2}\right)$$

$= -2e^3\ln 3$

$\Rightarrow$ option 'b' is correct

Now $L=\lim_{x\to 1}\frac{f(x)}{(x-1)^2}=\lim_{x\to 1}\frac{e^x\ln\left(\frac{4x-3}{x^4}\right)}{(x-1)^2}$

$$\Rightarrow L=\lim_{x\to 1}\frac{e\ln\left(1+\left(\frac{4x-3}{x^4}-1\right)\right)}{(x-1)^2}$$

$$= e\lim_{x\to 1}\frac{\ln\left(1+\frac{4x-3-x^4}{x^4}\right)}{(x-1)^2}$$

$$= e\lim_{x\to 1}\frac{4x-3-x^4}{x^4(x-1)^2}$$

$$= -e\lim_{x\to 1}\frac{x^4-4x+3}{(x-1)^2}$$

$$= -e\lim_{x\to 1}\frac{(x-1)^2(x^2+2x+3)}{(x-1)^2}$$

$$= -6e$$

$\Rightarrow$ Option d is correct

43. Answer (45)

1B 1B 1B 1B 1B…….blue balls in box

B B B B B ……B_k B_{2019} B_{2020} $\rightarrow$ Boxes

1R 2R 3R 4R ……KR 2019R 2020R $\rightarrow$ Red balls in the boxes

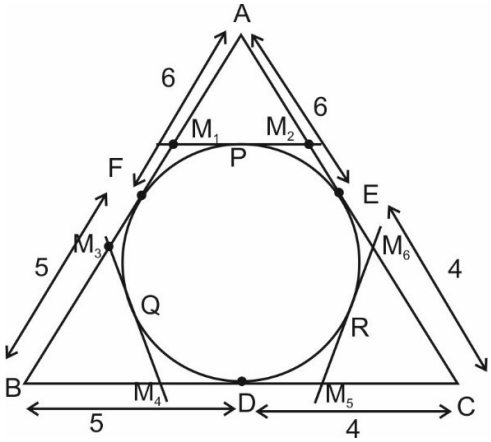
Take p(n) : Probability that mam stops after drawing exactly n balls. i.e. at the nth position red ball must be drawn

$$\therefore\ p(n)=\frac{1}{2}.\frac{2}{3}.\frac{3}{4}.....\frac{n-2}{n-1}.\frac{n-1}{n}.\underbrace{\frac{1}{n+1}}_{\text{Red}}\ i.e.,\frac{1}{n(n+1)}$$

$$So,\ \frac{1}{n(n+1)}<\frac{1}{2020}\Rightarrow n(n+1)>2020$$

$$\Rightarrow n\geq 45$$

44. Answer (37)



In the given diagram

a = 5 + 4 = 9, b = 6 + 4 = 10 & c = 5 + 6 = 11

$AM_1+M_1P=6$ ...(i) $(M_1P=M_1F)$

$AM_2+M_2P=6$ ...(ii) $(M_2P=M_2E)$

(i) + (ii)

$AM_1+AM_2+M_1M_2=12$ …(iii)

ΔAM_1M_2 & ΔABC are similar triangles

$$\Rightarrow\frac{AM_1}{11}=\frac{AM_2}{10}=\frac{M_1M_2}{9}$$

$$\Rightarrow AM_1=\frac{11M_1M_2}{9}\ \&\ AM_2=\frac{10M_1M_2}{9}$$

Use these values in (iii)

$$\Rightarrow\frac{11M_1M_2}{9}+\frac{10M_1M_2}{9}+M_1M_2=12$$

$$\Rightarrow 30M_1M_2=108$$

$$\Rightarrow M_1M_2=\frac{108}{30}=\frac{36}{10}=\frac{18}{5}$$

Similarly $M_3M_4=\frac{100}{30}=\frac{10}{3}$

And similarly $M_5M_6=\frac{44}{15}$

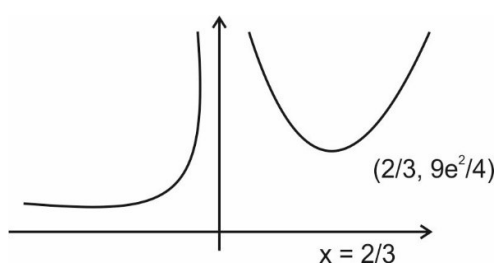
So $\alpha+\beta+\gamma=\frac{18}{5}+\frac{10}{3}=\frac{148}{15}$

$$\Rightarrow 15(\alpha+\beta+\gamma)=148$$

$$\Rightarrow\frac{15}{4}(\alpha+\beta+\gamma)=\frac{148}{4}=37$$

45. Answer (17)

Graph of $f(x)=\frac{e^{3x}}{x^2}$



Let $f(x)=\frac{e^{3x}}{x^2}$

$$f'(x)=\frac{x^2.3e^{3x}-e^{3x}.2x}{x^4}$$

$$\Rightarrow f'(x) = \frac{(3x^2 - 2x).e^{3x}}{x^4} = \frac{(3x-2).e^{3x}}{x^3}$$

$$\Rightarrow K > \frac{9e^2}{4} \Rightarrow K > 16.625$$

$$\Rightarrow K = 17$$

46. Answer (01)

$$\because \frac{1}{a_n} - \frac{1}{a_{n+1}} = n \,\forall\, n > 1 \text{ and}$$

$$S = \left(\frac{1}{a_1} - \frac{1}{a_2}\right)\left(\frac{1}{a_1} + \frac{1}{a_2}\right) + \frac{1}{3}\left(\frac{1}{a_3} - \frac{1}{a_4}\right)\left(\frac{1}{a_3} + \frac{1}{a_4}\right)$$

$$+\frac{1}{5}\left(\frac{1}{a_5} - \frac{1}{a_6}\right)\left(\frac{1}{a_5} + \frac{1}{a_6}\right) + \ldots.$$

$$S = \frac{1}{a_3} + \frac{1}{a_4} + \frac{1}{a_5} + \frac{1}{a_6} + \ldots. + \frac{1}{a_{2020}}$$

S = –[1 + 4 + 8 + 13 + 19 + …2018 terms]

$$S = -\frac{1009}{3}\left[(2018)^2 + 6(2018) - 1\right]$$

$$\therefore -\frac{3S}{1009 \times (2018)^2} = 1 + \frac{6(2018) - 1}{(2018)^2}$$

47. Answer (18)

Roots are $\alpha_1, \alpha_2, \alpha_3$

Then $\alpha_1 + \alpha_2 + \alpha_3 = -a$, $\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1 = b$

and $\alpha_1 \alpha_2 \alpha_3 = -c$

a + b + c + 1 = – 105

–a – b – c – 1 = 105

$$(\alpha_1 + \alpha_2 + \alpha_3) - (\alpha_1\alpha_2 + \alpha_2\alpha_3 + \alpha_3\alpha_1) + \alpha_1\alpha_2\alpha_3 - 1 = 105$$

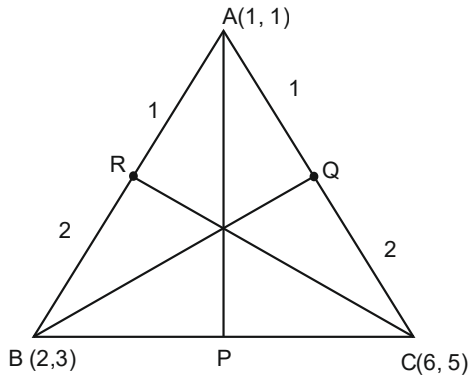
$$(\alpha_1 - 1)(\alpha_2 - 1)(\alpha_3 - 1) = 3 \times 5 \times 7$$

$$\alpha_1 = 4, \alpha_2 = 6, \alpha_3 = 8$$

$$\alpha_1 + \alpha_2 + \alpha_3 = 18$$

48. Answer (02)

In ΔABC



$$\Rightarrow \frac{AR}{RB} \times \frac{BP}{PC} \times \frac{CQ}{QA} = 1$$

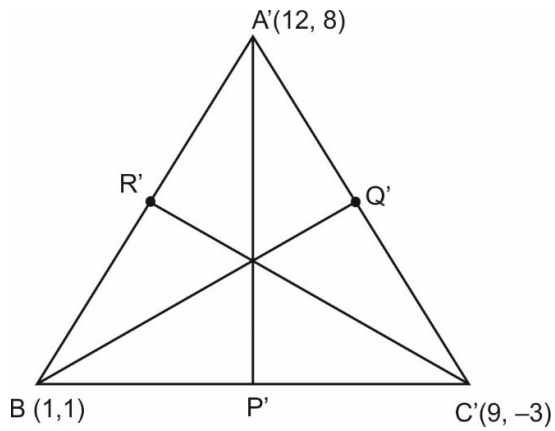
$$\Rightarrow \frac{1}{2} \times \frac{BP}{PC} \times 2 = 1$$

$$\Rightarrow \frac{BP}{PC} = 1$$

$$\Rightarrow P \equiv (4,4)$$

$\Rightarrow$ Equation of AP $\equiv y = x$ …(i)

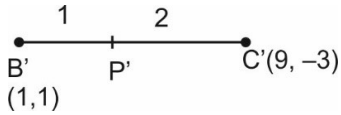
In ΔA'B'C'



$$\frac{A'R'}{R'B'} \times \frac{B'P'}{P'C'} \times \frac{C'Q'}{Q'A'} = 1$$

$$\Rightarrow \frac{2}{3} \times \frac{B'P'}{P'C'} \times \frac{3}{1} = 1$$

$$\Rightarrow \frac{B'P'}{P'C'} = \frac{1}{2}$$



$$\Rightarrow P' \equiv \frac{11}{3}, -\frac{1}{3}$$

Equation of *A'P'*

$$\frac{y-8}{x-12}=\frac{8+\frac{1}{3}}{12-\frac{11}{3}}=\frac{25}{25}=1$$

$\Rightarrow y-8=x-12$

$\Rightarrow y=x-4$ …(ii)

$\because$ Lines given by (i) and (ii) are parallel, therefore they will be the tangents to circle at diametric ends

$$\Rightarrow 2r=\frac{4}{\sqrt{2}}$$

$$\Rightarrow r=\sqrt{2}$$

Now,

$$1+\frac{1}{r^2}+\frac{1}{r^4}+....\infty$$

$$=1+\frac{1}{2}+\frac{1}{4}+.....$$

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

49. Answer (02)

Using Cauchy's Inequality

$$\left(\left(\left(\sqrt{x+1}\right)1+\left(\sqrt{x+1}\right)1+....2019\text{times}\right)\right)^2+\left(\sqrt{2-2019x}\right)1$$
$$\le\left(2019x+2019+2-2019x\right)\times 2020$$

$$\Rightarrow\left(\left(2019\right)\sqrt{x+1}+\sqrt{2-2019x}\right)^2\le\left(2021\right)\left(2020\right)$$

$$\Rightarrow\left(2019\right)\sqrt{x+1}+\sqrt{2-2019x}\le\sqrt{2021\times 2020}$$

In the above equation equality holds when

$x+1=2-2019x$

$$\Rightarrow 2020x=1$$

$$\Rightarrow x=\frac{1}{2020}$$

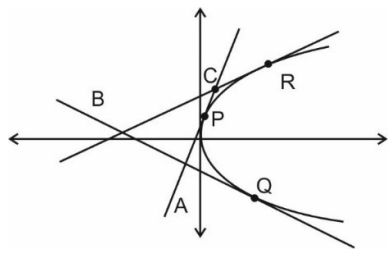
$$\Rightarrow a=\frac{1}{2020} \quad \text{…(i)}$$

Now $\left[\frac{2020}{2019}+\left(2020\right)a\right]$

([ ] is greatest integer function)

$$=\left[\frac{2021}{2019}+1\right]=2$$

50. Answer (12)

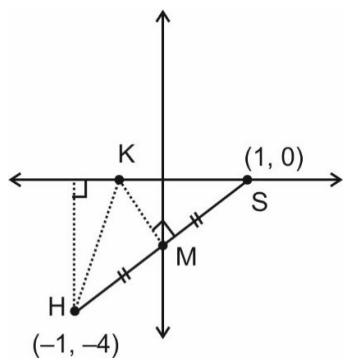


Orthocentre of ΔABC lies on

$(-a, a(t_1+t_2+t_3+t_1t_2t_3)$

$\Rightarrow$ Orthocentre, $H\equiv\left(-1,-4\right)$

Now



Slope of HS = $\frac{4}{2}=2$

$\Rightarrow$ Slope of $\perp$r bisector KM = $-\frac{1}{2}$

Now equation of KM

$$\frac{y+2}{x}=-\frac{1}{2}$$

$$\Rightarrow 2y+4=-x$$

$$\Rightarrow x+2y+4=0$$

$$\Rightarrow K\equiv\left(-4,0\right)$$

$\Rightarrow$ area of ΔSKH, $\alpha=\frac{1}{2}\times 5\times 4=10$

Now

$$\sum_{n=1}^{\infty}\left[1+\frac{2020}{\alpha^n}\right]$$
$$=\left[1+\frac{2020}{10}\right]+\left[1+\frac{2020}{10^2}\right]+\left[1+\frac{2020}{10^3}\right]+...$$
$$+\left[1+\frac{2020}{10^4}\right]+....$$

= 203 + 21 + 2

= 227

51. Answer (D)

(P)

$$S=\lim_{n\to\infty}\sum_{r=1}^{n}\frac{r^2}{n}\left(\frac{\frac{n(n+1)(2n+1)}{6}-\frac{(n+1)(2n^2-5n-6)}{6}}{\left(\frac{n(n+1)}{2}\right)^2}\right)$$

$$S=\lim_{n\to\infty}\sum_{r=1}^{n}\frac{r^2}{n}\left(\frac{\frac{(n+1)}{6}\left(n(2n+1)-(2n^2-5n-6)\right)}{\left(\frac{n(n+1)}{2}\right)^2}\right)$$

$$\lim_{n\to\infty}\sum_{r=1}^{n}\frac{r^2}{n}\left(\frac{\frac{(n+1)}{6}(2n^2+n-2n^2+5n+6)}{\left(\frac{n(n+1)}{2}\right)^2}\right)$$

$$\Rightarrow S=\lim_{n\to\infty}\sum_{r=1}^{n}\frac{r^2}{n}\left(\frac{\frac{(n+1)}{6}\times 6(n+1)}{\frac{n^2(n+1)^2}{4}}\right)$$

$$\Rightarrow S=\lim_{n\to\infty}\sum_{r=1}^{n}\frac{r^2}{n}\left(\frac{4}{n^2}\right)$$

$$\Rightarrow S=\lim_{n\to\infty}\sum_{r=1}^{n}\frac{1}{n}\times 4\times\left(\frac{r}{n}\right)^2$$

$$\Rightarrow S=\int_0^1 4x^2dx$$

$$\Rightarrow S=4\left(\frac{x^3}{3}\right)\Bigg|_{10}^{1}$$

$$\Rightarrow S=\frac{4}{3}$$

$$\Rightarrow 4S=\frac{16}{3}$$

$$\Rightarrow \{4S\}=\frac{1}{3}$$

(Q) Consider

$Q = 2\tan^{-1}(\text{cosec}(\tan^{-1}x) - \tan(\cot^{-1}x)$

Put $x = \tan\theta$

$$\Rightarrow q=2\tan^{-1}\left(\text{cosec}\theta-\tan\left(\frac{\pi}{2}-\theta\right)\right)$$

$$\Rightarrow q=2\tan^{-1}(\text{cosec}\theta-\cot\theta)$$

$$\Rightarrow q=2\tan^{-1}\left(\frac{1-\cos\theta}{\sin\theta}\right)$$

$$\Rightarrow q=2\tan^{-1}\left(\frac{2\sin^2\left(\frac{\theta}{2}\right)}{2\sin\left(\frac{\theta}{2}\right)\cos\left(\frac{\theta}{2}\right)}\right)$$

$$\Rightarrow q=2\tan^{-1}\tan\left(\frac{\theta}{2}\right)$$

$$\Rightarrow q=\theta$$

$$\Rightarrow q=\tan^{-1}x$$

Now

L becomes

$$L=\lim_{x\to 0}\frac{(\tan^{-1}x)}{(3\sin 2x+2\tan^{-1}3x)}$$

$$\Rightarrow L=\frac{1}{6+6}=\frac{1}{12}$$

$$\Rightarrow \{4L\}=\left\{\frac{1}{3}\right\}=\frac{1}{3}$$

(R) $x^2 - 4x + 2[x] + [-x] + 4 = 0$

Case 1 ($x \in I$)

$x^2 - 4x + 2x - x + 4 = 0$

$\Rightarrow x^2 - 3x + 4 = 0$

$D < 0$

$\Rightarrow$ No real values of x

Case 2

$(x \in I)$

$x^2 - 4x + [x] + ([x] + [-x]) + 4 = 0$

$$\Rightarrow x^2-4x+[x]-1+4=0 \quad \ldots(i)$$

$$\Rightarrow x^2-4x+(x-\{x\})+3=0$$

$$\Rightarrow \{x\}=x^2-3x+3=0$$

Now

$$0\le\{x\}<1$$

$$\Rightarrow 0\le x^2-3x+3<1$$

Case 2a

$x^2 - 3x + 3 \geq 0$

Always true

Case 2(b)

$x^2 - 3x + 3 < 1$

$\Rightarrow x^2 - 3I + 2 < 0$

$\Rightarrow (x - 1)(x - 2) < 0$

$\Rightarrow 1 < x < 2$

$\Rightarrow [x] = 1$ …(ii)

Substituting (ii) in (i)

$\Rightarrow x^2 - 4x + 1 - 1 + 4 = 0$

$\Rightarrow x^2 - 4x + 4 = 0$

$\Rightarrow x = 2$

But $1 < x < 2$ and also $x \in I$

$\Rightarrow$ No values of x

From C-1 and C-2

No values of x is possible

(S) $4\sqrt{\log_3 x - 2} + \log_{1/3}(x)^5 + 11 \geq 0$

$\Rightarrow 4\sqrt{\log_3 x - 2} - 5\log_3 x + 11 \geq 0$

Case 1

$x > 0$

Case 2

$\log_3 x - 2 \geq 0$

$\Rightarrow x \geq 9$

Now consider $\log_3 x - 2 = t^2$

$\Rightarrow$ (i) becomes

$4t - 5\left(t^2 + 2\right) + 11 \geq 0$

$\Rightarrow 4t - 5t^2 - 10 + 11 \geq 0$

$\Rightarrow 4t - 5t^2 + 1 \geq 0$

$\Rightarrow 5t^2 - 4t - 1 \leq 0$

$\Rightarrow 5t^2 - 5t + t - 1 \leq 0$

$\Rightarrow 5t(t-1) + (t-1) \leq 0$

$\Rightarrow (5t+1)(t-1) \leq 0$

$\Rightarrow -\frac{1}{5} \leq t \leq 1$

$\Rightarrow 0 \leq t \leq 1 \quad [\because t \geq 0]$

$\Rightarrow \log_3 x - 2 \leq 1$

$\Rightarrow \log_3 x \leq 3$

$\Rightarrow x \leq 3^3$

$\Rightarrow x \leq 27$ …(ii)

From (i) and (ii)

$\Rightarrow$ Total integral multiplies of 9 possible = 3

52. Answer (B)

As the given line lies in the plane

3+5-2d=0 and $2 + 3 + 2\alpha + \beta = 0$

$\Rightarrow \alpha = -6$ and $\beta = 7$

(A) number of terms = ${}^{\beta+r-1}C_{r-1} = {}^{9}C_2$

(B) $\sum_{i=0}^{n-r} {}^{n-i}C_r = {}^{n}C_r + {}^{n-1}C_r + {}^{n-2}C_r + \ldots + {}^{r}C_r$

$= {}^{n+1}C_r$

As n=13 $\Rightarrow {}^{14}C_r$

(C) $x_1x_2x_3 = 42 = 2\times3\times7$

number of positive integral solutions = ${}^{3}C_1 \times 27 + {}^{3}C_3 \times 27$

=81+27=108

Total integral solutions = 108+27=135

(D) Perpendicular distance from the point

$= \left|\frac{1+3-\alpha+\beta}{\sqrt{1+9+1}}\right| = \frac{17}{\sqrt{11}}$

53. Answer (B)

(P) Total ways is equal to the number of inserting separators between two consecutive vowels. Note that CORONA as a whole will also be considered as one partition for which we don't need to inert any separator

$\Rightarrow$ Total ways = 3 × 3 = 9

(Q) $\| AdjA \,|adj(adjA)| = 27^{13}$

$$\Rightarrow \left(|A|^{n-1}\right)^n |adj(adjA)| = 27^{13}$$

$$\Rightarrow |A|^{n^2-n}|A|^{(n-1)^2} = 27^{13}$$

$$\Rightarrow \left(\sqrt{3}\right)^{n^2-n+n^2+1-2n} = 3^{39}$$

$$\Rightarrow \frac{2n^2-3n+1}{2} = 39$$

$\Rightarrow 2n^2 - 3n + 1 = 78$

$\Rightarrow 2n^2 - 3n - 77 = 0$

$\Rightarrow 2n^2 - 14n + 11n - 77 = 0$

$\Rightarrow 2n(n-7) + 11(n-7) = 0$

$\because$ n can't be $-\frac{11}{2}$

$\Rightarrow n = 7$

(R) $5\cos 4x + 14\cos 2x + 10 = 32(\cos x)^6$

Consider

R.H.S = $32(\cos x)^6$

Now $e^{ix} = \cos x + i\sin x$

$e^{-ix} = \cos x - i\sin x$

$\Rightarrow e^{ix} + e^{-ix} = 2\cos x$

$$\Rightarrow \cos x = \frac{e^{ix}+e^{-ix}}{2}$$

Now $\quad 32(\cos x)^6 = 32\left(\frac{e^{ix}+e^{-ix}}{2}\right)^6$

$$\Rightarrow 32(\cos x)^6 = \frac{32}{64}\begin{bmatrix}\left(e^{ix}\right)^6 + 6\left(e^{ix}\right)^5\left(e^{-ix}\right) \\ +15\left(e^{ix}\right)^4\left(e^{-ix}\right)^2 + 20 \\ +15\left(e^{ix}\right)^2\left(e^{-ix}\right)^4 + 6\left(e^{ix}\right)\left(e^{-ix}\right)^5 \\ +\left(e^{-ix}\right)^6\end{bmatrix}$$

$$= \frac{32}{64}\left[e^{i6x} + 6e^{i4x} + 15e^{i2x} + 20 + 15e^{-i2x} + 6e^{-i4x} + e^{-i6x}\right]$$

$$= \frac{1}{2}\times 2\left[\cos 6x + 6\cos 4x + 15\cos 2x + 10\right] \quad \ldots(i)$$

Now according to the question

$5\cos 4x + 14\cos 2x + 10 = \cos 6x + 6\cos 4x + 15\cos 2x + 10$

$\Rightarrow \cos(6x) + \cos(4x) + \cos(2x) = 0$

$\Rightarrow 2\cos 4x \cos 2x + \cos 4x = 0$

$\Rightarrow (\cos 4x)(2\cos 2x + 1) = 0$

Case 1

$\cos 4x = 0$

It will have four solutions in $[0, \pi]$

54. Answer (C)

Let α be the an interior angle of the polygon

$$\Rightarrow Z_n - Z_1 = (Z_2 - Z_1)e^{i\alpha} \Rightarrow Z_n = (1-e^{i\alpha})Z_1 + e^{i\alpha}Z_2$$

$$\Rightarrow \bar{Z}_n = (1-e^{-i\alpha})\bar{Z}_n + e^{-i\alpha}\bar{Z}_2 \ldots(1)$$

And

$$Z_3 - Z_2 = (Z_1 - Z_2)e^{-i\alpha}$$

$$\Rightarrow Z_3 = e^{-i\alpha}Z_1 + (1-e^{-i\alpha})Z_2$$

$$\Rightarrow \bar{Z}_3 = e^{i\alpha}\bar{Z}_1 + (1-e^{i\alpha})\bar{Z}_2 \quad \ldots(2)$$

by (1) + (2)

$$\Rightarrow \bar{Z}_n + \bar{Z}_3 = \bar{Z}_1(1+e^{i\alpha}-e^{-i\alpha}) + \bar{Z}_2(1+e^{-i\alpha}-e^{i\alpha})$$

$$\Rightarrow \bar{Z}_3 + \bar{Z}_n = (1+2i\sin\alpha)\bar{Z}_1 + \bar{Z}_2(1-2i\sin\alpha)$$

$$\Rightarrow A = (1+2i\sin\alpha) \text{ and } B = (1-2i\sin\alpha)$$

$$|A| = \sqrt{1+4\sin^2\alpha} = \sqrt{3-2\cos 2\alpha}$$

$$\Rightarrow = |A|\sqrt{3-2\cos\frac{4\pi}{n}} \quad \left(\because \alpha = \frac{2n-4}{n}.\frac{\pi}{2}\right)$$

$AB = 1 + 4\sin^2\alpha \Rightarrow$ range of AB is $[1, 5]$

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