FIITJEE

ALL INDIA TEST SERIES

OPEN TEST

JEE (Advanced)-2021

PAPER –1

TEST DATE: 24-01-2021

ANSWERS, HINTS & SOLUTIONS

Physics **PART – I**

SECTION – A

1. B

Sol. In a rotational equilibrium net torque about the CM must be zero i.e. F must pass through CM.

2. A

Sol. Coefficient of friction is small so there will be slipping between the blocks.

3. C

Sol. $\Delta U = \frac{f}{2} nR(T_2 - T_1)$

$= \frac{3}{2}(P_f V_f - P_i V_i)$

$= \frac{3}{2}\left(10^5 \times 4 - 10^5 \times 6\right) = -3 \times 10^5\ J$

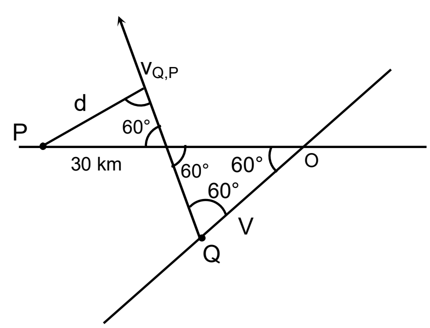
4. B

Sol. Motion of Q with respect to P

$\vec{v}_{Q,P} = \vec{v}_Q - \vec{v}_P$

$\frac{d}{30} = \sin 60°$

$d = 15\sqrt{3}\ km$

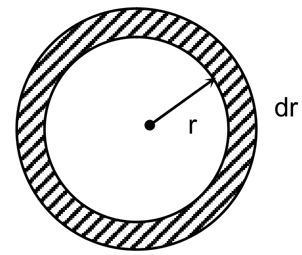


5. B

Sol. $E_A = E_B = \frac{\lambda}{2\pi\varepsilon_0 D}$

6. A

Sol. $d\tau = r.dqE$



$d\tau = r.(\rho 2\pi r.dr\ell)\, E$

$E = \frac{r}{2}\frac{dB}{dt}$

$\tau = \frac{QR^2}{4}\frac{dB}{dt}$

$\therefore \int \tau dt = \frac{MR^2}{2}(\omega - 0)$

$\omega = \frac{Q}{2M}B_0$

7. C, D

Sol. $H = -K_0 x 4\pi x^2 \frac{dT}{dx}$

$\frac{H}{4\pi K_0}\int_{R_0}^{2R_0}\frac{dx}{x^3} = -\int_{2T_0}^{T_0} dT$, it will give H

and $\frac{H}{4\pi K_0}\int_{R_0}^{x}\frac{dx}{x^3} = -\int_{2T_0}^{T} dT$, it will give T = f(x).

8. B, C, D

Sol. Optical path length = $\int_0^D \mu dy = 2\mu_0 D$

$t = \frac{2\mu_0 D}{c}$

9. B, D

Sol. When the distance increases, intensity gets reduced as $I \alpha \frac{1}{r^2}$

K_{max} depends on the frequency of light.

10. A, D

Sol. $\frac{md\vec{v}}{dt} = qE_0\hat{i} + q\left(v_x\hat{i} + v_y\hat{j} + v_z\hat{k}\right) X B_0\hat{j}$

Solving we get $v_y = 0$

and $v_{x(max)} = \sqrt{v_0^2 + \frac{E_0^2}{B_0^2}}$

11. A, C

Sol. Conceptual

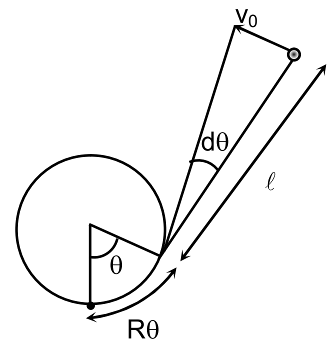
12. B, C, D

Sol. $T = \frac{mv_0^2}{\ell}$, ℓ decreases.

$\ell = 2\pi R - R\theta$

$\Rightarrow \frac{d\theta}{dt} = \frac{v_0}{\ell} \Rightarrow \frac{d\theta}{dt} = \frac{v_0}{2\pi R - R\theta}$

$\Rightarrow \int_0^{2\pi} (2\pi R - R\theta) d\theta = v_0 \int_0^t dt$



SECTION – C

13. 00007.70

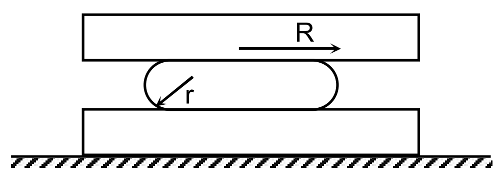
Sol. $mg = \frac{1}{3}\pi\left(\frac{R}{3}\right)^2 \frac{H}{3}\rho_w g$

$mg + \frac{1}{3}\pi\left(\frac{R}{2}\right)^2 \frac{H}{2}\rho g = \frac{1}{3}\pi R^2 H \rho_w g$

Solving these equation, $\frac{\rho}{\rho_w} = 7.70$

14. 00000.15

Sol. $mg = \pi R^2 \Delta P$



Where $\Delta P = S\left(\frac{1}{r} + \frac{1}{R}\right)$

Since R >> r

$\therefore \quad \Delta P = S\left(\frac{1}{r}\right)$

$\Rightarrow \quad mg = \pi R^2 \frac{S}{r}$

$Mg + mg = \pi R'^2 \Delta P'$

$\Delta P' = S\left(\frac{1}{r}, + \frac{1}{R'}\right)$

$r' = \frac{r}{2}, R' >> r'$

$\therefore \quad \Delta P' = S\left(\frac{2}{r}\right)$

$\pi R^2.2r = \pi R'^2.2r'$

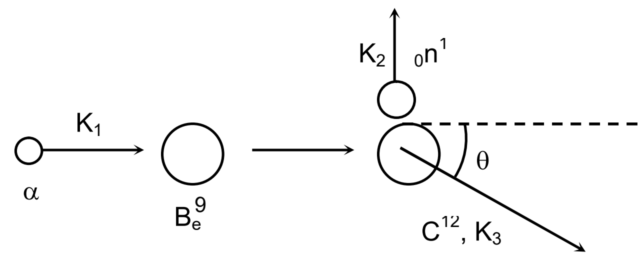
$\Rightarrow \quad R' = R\sqrt{2}$

$\Rightarrow \quad Mg + mg = \pi\left(2R^2\right)S\left(\frac{2}{r}\right)$

$4\pi R^2 \frac{S}{r}$

= 4 mg
$\Rightarrow$ M = 3m
= 3 × 0.050
= 0.15 Kg

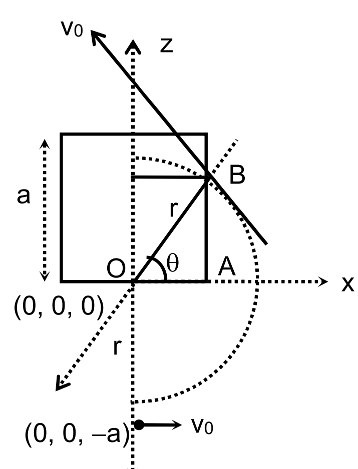
15. 00002.49
Sol. Conservation of momentum
$\sqrt{2\times 4K_1} = \sqrt{2\times 12K_3}\cos\theta$
and $\sqrt{2\times 1\times K_2} = \sqrt{2\times 12K_3}\sin\theta$
and Q = $K_3 + K_2 - K_1$
$\Rightarrow$ 5.80 = $K_2 + K_3 - 5.32$
Solving it K_3 = 2.49 MeV.



16. 00001.23
Sol. $K_{e\ max} = \frac{hc}{\lambda} - \phi$
$= \frac{12400}{124} - 10 = 90\,eV$
K_e of fastest electron falling in collector is 10090 eV
$\therefore\ \lambda_C = \frac{hc}{eV}$
$\frac{12400}{10090} = 1.23$

17. 00000.25
Sol. Power, P = mgv_0
= 2 × 10 × 2.5
= 50W
$P = 2H\frac{dT}{dt}$
$\frac{dT}{dt} = \frac{50}{200} = 0.25\,°C/s$

18. 00019.60
Sol. If E = 0
Let particle strikes at point B.
$\Rightarrow AB^2 = OB^2 - OA^2$
$= r^2 - \frac{3a^2}{4} = a^2 - \frac{3a^2}{4} = \frac{a^2}{4}$
$AB = \frac{a}{2}$
$\sin\theta = \frac{AB}{OB} = \frac{\frac{a}{2}}{a} = \frac{1}{2}$
Time taken to reach at B, t = $\frac{\left(\frac{2\pi}{3}\right)m}{q_0B}$
E ≠ 0, this time displacement along y-axis during



$$y = 0 + \frac{1}{2}\frac{qE}{m} \times \left(\frac{2\pi}{3}\right)^2 \frac{m^2}{q_0^2 B^2} = \frac{Em}{2q_0 B^2}\left(\frac{2\pi}{3}\right)^2 = \frac{a}{2}$$

Co-ordinate of point of impact

$$= \left(\frac{\sqrt{3}a}{2}, \frac{a}{2}, \frac{a}{2}\right)$$

Velocity at point of impact

$$\vec{v} = -v_0 \cos 60\hat{i} + \frac{E}{B}\frac{2\pi}{3}\hat{j} + \frac{\sqrt{3}v_0}{2}\hat{k} = \frac{a}{2}(-\hat{i} + \hat{j} + \sqrt{3}\hat{k})$$

Angular momentum of particle before collision about O,

$$\vec{L} = 1 \times \frac{a}{2}(\sqrt{3}\hat{i} + \hat{j} + \hat{k}) \times \frac{a}{2}(-\hat{i} + \hat{j} + \sqrt{3}\hat{k})$$

$$= 4\left\{(\sqrt{3} - 1)\hat{i} - 4\hat{j} + (\sqrt{3} + 1)\hat{k}\right\}$$

$$|\vec{L}| = 8\sqrt{6} \text{ kg-m}^2\text{/sec}$$

Chemistry PART – II

SECTION – A

19. D

Sol. Possible isomers are

$K_3\left[Fe(CN)_6\right]$ $K_3\left[Fe(NC)_6\right]$

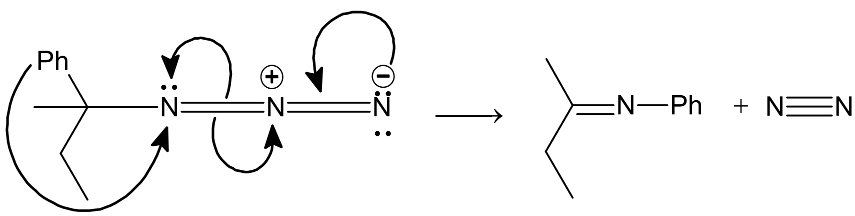
$K_3\left[Fe(CN)_5(NC)\right]$ $K_3\left[Fe(NC)_5(CN)\right]$

$K_3\left[\underset{\text{cis and trans}}{Fe(CN)_4(NC)_2}\right]$ $K_3\left[\underset{\text{cis and trans}}{Fe(NC)_4(CN)_2}\right]$

$K_3\left[\underset{\text{fac and mer}}{Fe(CN)_3(NC)_3}\right]$

20. A

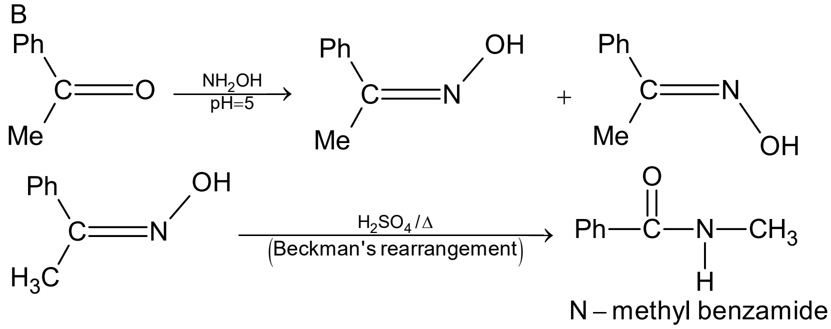
Sol.



Here phenyl group preferentially migrates due to its high migratory aptitude.

21. B

Sol.



22. B

Sol.

	$H_2(g)+I_2(g)\rightleftharpoons 2HI(g)$		
Initial mol	1	1	0
mol at eqbm	$(1-x)$	$(1-x)$	$2x$
eqbm conc	$\frac{(1-x)}{V}$	$\frac{(1-x)}{V}$	$\frac{2x}{V}$

Now, equivalents of hypo used = equivalents of I_2 present at equilibrium

$0.1(10\times 1)=(1-x)\times 2$

x = 0.5

$$\text{So, } K_c=\frac{(1)^2}{\left(\frac{1}{2}\right)\times\left(\frac{1}{2}\right)}=4$$

So, K_c for the reaction

$HI(g) \rightleftharpoons \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$ will be $\left(\frac{1}{4}\right)^{\frac{1}{2}} = \frac{1}{2} = 0.5$

Hence, (B)

23. D

Sol. $q_p = 806 \times 100 = 80600$ J

So, $\Delta H_{vap} = \frac{80600}{2} = 40300 \text{ J mol}^{-1} = 40.3 \text{ kJmol}^{-1}$

$\Delta S_{vap} = \frac{n \times \Delta H_{vap}}{\text{boiling point}} = \frac{80600}{373} = 216.08 \text{ J K}^{-1}$

$\Delta U_{vap} = \Delta H_{vap} - \Delta n_g RT$

$= 80.6 - 2 \times 8.314 \times 373 \times 10^{-3}$

$= 74.3$ kJ

Since, the system is at equilibrium so $\Delta G = 0$.

Hence, (D) is incorrect.

24. D

Sol. Correct reaction is

$CH_2 = CH_2 \xrightarrow[2.\ CH_3COOH]{1.\ B_2H_6-THF} CH_3 - CH_3$

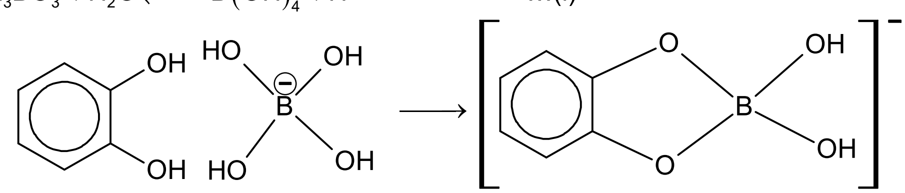
25. B

Sol. (A) Highly pure dilute solution of sodium in liquid ammonia is blue and not red.

(B) $4NaNO_3(s) \xrightarrow{>800^oC} 2Na_2O + 2N_2(g) + 5O_2(g)$

(C) $\underset{}{Na} + \underset{(\text{excess})}{O_2} \longrightarrow Na_2O_2 + \underset{(\text{traces})}{NaO_2}$

(D) (i) $H_3BO_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$ ...(i)

(ii) 

So, in accordance with Le Chatlier's principle, Eq. (i) shifts in forward direction due to reaction (ii) and hence pH decreases.

26. A, C, D

Sol. (A) $\Delta S_{X \to Z} = \frac{q}{T} = 0$ (reversible adiabatic change)

(B) $\Delta S_{X \to Z \to Y} = \Delta S_{X \to Y} = 2.303 \times 5 \times 8.314 \log_{10} \frac{100}{10} = 95.7 \text{ JK}^{-1}$

(because 'S' is a state function).

(C) $\Delta S_{X \to Y} = 95.7 \text{ JK}^{-1}$ (Reversible isothermal expansion)

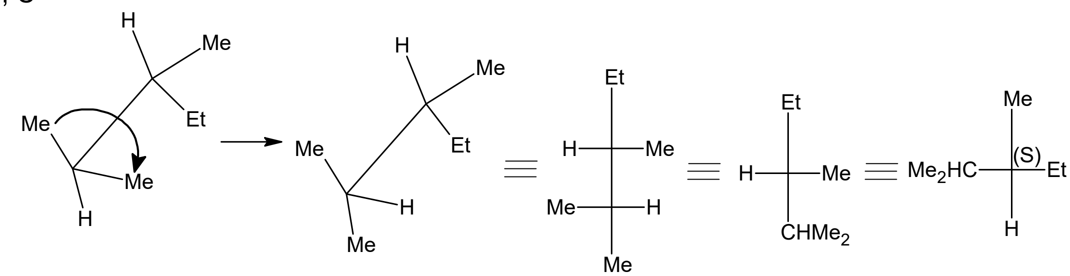
(D) Since 'S' is a state function, so $\Delta S_{X \to Y} = \Delta S_{X \to Z} + \Delta S_{Z \to Y} = 95.7 \text{ JK}^{-1}$

$= 0 + \Delta S_{z \to Y} = 95.7$

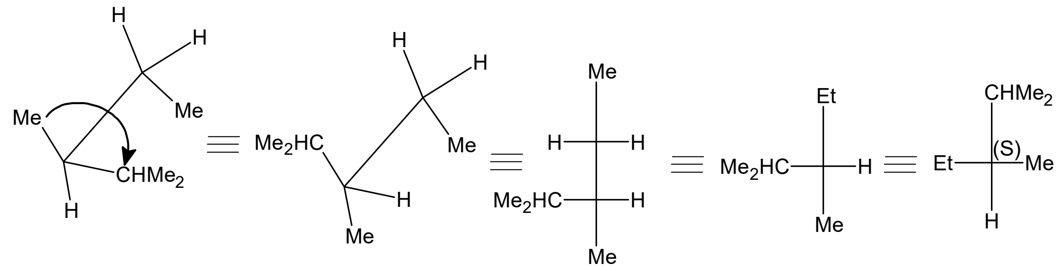
So, A, C and D are correct.

27. A, B, C

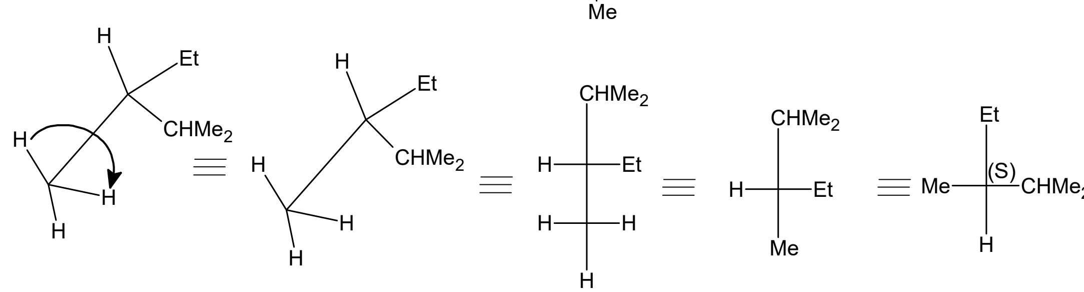
Sol. (A)



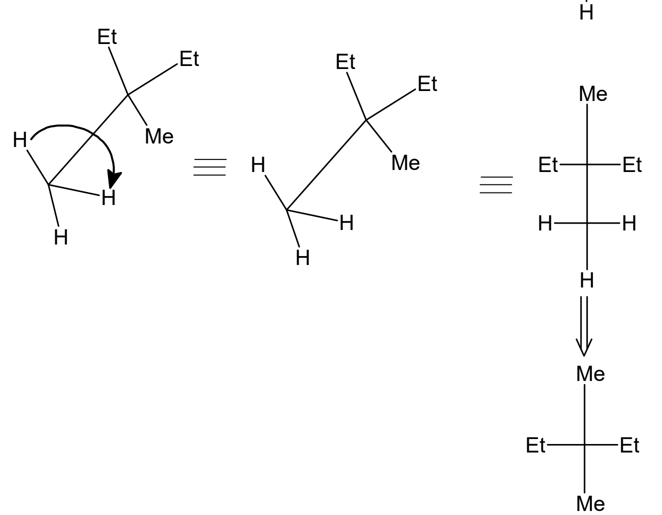
(B)



(C)



(D)



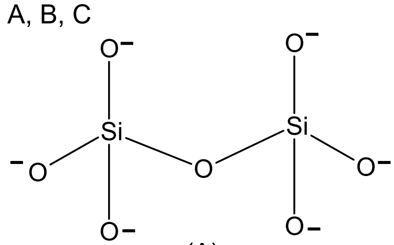
(achiral)

28. A, C, D

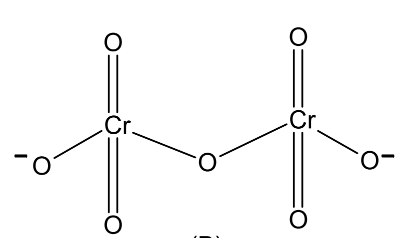
Sol. Resonance effect of ester is less dominant than aldehydes and ketones.

29. A, B, C

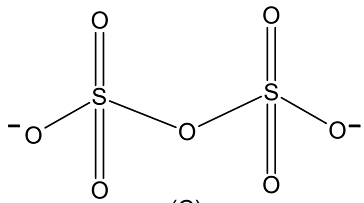
Sol.



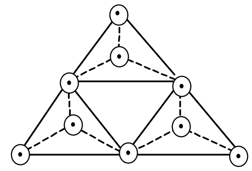
(A)



(B)



(C)

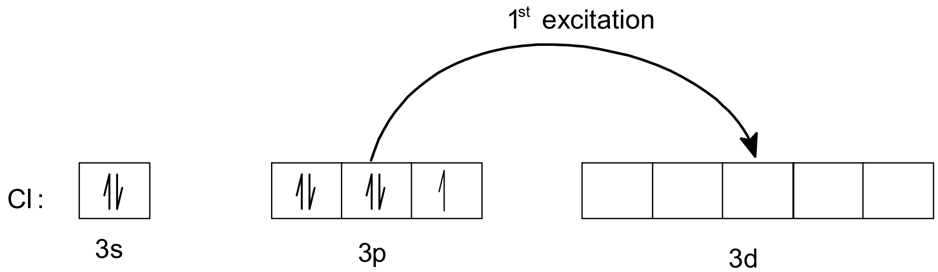


(D)

(Cyclic silicate)

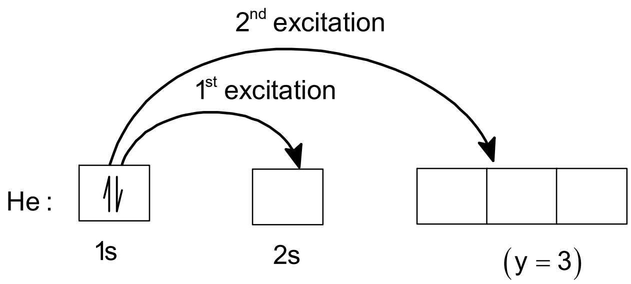
30. A, B, D

Sol. (A)

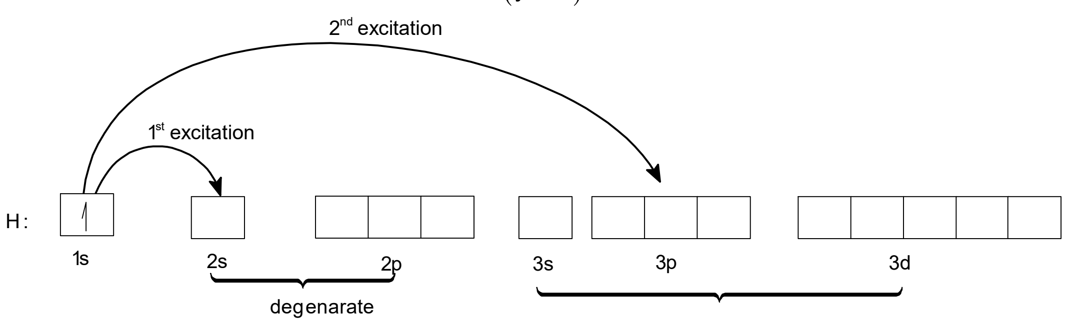


So, x = 5

(B)



(C)

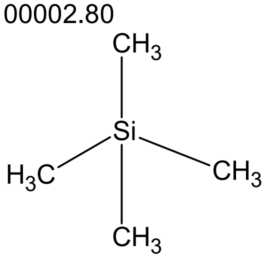


So, z = 9

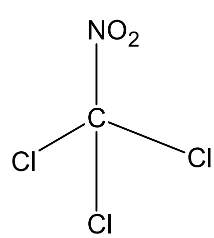
SECTION – C

31. 00002.80

Sol.



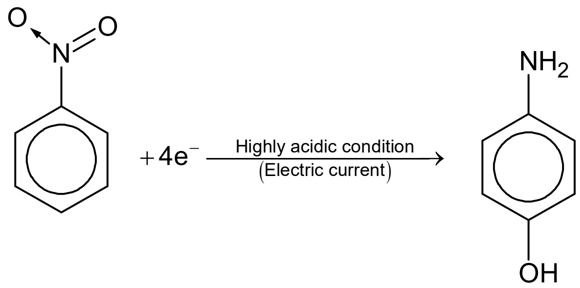
tetra methyl silane
(x = 6)

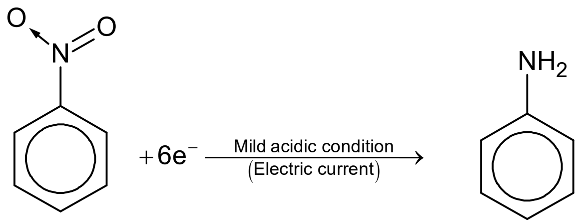


tear gas
(y = 14)

32. 00001.50

Sol.





So, n = 4 F, m = 6 F

33. 00001.80

Sol. **Blue coloured compound**

$O_2(\ell)$, $O_3(g)$, $\left[Cu(NH_3)_4\right]SO_4$,

$K\overset{III}{Fe}\left[\overset{II}{Fe}(CN)_6\right]$, $K\overset{II}{Fe}\left[\overset{III}{Fe}(CN)_6\right]$,

$N_2O_3(\ell)$

x = 6

Red coloured compound

HgI_2, Pb_3O_4

Ag_2CrO_4, KO_3, Cu_2O

y = 5

$CuO \Rightarrow$ Black

$(C_2H_5)_3BO_3 \Rightarrow$ colourless

$CaC_2O_4 \Rightarrow$ white

z = 3

34. 00009.90

Sol. $t_{1/2} = \dfrac{\ell n2}{(k_f + k_b)}$

35. 00005.60

Sol. $\%\text{ of N} = \dfrac{1.4 \times \text{meqvts of acid used}}{w}$

$= \dfrac{1.4 \times 20}{5} = 5.60$

36. 00002.50

Sol. $Z = 1 + \dfrac{Pb}{RT}$

So, slope $= \dfrac{b}{RT} = \dfrac{\pi}{492.6}$

$b = \dfrac{\pi}{492.6} \times RT = 4 \times \dfrac{4}{3}\pi r^3 \times N_A$

So, $r = 2.50 A^{\circ}$

Mathematics

PART – III

SECTION – A

37. C

Sol. $(x-2)(x+2)\left(x^2-4\sqrt{3}\tan\theta x+16\right)=0$

$\Rightarrow \left(x^2-4\sqrt{3}\tan\theta x+16\right)=0$ must have at least one positive root

$\therefore\ 4\sqrt{3}\tan\theta>0 \Rightarrow \tan\theta>0$ and $\left(4\sqrt{3}\tan\theta\right)^2-16\ge 0 \Rightarrow 3\tan^2\theta\ge 1$

$\therefore\ \tan\theta\ge\frac{1}{\sqrt{3}}$

$\therefore\ \theta\in\left[n\pi+\frac{\pi}{6}, n\pi+\frac{\pi}{2}; n\in z\right)$

38. B

Sol. Required circles C_1 and C_2 are given by

$(x-1)^2+(y-1)^2+k(3x+4y-7)=0$

$\because$ It touches x axis

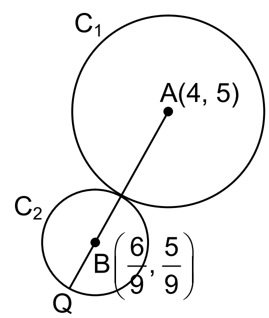
$\therefore\ x^2+(3k-2)x+(2-7k)=0$ has equal roots

$\therefore\ k=-2, 2/9$

$C_1 = x^2+y^2-8x-10y+16=0$

$C_2 = x^2+y^2-\frac{4}{3}x-\frac{10}{8}y+\frac{4}{9}=0$

Slope of $AB=\frac{4}{3}$, $Q=\left(\frac{6}{9}-\frac{5}{9}\times\frac{3}{5}, \frac{5}{9}-\frac{5}{9}\times\frac{4}{5}\right)$ i.e. $\left(\frac{1}{3}, \frac{1}{9}\right)$



39. C

Sol. $\frac{dy}{dx}+\frac{\left(2x^3+1\right)}{x\left(1-x^3\right)}y=\frac{3x}{\left(1-x^3\right)^2}$

If = $e^{\int\frac{2x^3+1}{x\left(1-x^3\right)}dx}=e^{\int\frac{2x+\frac{1}{x^2}}{\left(\frac{1}{x}-x^2\right)}dx}=\frac{x}{1-x^3}$

Solution is $y\cdot\frac{x}{1-x^3}=\int\frac{3x^2}{\left(1-x^3\right)^3}dx$, $\frac{yx}{1-x^3}=\frac{1}{2\left(1-x^3\right)^2}+c \Rightarrow y=\frac{1}{2x\left(1-x^3\right)}$

40. C

Sol. Equation of auxiliary circle $(x-1)^2+(y-4)^2=a^2$

$\Rightarrow a=5 \because\ ae=5\sqrt{2}\ \therefore e=\sqrt{2}$

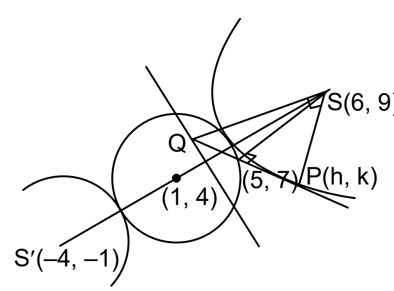
Point on directrix $LL'\equiv\left(\frac{7}{2}, \frac{13}{2}\right)$

Equation of directrix is $x+y-10=0$

Equation of tangent through (5, 7) is $x+2y-19=0$

Point Q(1, 9) $\because\ \angle PSQ=90^\circ$

$\therefore$ P(h, k) is $\left(6, \frac{13}{2}\right)$



41. C
Sol. Use graph

42. C
Sol. $\bar{r} = x\vec{a} + y\vec{b} + z(\bar{a} \times \bar{b})$ ..... (1)

$\bar{r} \times (\bar{a} \times \bar{b}) = (\bar{r} \cdot \bar{b})\bar{a} - (\bar{r} \cdot \bar{a})\bar{b}$

$\Rightarrow \bar{r} \cdot \bar{b} = 2,\ \bar{r} \cdot \bar{a} = 3$

Moreover $x = \frac{3}{2}, y = 1$

Also, $|\bar{r}| = \sqrt{\frac{15}{2}} \Rightarrow z = \frac{1}{2}$

$[\bar{r}\ \bar{a}\ \bar{b}] = 2$

43. A, B, D
Sol. $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$; ad – bc $\neq 0$

a + b + c + d = 5, $a_{ij} \in \{0, 1, 2, 3, 4, 5\}$

(A) (i) Exactly one zero

Number of matrices = $\frac{4!}{2!} + \frac{4!}{2!} = 24$

(ii) Exactly 2 zeros

Number of matrices = $2 \times {}^{5-1}C_{2-1} = 8$

$\therefore$ Total matrices = 32

(B) Number of symmetric matrices = $\sum_{b=0}^{2}(6 - 2b) = 12$

(C) Det A = ad – bc is odd

$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ if A = A^T then b = c

$\therefore$ Det A = ad – b^2, a + d = 5 – 2b

(i) b = 0, a + d = 5 not possible
(ii) b = 1, a + d = 3 4 cases
(iii) b = 2, a + d = 1 not possible

44. A, B, D
Sol. $P(n) = (1 - P(n-1)) \cdot \frac{1}{4}$

P(2) = 0

$P(3) = (1 - P(2))\frac{1}{4} = \frac{1}{4}$

$P(4) = \left(1 - \frac{1}{4}\right) \cdot \frac{1}{4} = \frac{3}{16}$

$P(5) = \left(1 - \frac{3}{16}\right) \cdot \frac{1}{4} = \frac{13}{64}$

$P(6) = \left(1 - \frac{13}{64}\right) \cdot \frac{1}{4} = \frac{51}{256}$

45. B, C, D

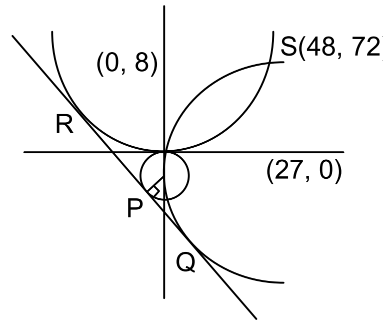
Sol. Foot of perpendicular P ≡ (–6, –9)

$Q \equiv (12, -36)$

and $R \equiv (-24, 18)$

$\therefore\ S_1 \equiv y^2 - 108x = 0$

$S_2 \equiv x^2 - 32y = 0$

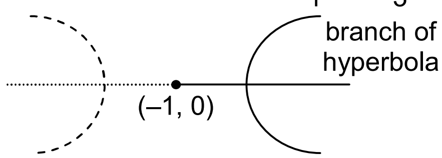


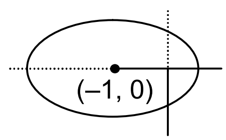
46. A, B, C

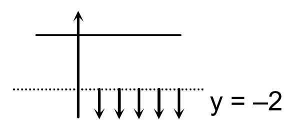
Sol. $z + \bar{z} + 1 = |z - 1|$

$\Rightarrow (2x + 1)^2 = (x - 1)^2 ;\ x \ge -\dfrac{1}{2}$

$\Rightarrow 3x^2 + 6x - y^2 = 0 \Rightarrow \dfrac{(x+1)^2}{1} - \dfrac{y^2}{3} = 1$







|z – 1| + |z + 3| = 6 ⇒ z lies on an ellipse $\dfrac{(x+1)^2}{9} + \dfrac{y^2}{5} = 1$

Re z > 0, Im (z) ≤ –2

Let ax + by = 1 be a chord of curve $S_1 = 0$

$3(x)^2 - y^2 + 6x(ax + by) = 0$

If angle subtended is 90°, then

$3(1 + 2a) - 1 = 0 \Rightarrow a = -\dfrac{1}{3}$. Chord is $-\dfrac{x}{3} + by - 1 = 0$ which passes through (–3, 0)

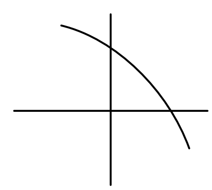
47. C, D

Sol. Let $f(x) = x^3 - x^4 - x^2 + 2020$

$f'(x) = 3x^2 - 4x^3 - 2x = -x(4x^2 - 3x + 2)$

⇒ f(x) is decreasing ∀ x > 0

$S_n < \lim\limits_{n\to\infty} \sum\limits_{k=0}^{n-1} \dfrac{1}{n} f\left(\dfrac{r}{n}\right) < T_n$



48. B, D

Sol. $f(x) = x \tan x$; $g(x) = \dfrac{x}{1 + x\tan x}$; $g'(x) = \dfrac{1 + x\tan x - x\left(x\sec^2 x + \tan x\right)}{\left(1 + x\tan^2 x\right)^2}$

$= \dfrac{(\cos x - x)(\cos x + x)}{\cos^2 x (1 + x\tan x)^2} = 0 \Rightarrow x = \alpha,\ \alpha \in \left(0, \dfrac{\pi}{2}\right)$

$\Rightarrow g'(x) > 0\ \forall\ 0 < x < \alpha$; $g'(x) < 0\ \forall\ \alpha < x < \dfrac{\pi}{2}$

SECTION – C

49. 00300.00

Sol. $S_n = \sum_{k=0}^{n} {}^{n+k}C_k \cdot k = 1\ {}^{n+1}C_n + 2\ {}^{n+2}C_n + ... - n\ {}^{2n}C_n$

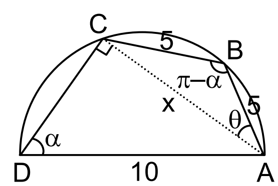
= coefficient of x^n in $\left\{(1+x)^{n+1} + 2(1+x)^{n+2} + 3(1+x)^{n+3} + ... n(1+x)^{2n}\right\}$

= coefficient of x^n in $\left\{\frac{n(1+x)^{2n+1}}{x} + \frac{(1+x)^{n+1} - (1+x)^{2n+1}}{x^2}\right\}$

= $n\ {}^{2n+1}C_{n+1} - {}^{2n+1}C_{n+2}$

$S_{100} = \frac{100 \cdot 201!}{101!\,100!} - \frac{201!}{102!\,99!} = \frac{201!}{99!}\left(\frac{1}{101!} - \frac{1}{102!}\right) \Rightarrow A + B = 300$

50. 00025.00



Sol. $\cos\alpha = \frac{\sqrt{100 - x^2}}{10}$

$\cos(\pi - \alpha) = \frac{50 - x^2}{50} \Rightarrow \frac{\sqrt{100 - x^2}}{10} = \frac{x^2 - 50}{50}$

$\Rightarrow 25(100 - x^2) = (x^2 - 50)^2 = x^4 + 2500 - 100x^2$

$\Rightarrow x = 5\sqrt{3}$ and $\alpha = \frac{\pi}{3} \Rightarrow \angle ABC = \frac{2\pi}{3}$

51. 00004.00

Sol. $I = \int_0^{\pi/3} \left(\log_2\left(1 + \sqrt{3}\tan\left(\frac{\pi}{3} - x\right)\right)\right)\left(\pi\left(\frac{\pi}{3} - x\right) - 3\left(\frac{\pi}{3} - x\right)^2\right)^2 dx$

$= \int_0^{\pi/3} \left(\pi x - 3x^2\right)^2 \log_2\left(\frac{4}{1 + \sqrt{3}\tan x}\right) dx$

$I = \int_0^{\pi/3} \left(\pi x - 3x^2\right)^2 dx = \frac{\pi^5}{810}$

52. 00082.00

Sol. $S_1(n) = -64n^2,\ S_2(k) = \frac{k}{3}(k^2 + 3k - 1)$

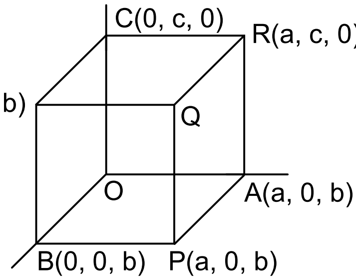
53. 00009.00

Sol. In radius of $\Delta DEF = 2R \cos A \cos B \cos C = \frac{R}{4}$

$\Rightarrow \cos A \cos B \cos C = \frac{1}{8} \Rightarrow \Delta ABC$ is equilateral

$R = \frac{a^3}{4\frac{\sqrt{3}}{4}a^2} = \sqrt{3} \Rightarrow a = 3$

54. 00192.00



Sol. $\overrightarrow{OP} = a\hat{i} + b\hat{k}$

$\overrightarrow{PC} = -a\hat{i} + c\hat{j} - b\hat{k}$

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

Equation of PC, $\bar{r} = a\hat{i} + b\hat{k} + \lambda\left(-a\hat{i} + c\hat{j} - b\hat{k}\right)$

Equation of OA, $\bar{r} = \mu a\hat{i}$

Shortest distance = $\left|\left(a\hat{i} + b\hat{k}\right)\cdot\left(ac\hat{k} - ab\hat{j}\right)\dfrac{(ac)\hat{k} - b\hat{j}}{a\sqrt{b^2 + c^2}}\right|$

$\ell_1 = \dfrac{abc}{a\sqrt{b^2 + c^2}} = \dfrac{bc}{\sqrt{b^2 + c^2}}$ $\therefore$ Similarly $\ell_2 = \dfrac{ac}{\sqrt{a^2 + c^2}}$, $\ell_3 = \dfrac{ab}{\sqrt{a^2 + b^2}}$

$$\frac{1}{\ell_1^2} + \frac{1}{\ell_2^2} + \frac{1}{\ell_3^2} = 2\left(\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2}\right) \geq 2\left(\frac{1}{ab} + \frac{1}{bc} + \frac{1}{ca}\right)$$