MOTION IIT-JEE
(Where Faith Counts the Success)

TARGET IIT-JEE
HINT & SOLUTIONS

ANSWER KEY WITH SOLUTION

PAPER-I CLASS XII & XIII (DATE 09-08-09)

MATHEMATICS

Q.	1	2	3	4	5	6	7	8	9	10	11	12
A.	A	C	B	C	C	A	A	B	B,C,D	A,C	A,B,D	C,D
Q.	13	14	15	16	17	18						
A.	B	C	A	A	C	B						

Q.	19	20
A.	(A)–QRS, (B)–PR, (C)–QR, (D)–R	(A) – R, (B) – S, (C) – P, (D) – Q

PHYSICS

21. A 22. B 23. B 24. B 25. C 26. C 27. A
28. D 29. A, C,D 30. A,D 31. B,C 32. A,B,C,D 33. D 34. A
35. C 36. B 37. C 38. C
39. (A) $\rightarrow$ P,R ; (B) $\rightarrow$ Q, S; (C) $\rightarrow$ Q,R; (D) $\rightarrow$ (P,S)
40. (A) $\rightarrow$ Q,S ; (B) $\rightarrow$ P ; (C) $\rightarrow$ Q,R,S; (D) $\rightarrow$ (R)

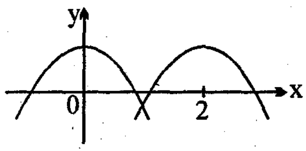
CHEMISTRY

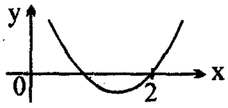
41. C 42. B 43. A 44. D 45. C 46. B 47. B
48. B 49. B,C,D 50. B 51. A,C 52. C,D 53. D 54. A
55. D 56. B 57. A 58. B
59. A $\rightarrow$ Q ; B $\rightarrow$ R ; C $\rightarrow$ P,S; D $\rightarrow$ Q
60. A $\rightarrow$ P,Q ; B $\rightarrow$ P,R,S ; C $\rightarrow$ P,Q ; D $\rightarrow$ P,Q

SOLUTIONS

MATHEMATICS

1. f (0) · f (2) < 0
$(k^2 + 5)(k^2 + 2k - 3)$
$k^2 + 2k - 3 < 0$
$(k + 3)(k - 1) < 0$
$-3 < k < 1$





if one root is x = 2
then f (2) = 0
$k^2 + 2k - 3 = 0$
$\Rightarrow$ k = 1 or k = – 3
if k = 1
$2x^2 - x - 6 = 0 \Rightarrow$
$2x^2 - 4x + 3x - 6 = 0$
$\Rightarrow$ 2x(x – 2) + 3(x – 2) = 0
$\Rightarrow$ x = 2 or x = – 3/2
other roots does not lie in (0, 1)
|||ly when k = – 3
roots are 2, – 7
$\Rightarrow$ k = – 3 is also not possible

2. If $x = r\cos\theta$ and $y = r\sin\theta$ then $E = x^2 + y^2 = r^2$. Hence we have to minimise r^2. Now in the given equation substituting $x = r\cos\theta$ and $y = r\sin\theta$,
we get $r^2 = 4\,\text{cosec}\,4\theta$

$\Rightarrow \quad r^2\big|_{min} = 4$ Ans.]

3. for $k \le -1$, D = 2 and for $k \ge 0$,
$D = 8k + 6 > 0 \ \forall \ k \ge 0$
$\Rightarrow$ roots are real and distinct.]

4. Given $f'(x) + f(x) \le 1$
multiplying by e^x
$f'(x)e^x + f(x)e^x \le e^x$

$$\frac{d}{dx}\left(e^x \cdot f(x)\right) \le e^x$$

integrating between 0 and 1

$$\int_0^1 \frac{d}{dx}\left(e^x f(x)\right)dx \le \int_0^1 e^x\,dx$$

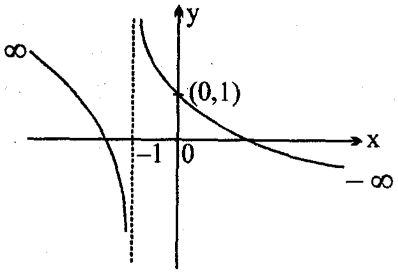
$$e^x f(x)\Big|_0^1 \le e^x\Big|_0^1$$

$$e \cdot f(1) - e^0 \cdot f(0) \le e - 1$$

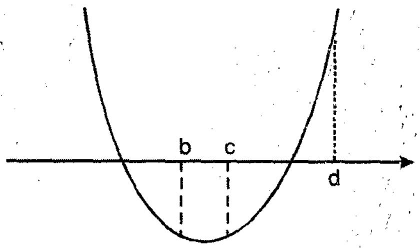
$$f(1) \le \frac{e-1}{e}$$

5. $f'(x) = -\dfrac{3}{(x+1)^4} - 3 + \cos x < 0$

hence f (x) is always decreasing, Also as $x \to \infty$, $f(x) \to -\infty$
and as $x \to -\infty$, $f(x) \to +\infty$
hence one positive and one negative root
Graph is as shown



6. We can rewrite (1) as
$ax^2 - a(b + c)x + abc + x - d = 0$
or $a(x - b)(x - c) + x - d = 0$
Let $f(x) = a(x - b)(x - c) + x - d$.
As a > 0, y = $f(x)$ represents a parabola which open upwards.



Also, $f(b) = b - d < 0$
$f(c) = c - d < 0$, and $f(d) = a(d - b)(d - c) > 0$
Thus, $f(x) = 0$ has a root between $-\infty$ and b and a root between c and d.

7. $\alpha = \sin^{-1}\left[\cot\left(\theta + \dfrac{\pi}{6} + \dfrac{\pi}{4}\right)\right]$ where $\sin^2\theta = \dfrac{2-\sqrt{3}}{4}$.

$$= \sin^{-1}\left[\frac{\cot\theta\cot(\pi/4 + \pi/6) - 1}{\cot\theta + \cot(\pi/4 + \pi/6)}\right]$$

Now, $\cot\theta = \sqrt{\dfrac{4}{2-\sqrt{3}} - 1} = \sqrt{\dfrac{2+\sqrt{3}}{2-\sqrt{3}}} = 2 + \sqrt{3}$ and

$$\cot\left(\frac{\pi}{4}+\frac{\pi}{6}\right) = \frac{\cot\frac{\pi}{6}-1}{1+\cot\frac{\pi}{6}} = \frac{\sqrt{3}-1}{\sqrt{3}+1} =$$

$$\frac{(\sqrt{3}-1)^2}{2} = 2-\sqrt{3}.$$

So $\alpha = \sin^{-1} 0 = 0$.

8. The equation

$$\frac{1-\sin x+\ldots+(-1)^n \sin^n x+\ldots}{1+\sin x+\ldots+\sin^n x+\ldots} = \frac{1-\cos 2x}{1+\cos 2x}$$

$$\Rightarrow \quad \frac{1}{1+\sin x} \times \frac{1-\sin x}{1} = \frac{2\sin^2 x}{2\cos^2 x}$$

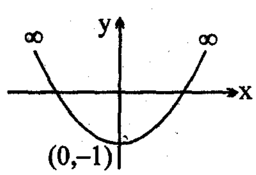
as $-1 < \sin x < 1$

$$\Rightarrow 1-\sin x = \frac{\sin^2 x(1+\sin x)}{1-\sin^2 x}$$

$\Rightarrow (1-\sin x)^2 = \sin^2 x \;\Rightarrow 1-2\sin x = 0$
$\Rightarrow \sin x = 1/2 = \sin(\pi/6)$
$\Rightarrow x = n\pi + (-1)^n \pi/6$.

9. $f'(x) = \dfrac{2-x}{x^3}$ and $f''(x) = \dfrac{x-3}{x^4}$. Now interpret.

10. Graph of $y = f(x) \Rightarrow$ (A) and (C)



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11. $(\sin^2x+\cos^2x)^3 - 3\sin^2 x\cos^2x(\sin^2x+\cos^2x) > \dfrac{5}{8}$

$$= 1-3\sin^2x\cos^2x > \frac{5}{8}$$

$$\Rightarrow \quad 1-\frac{5}{8} > 3\sin^2 x\cos^2x$$

$$\Rightarrow \quad \frac{3}{8} > 3\sin^2x\cos^2x$$

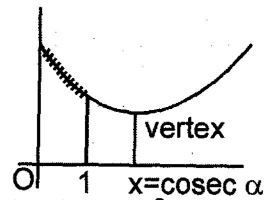
$$\Rightarrow \quad 1-2\sin^2 2x > 0 \;\Rightarrow\; \cos 4x > 0$$

$$4x \in \left(2n\pi-\frac{\pi}{2}, 2n\pi+\frac{\pi}{2}\right) \text{ using graph}$$

$$x \in \left(\frac{n\pi}{2}-\frac{\pi}{8}, \frac{n\pi}{2}+\frac{\pi}{8}\right); n \in I$$

12. Abscissa corresponding to the vertex is given by

$$x = \frac{1}{\sin\alpha} > 1 \text{ is the vertex}$$



the graph of $f(x) = (\sin\alpha)x^2 - 2x + b$ as shown $\forall\, x \le 1$

$\therefore$ minimum of $f(x) = (\sin\alpha)x^2 - 2x + b - 2$ must be greater than zero where minimum is at $x = 1$

i.e. $\sin\alpha - 2 + b - 2 \ge 0$; $\quad b \ge 4 - \sin\alpha, \alpha \in (0, \pi)$

$b \ge 4$ as $\sin\alpha > 0$ in $(0, \pi)$

Hence (C) and (D) are correct

13. Given cubic

$f(x) = (x-1)(x-\cos\theta)(x-\sin\theta)$

$\therefore$ roots are 1, $\sin\theta$ and $\cos\theta$

$\therefore x_1^2 + x_2^2 + x_3^2 = 1 + \sin^2\theta + \cos^2\theta = 2$ Ans.

now if $1 = \sin\theta \quad \Rightarrow \quad \theta = \dfrac{\pi}{2}$

if $1 = \cos\theta \quad \Rightarrow \quad \theta = 0, 2\pi$

and if $\sin\theta = \cos\theta \quad \Rightarrow \quad \tan\theta = 1$

$$\therefore \quad \theta = \frac{\pi}{4}, \frac{5\pi}{4}$$

14. $\therefore$ number of values of θ in $[0, 2\pi]$ is Ans. 5 Ans.

15. again maximum possible difference between the two roots is 2

$$\underbrace{1-\sin\theta}_{\text{when } \theta=3\pi/2} \quad \text{or} \quad \underbrace{1-\cos\theta}_{\text{when } \theta=\pi}$$

16. $y = e^{a+bx^2}$, passes through (1, 1)

$1 = e^{a+b} \;\Rightarrow\; a+b = 0$

also $\left.\dfrac{dy}{dx}\right|_{(1,1)} = -2$

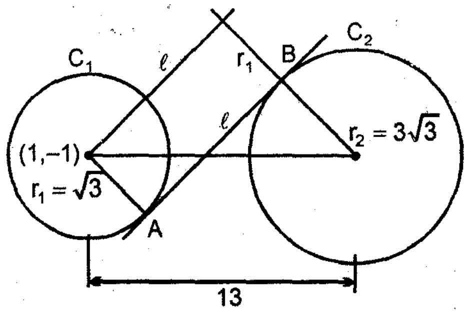
$e^{a+bx^2} \cdot 2bx = -2 \;\Rightarrow\; e^{a+b} \cdot 2b(1) = -2$

$\Rightarrow \quad b = -1$ and $a = 1$

$\Rightarrow \quad (a, b) = (1, -1)$

$\Rightarrow \quad a^2 + b^2 = 2 \qquad$ **Ans.**

17.



hence $\begin{matrix} C_1 : (x-6)^2 + (y+1)^2 = (\sqrt{3})^2 \\ C_2 : (x-6)^2 + (y-11)^2 = (3\sqrt{3})^2 \end{matrix}\Bigg] \begin{matrix} C_1 \ \& \ C_2 \\ \text{are separated} \end{matrix}$

$AB^2 = \ell^2 = d^2 - (r_1 + r_2)^2 = 169 - (4\sqrt{3})^2 = 121$

AB = 11 Ans.

18. again $f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$; f(1) = 1

$$= \frac{f(x)\left[\frac{f(x+h)}{f(x)} - 1\right]}{h}$$

$$= \frac{f(x)}{x} \lim_{h \to 0}\left[\frac{f\left(1+\frac{h}{x}\right) - 1}{\frac{h}{x}}\right] = \frac{f'(1).f(x)}{x} = \frac{2f(x)}{x}$$

(as $f(1) = f^2(1)$ but $f(1) \neq 0 \Rightarrow f(1) = 1$)

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

$\ell n(f(x)) = 2 \ \ell n \ x + C$

$x = 1, f(1) = 1 \Rightarrow C = 0$

$f(x) = x^2$

$\therefore I = \int_b^a f(x) d(\ell n \ x) = \int_{-1}^{1} x^2 \, d(\ell n \ x)$

$$= \int_{1/e}^{e} x \, dx = \left.\frac{x^2}{2}\right]_{1/e}^{e} = \frac{e^2 - e^{-2}}{2} \text{ Ans.}$$

19. $f_n(x) + f_n(y) = \frac{x^n + y^n}{x^n y^n}$ ....(1)

Put x = y = 1 in eq. (1) $\Rightarrow f_n(1) = 1$

put y = 1 in eq. (1) $\Rightarrow f_n(x) = \frac{1}{x^n}$

$\Rightarrow f_{2k}(\text{cosec } \theta) = \frac{1}{(\text{cosec } \theta)^{2k}} = (\sin \theta)^{2k}$

(A) $\sum_{k=1}^{\infty} f_{2k}(\text{cosec } \theta) + \sum_{k=1}^{\infty} f_{2k}(\sec \theta)$

$= (\sin^2 \theta + \sin^4 \theta + \ldots.. \infty) + (\cos^2 \theta + \cos^4 \theta + \ldots..\infty)$

$= \frac{\sin^2 \theta}{1 - \sin^2 \theta} + \frac{\cos^2 \theta}{1 - \cos^2 \theta} = \tan^2 \theta + \cot^2 \theta \geq 2$

$\Rightarrow$ Possible values are 2, 3, 4

$h(x) = \frac{\text{sgn} \, x}{x^n}$. For h(x) to be even h(x) = h(–x)

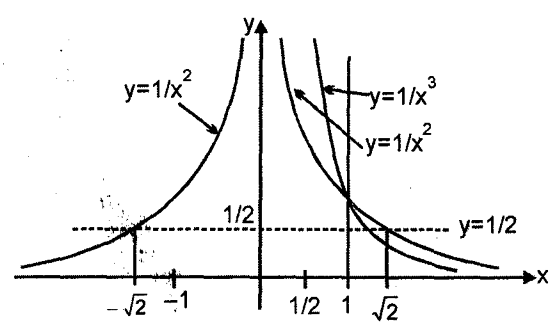
(B) $h(-x) = h(x) \Rightarrow \text{sgn}(-x) \frac{1}{(-x)^n} = -\text{sgn} \, x$

$\frac{1}{(-x)^n} = \text{sgn} \, x \frac{1}{x^n}$

$\Rightarrow$ n is odd. **Ans.** n = 1, 3

now, $f_2(x) = \frac{1}{x^2}$ and $f_3(x) = \frac{1}{x^3}$

(C) $g(x) = \begin{cases} \frac{1}{x^3} & \frac{1}{2} \leq x \leq 1 \\ \frac{1}{x^2} & 1 < x \leq \sqrt{2} \\ \frac{1}{2} & \sqrt{2} < x \leq 2 \end{cases}$



$\int_{1/2}^{2} g(x) \, dx \int_{1/2}^{1} \frac{1}{x^3} dx + \int_{1}^{\sqrt{2}} \frac{1}{x^2} dx + \int_{\sqrt{2}}^{2} \frac{1}{2} dx$

$= \frac{7}{2} - \sqrt{2}$ **Ans.** 2, 3 $(3.5 - 1.141 \cong 2)$

(D) g(x) is not differentiable at $x = 1, \sqrt{2}, -\sqrt{2}$

20. (A) $2\log x - 3\log y = 1$

$2\log x + 3\log y = 7$

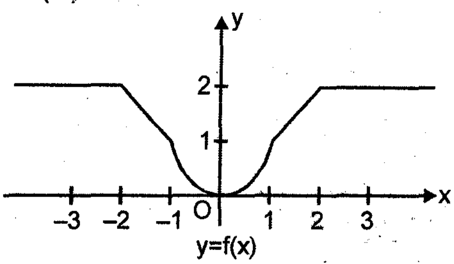
$4\log x = 8 \Rightarrow \log x = 2;$

$\therefore \log y = 1$

$\therefore \log x + \log y = 3 \Rightarrow \log(xy) = 3$

Ans. $\Rightarrow$ (R)

(B)



$$f(x) = \begin{cases} 2 & -5 \le x \le -2 \\ |x| & 1 < |x| < 2 \\ x^2 & -1 \le x \le 1 \end{cases}$$

function not derivable at x = –2, –1, 1, 2 $\Rightarrow$ 4

Ans. $\Rightarrow$ (S)

(C) $I = \int_0^2 \frac{2x^3 - 6x^2 + 9x - 5}{x^2 - 2x + 5}dx$ (put x – 1 = t

ax $x \to 0, t = -1$ and $x \to 2, t \to 1$).

$$= \int_{-1}^{1} \frac{2(1+t)^3 - 6(1+t)^2 + 9(1+t) - 5}{t^2 + 4}dx = \int_{-1}^{1} \frac{2t^3 + 3t}{t^2 + 4}dx$$

$\Rightarrow$ I = 0 Ans. $\Rightarrow$ (P)

(D) Consider $4^{x^2} + 4^{(x-1)^2}$

AM ≥ GM for two positive numbers

4^{x^2} and $4^{(x-1)^2}$

$$\frac{4^{x^2} + 4^{(x-1)^2}}{2} \ge [4^{x^2} \cdot 4^{(x-1)^2}]^{1/2}$$

$$= 2^{x^2} \cdot 2^{(x-1)^2}$$

$$= 2^{x^2 + (x-1)^2}$$

$$4^{x^2} + 4^{(x-1)^2} \ge 2^{x^2 + (x-1)^2 + 1}$$

now $z = x^2 + (x-1)^2 + 1$

$\frac{dz}{dx} = 2x + 2(x-1) = 0$ for maximum

or minimum $\Rightarrow x = \frac{1}{2}$

hence $z_{min} = \frac{1}{4} + \frac{1}{4} + 1 = \frac{3}{2}$

$\therefore$ $4^{x^2} + 4^{(x-1)^2}$ has the minimum value = $2^{3/2}$

hence $f(x) \ge \log_2(2)^{3/2} = \frac{3}{2}$

$\therefore$ $y \ge \frac{3}{2} \Rightarrow$ range is $\left[\frac{3}{2}, \infty\right) \Rightarrow$

$a = \frac{3}{2}$ Ans. $\Rightarrow$ (Q)

PHYSICS

21. **A**

$2\mu_1 t = (2n-1)\frac{\lambda}{2}$, $t = \frac{(2n-1)\frac{\lambda}{2}}{2\mu_1}$

t = 120 nm, 360 nm,........

22. **B**

Maximum tension in string = T = mg + $m\omega^2 A$

$$\mu(3mg) = mg + m\left(\frac{2\pi}{\pi/2}\right)^2 \Rightarrow \mu = \frac{13}{15}$$

23. **B**

As initially string is vertical, angular amplitude will be θ and

$g_{eff} = g\cos\theta$

$\therefore v_{max} = \sqrt{2g_{eff}l(1-\cos\theta)} = \sqrt{2gl\cos\theta(1-\cos\theta)}$

24. **B**

Resistent of cylinder $R = \int_0^l \frac{1}{\sigma}\frac{dx}{a} = \frac{2\sqrt{l}}{3a\sigma_0}$

$$I = \frac{E}{R}$$

Electric field = $\frac{J}{\sigma} = \frac{I}{a\sigma} = \frac{E\sqrt{x}}{Ra\sigma_0 l} = \frac{E(\sqrt{l})}{\frac{2\sqrt{l}}{3a\sigma_0}a\sigma_0 l} = \frac{3E}{2l}$

25. **C**

Net flux is zero, so $q + \lambda R\sqrt{2} = 0$

26.

27. **A**

Velocity of vertical rod with respect to horizontal rod is

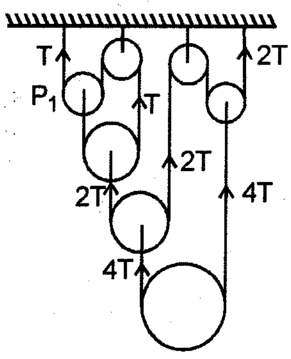
$\vec{v}_{rel} = v\hat{i} - (-2v\hat{j})$

$\therefore \quad \hat{v}_{rel} = \frac{v\hat{i} + 2v\hat{j}}{\sqrt{v^2 + (2v)^2}} = \frac{\hat{i} + 2\hat{j}}{\sqrt{5}}$

$\therefore$ unit vector along friction force = $-\hat{v}_{rel}$

28. **D**

29. **A, C,D**



On $P_1 \Rightarrow 2T = T \Rightarrow T = 0$

30. **A,D**

31. **B,C**

$\vec{F} = q\vec{E} = qE_0\hat{i}$

$\vec{v}(t) = v_0\hat{j} + \frac{qE_0}{m}t\hat{i}$

$y(t) = v_0 t$

$x(t) = \frac{1}{2}\frac{qE_0}{m}t^2$

When $x = x_0 = \frac{1}{2}\frac{qE_0}{m}t^2$

$t = \frac{2x_0}{v_0}$

so $|\vec{v}| = \sqrt{2}v_0$

$|\vec{v}| = v_0\hat{i} + v_0\hat{j}$

$a = \sqrt{(a_{\parallel})^2 + (a_{\perp})^2}$

$\Rightarrow \quad \left(\frac{qE_0}{m}\right)^2 = \left(\frac{\vec{a}.\vec{v}}{|v|}\right)^2 + (a_{\perp})^2$

$\Rightarrow \quad \frac{1}{4}\frac{v_0^4}{x_0^2} = \frac{1}{8}\frac{v_0^4}{x_0^2} + (a_{\perp})^2$

$\Rightarrow \quad a_{\perp} = \frac{v_0^2}{2\sqrt{2}x_0} = \frac{|\vec{v}|^2}{R}$

$R = 4\sqrt{2}x_0$

32. **A,B,C,D**

33. **D**

34. **A**

35. **C**

$T^2 \propto R^3$

$T_e^2 = kR_e^3$; $T_m^2 = kR_m^3$; $T^2 = kR^3$

$R = \frac{R_e + R_m}{2}$

$\Rightarrow \quad T^2 = k\left[\frac{T_e^{2/3}}{k^{1/3}} + \frac{T_m^{2/3}}{k^{1/3}} \times \frac{1}{2}\right]^3$

$\Rightarrow \quad T = \left[\frac{T_e^{2/3} + T_m^{2/3}}{2}\right]^{3/2}$

$E_e = -\frac{GM_sM_e}{2R_e} = -\frac{GM_sM}{2R} = \frac{2R_eE_e}{M_e} \times \frac{M}{2\left(\frac{R_e + R_m}{2}\right)}$

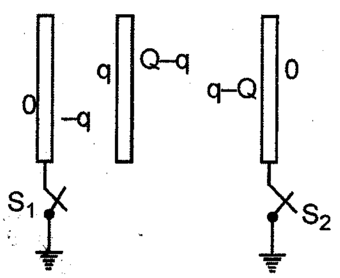
$= \frac{2M}{M_e}\left(\frac{R_e}{R_e + R_m}\right)E_e$

36. **B**

37. **C**

38. **C**

$\frac{(Q-q)3d}{\varepsilon_0 A} = \frac{qd}{\varepsilon_0 A} \Rightarrow q = \frac{3Q}{4}$



Sol. (A) → P,R ; (B) → Q, S; (C) → Q,R; (D) → (P,S)
In case of sine wave, node forms at x = 0

40.

Sol. (A) → Q,S ; (B) → P ; (C) → Q,R,S; (D) → (R)

41. C

42. B

Internal energy of (A + B) = Internal energy of the mixture.

$n_A C_v T_A + n_B C_v T_B = (n_A + n_B) C_V T_{mix}$

$$T_{mix} = \frac{n_A T_A + n_B T_B}{n_A + n_B}$$

43. A

Acedic order $-\overset{\overset{\large O}{\|}}{C}-OH > -CH_2-OH > -C \equiv CH$

44. D

45. C

m moles of NaOH = V_1x

m moles of $Ba(OH)_2 = V_2y$

m. moles of HCl = 100 × 0.1 = 10

HCl neutralize NaOH completely

m moles of HCl remaining after the Reaction with NaOH

$= 10 - V_1x =$ M.eq. of $Ba(OH)_2$

$10 - V_1x = 2V_2y$

$10 = V_1x + 2V_2y$

$\frac{V_1}{V_2} = \frac{1}{4}, \quad \frac{x}{y} = 4$

$\frac{V_1x}{V_2y} = 1 \Rightarrow V_1x = V_2y$

$10 = 3V_2y \Rightarrow V_2y = \frac{10}{3}$

meq. acid neutralize by $Ba(OH)_2 = 2V_2y$

fraction $= \frac{20}{3 \times 10} = \frac{2}{3} = 0.67$

46. B

$CH_3-CH=CH-CH_3 \xrightarrow[H_2O/Zn]{O_3/CC_4} 2CH_3CHO$

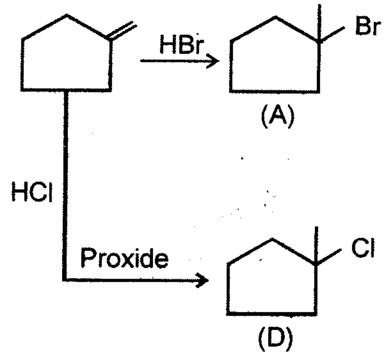
$\downarrow CaOCl_2$

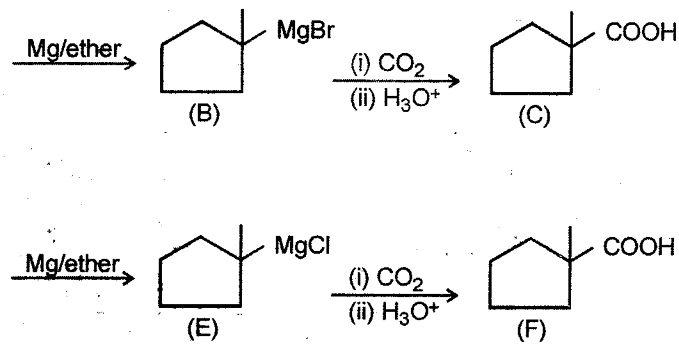
$(HCOO)_2Ca + CHCl_3$

$\downarrow$ Heat

$H-\overset{\overset{\large O}{\|}}{C}-H$

47. B





48. B

Meq. of $KMnO_4 = \frac{20 \times 0.05 \times 5}{25} \times 1000$

= meq. of $FeSO_4 . 7H_2O$

wt. of $FeSO_4 . 7H_2O = 80 \times 278 \times 10^{-3}$

% of $FeSO_4 = \frac{80 \times 278 \times 10^{-3}}{32} \times 100 = 69.5\%$

49. B,C,D

50. B

Catalyst decreases the activation energy of both by backward and forward reaction

∴ concentration of reactant and product remain unchanged by using catalyst

51. A,C

52. C,D

53. D

54. A

55. D

Rate of formation of

$\dot{C}H_3 = K_1[CH_3CHO] + K_3[CH_3\dot{C}O]$

Rate of consumption of

$\dot{C}H_3 = K_2[CH_3CHO][\dot{C}H_3] + 2k_4[\dot{C}H_3]^2$

$\therefore\ K_1[CH_3CHO] + K_3[CH_3\dot{C}O]$

$= K_2[CH_3CHO][\dot{C}H_3] + 2K_4[\dot{C}H_3]^2$ ...(i)

Similarly,

$K_2[CH_3CHO][\dot{C}H_3] = K_3[CH_3\dot{C}O]$ ...(ii)

From (i) and (ii)

$$[\dot{C}H_3] = \left(\frac{K_1}{2K_4}\right)^{1/2}[CH_3CHO]^{1/2}$$

$$\therefore\ \frac{d[CH_4]}{dt} = K_2[CH_3CHO][\dot{C}H_3]$$

$$= K_2[CH_3CHO]\left(\frac{K_1}{2K_4}\right)^{1/2}[CH_3CHO]^{1/2} = K[CH_3CHO]^{3/2}$$

56. B

57. A

58. B

V I B BG G GY Y O R

Strong

field ligand ⟶ weak field ligand

As the no. of the Cl increases in coordination sphere ligand field decreases

A = $[Cr(H_2O)_6]Cl_3 \Rightarrow$ Violet

B = $[Cr(H_2O)_5Cl]Cl_2.H_2O \Rightarrow$ light green

C = $[Cr(H_2O)_4Cl_2]Cl.2H_2O \Rightarrow$ dark green

59. **(A) → Q, (B) → R, (C) → (P,S), (D) → (Q)**

60. **A → P,Q ; B → P,R,S ; C → P,Q ; D → P,Q**