1 - JEE Main Maths 28-Jan 2026 Shift -2

Q1 Solution:
(2)

$E\left(X\right) = \sum x_i P\left(X_i\right) = \frac{526k}{15 \times 7} = \frac{263}{15} \Rightarrow k = \frac{7}{2}$

X	14	15	16	17	18	19	20	21
P(X)	$\frac{2}{15}$	$\frac{1}{15}$	$\frac{2}{15}$	$\frac{1}{5}$	$\frac{1}{15}$	$\frac{2}{15}$	$\frac{1}{5}$	$\frac{1}{15}$

$P\left(X < 20\right) = \sum_{x=14}^{19} P\left(X\right) = \frac{11}{15}$

Q2 Solution:
(4)

[IMAGE 285]

$CA_1 = a = 4$

$CF_1 = ae = 2$

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

$LR = 2e\left(\frac{a}{e} - ae\right)$

$= 2 \times \frac{1}{2}\left(\frac{4}{1/2} - 2\right)$

$= 6$

Q3 Solution:
(1)

$S = (1+x)^{1000} + x(1+x)^{999} + x^2(1+x)^{998} + \cdots + x^{1000}$

$= (1+x)^{1000}\left(\frac{1 - \left(\frac{x}{1+x}\right)^{1001}}{1 - \frac{x}{1+x}}\right)$

$= (1+x)^{1001} - x^{1001}$

Required sum $= {}^{1001}C_{499} + {}^{1001}C_{500} = {}^{1002}C_{500}$

Q4 Solution:
(3)

$f(x) = \begin{cases} \cos(\pi x) & x \to 1^- \\ \frac{-\sin(x-1)}{x-1} & x \to 1^+ \end{cases}$

$\text{RHL} = \lim_{x \to 1} \frac{-\sin(x-1)}{x-1} = -1$

$\text{LHL} = \lim_{x \to 1} \cos\left(\pi x\right) = -1, \; f\left(1\right) = -1$

f(x) is continuous at $x = 1$

$$f(x) = \begin{cases} \frac{-\sin(x-1)}{-(x-1)} & x \to -1^- \\ \cos(\pi x) & x \to -1^+ \end{cases}$$

$$\text{RHL} = \lim_{x \to -1} \cos\left(\pi x\right) = -1$$

$$\text{LHL} = \lim_{x \to -1} \frac{-\sin(x-1)}{x-1} = \frac{\sin 2}{-2}$$

f(x) is discontinuous at $x = -1$

Q5 Solution:
(1)

$$f\left(x\right) = \int \frac{dx}{x^{2/3} + 2x^{1/2}}$$

Put $x = t^6 \Rightarrow dx = 6t^5 dt$

$$= \int \frac{6t^5}{t^4 + 2t^3} dt = 6\int \frac{\left(t^2 - 4\right) + 4}{t+2} dt$$

$$= 6\left[\int \left(t-2\right) dt + 4\int \frac{1}{t+2} dt\right]$$

$$= 6\left[\frac{t^2}{2} - 2t + 4ln\left(t+2\right)\right] + C$$

$$= 3x^{1/3} - 12x^{1/6} + 24ln\left(x^{1/6} + 2\right) + C$$

$$f(0) = 24ln2 + C = -26 + 24ln2 \ \left(\text{given}\right)$$

$$\Rightarrow C = -26$$

Now

$$f(1) = -35 + 24ln3 = a + bln3 \ \left(\text{as given in ques.}\right)$$

$$\Rightarrow a = -35, \ b = 24$$

$$\Rightarrow a + b = -11$$

Q6 Solution:
(3)

$$xdy - ydx = x^2 \cot x dx$$

$$x^2 \ d\left(\frac{y}{x}\right) = x^2 \cot x dx$$

$$d\left(\frac{y}{x}\right) = \cot x dx$$

$$\int d\left(\frac{y}{x}\right) = \int \cot x dx$$

$$\frac{y}{x} = \log_e\left(\sin x\right) + C$$

$$\text{given } y\left(\frac{\pi}{2}\right) = \frac{\pi}{2} \Rightarrow C = 1$$

$$y = x\left(\log_e\left(\sin x\right) + 1\right)$$

$$y\left(\frac{\pi}{6}\right) = \frac{\pi}{6}\left[-\log_e 2 + 1\right]$$

$$y\left(\frac{\pi}{4}\right) = \frac{\pi}{4}\left[-\frac{1}{2}\log_e 2 + 1\right]$$

$$6y\left(\frac{\pi}{6}\right) - 8y\left(\frac{\pi}{4}\right)$$

$= \pi\left[\left(-\log_e 2 + 1\right) + 2\left(\frac{1}{2}\log_e 2 - 1\right)\right]$

$= \pi[1 - 2] = -\pi$

Q7 Solution:
(1)

Let $\sin^{-1}\left(\frac{2}{\sqrt{13}}\right) = \theta$ & $\cos^{-1}\left(\frac{3}{\sqrt{10}}\right) = \phi$

$\sin\theta = \frac{2}{\sqrt{13}}$ & $\cos\phi = \frac{3}{\sqrt{10}}$

$\tan\left(2\theta - 2\phi\right) = \frac{\tan 2\theta - \tan 2\phi}{1 + \tan 2\theta \tan 2\phi}$

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

$= \frac{\frac{12}{5} - \frac{3}{4}}{1 + \frac{12}{5} \cdot \frac{3}{4}}$

$= \frac{33}{56}$

Q8 Solution:
(3)

$a = 4 - d,\ \alpha = 4 + d,\ b = 4 + 2d$

$\Rightarrow \left(4 + d\right)x^2 - \left(4 - d\right)x + 2\left(4 + d - 8 - 4d\right) = 0$

$\Rightarrow \left(4 + d\right)x^2 - \left(4 - d\right)x + 2\left(-4 - 3d\right) = 0$

Also $\frac{\frac{1}{a} + \frac{1}{b}}{2} = \frac{5}{16}$

$\Rightarrow \frac{\frac{1}{4 - d} + \frac{1}{4 + 2d}}{2} = \frac{5}{16}$

$\Rightarrow d = 2$

Equation becomes $6x^2 - 2x - 20 = 0$

$3x^2 - x - 10 = 0$

$x = 2,\ -\frac{5}{3}$

Q9 Solution:
(3)

$x \in \left(0, \frac{\pi}{2}\right) \Rightarrow y = 1 + 1 + 1 + 1 = 4$

$x \in \left(\frac{\pi}{2}, \pi\right) \Rightarrow y = 1 - 1 - 1 - 1 = -2$

$x \in \left(\pi, \frac{3\pi}{2}\right) \Rightarrow y = -1 - 1 + 1 + 1 = 0$

$x \in \left(\frac{3\pi}{2}, 2\pi\right) \Rightarrow y = -1 + 1 - 1 - 1 = -2$

$\therefore$ Range of y is $\left\{-2, 0, 4\right\}$

Required sum $= -2 + 0 + 4 = 2$

Q10 Solution:
(4)

$\cos 2\theta = \frac{3 - 1 - 3}{\sqrt{11} \cdot \sqrt{11}} = -\frac{1}{11}$

[IMAGE 286]

$1 - 2\sin^2\theta = -\frac{1}{11} \Rightarrow 2\sin^2\theta = \frac{12}{11} \Rightarrow \sin\theta = \sqrt{\frac{6}{11}}$

$\therefore \text{Area}\left(\Delta APB\right) = \frac{1}{2} \times \sqrt{11} \cdot \frac{\sqrt{5}}{2} \cdot \sqrt{\frac{6}{11}} = \frac{\sqrt{30}}{4}$

Q11 Solution:
(3)

$I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{12(3 + [x])}{3 + [\sin x] + [\cos x]} dx$

$I = \int_{-\frac{\pi}{2}}^{-1} \frac{12(1)\,dx}{2} + \int_{-1}^{0} \frac{12(2)\,dx}{2} + \int_{0}^{1} \frac{12(3)\,dx}{3} + \int_{1}^{\frac{\pi}{2}} \frac{12(4)\,dx}{3}$

$I = 6\left(\frac{\pi}{2} - 1\right) + 12\left(0 + 1\right) + 12\left(1 - 0\right) + 16\left(\frac{\pi}{2} - 1\right)$

$I = 3\pi - 6 + 12 + 12 + 8\pi - 16$

$I = 11\pi + 2$

Q12 Solution:
(4)

$|z - 2| \le 4 \Rightarrow (x - 2)^2 + y^2 \le 16$

$|z - 2| + |z + 2| = 5 \Rightarrow \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

$\Rightarrow \frac{4x^2}{25} + \frac{4y^2}{9} = 1$

[IMAGE 287]

Maximum value of $\left|z_1 - z_2\right| = 6 + \frac{5}{2} = \frac{17}{2}$

Q13 Solution:
(2)

[IMAGE 288]

Area bounded between P_1 & P_2 is

$\int_{-3}^{3} \left(\left(x^2 + 27\right) - \left(4x^2\right)\right) dx$

$\left(\text{P.O.I. of } P_1 \text{ \& } P_2 \text{ is } x = \pm 3\right)$

$= 2\int_{0}^{3} \left(27 - 3x^2\right) dx = 2\left[27x - x^3\right]_0^3$

$= 2[81 - 27] = 108$

$\therefore$ Area bounded between P_1 & L is 18 sq. units

$\left(\text{Area between } x^2 = 4ay \text{ \& line } x = my \text{ is } \frac{8a^2}{3m^3}\right)$

$\therefore$ Area between $x^2 = \frac{y}{4}$ & $x = \frac{y}{\alpha}$ is

$\frac{8\left(\frac{1}{16}\right)^2}{3\left(\frac{1}{\alpha}\right)^3} = 18$

$\Rightarrow \frac{\frac{8}{16\cdot 16}}{\frac{3}{\alpha^3}} = 18 \Rightarrow \alpha^3 = 2^6 \cdot 3^3$

$\Rightarrow \alpha = 12$

Q14 Solution:
(2)

[IMAGE 289]

drs of PN $= \langle r - 2,\ 2r - 2,\ r \rangle$

$1(r - 2) + 2(2r - 2) + 1(r) = 0$

$6r = 6 \Rightarrow r = 1$

$\therefore N \equiv (2, 2, 2)$

$\Rightarrow Q \equiv (1, 2, 3)$

[IMAGE 290]

$AQ = \sqrt{64 + 49 + 4} = \sqrt{117}$

$AM = \frac{|24 + 14 - 4|}{\sqrt{9 + 4 + 4}} = \frac{34}{\sqrt{17}} = 2\sqrt{17}$

$\therefore QM = \sqrt{117 - 68} = \sqrt{49} = 7$

Q15 Solution:
(2)

Let point of intersection $R(h, k)$

$m_{BR} = m_{BP} \Rightarrow \frac{k}{h + 2} = \frac{2\sin\alpha}{2\cos\alpha + 2} \Rightarrow \frac{k}{h + 2} = \tan\frac{\alpha}{2}$

$m_{AR} = m_{AQ} \Rightarrow \frac{k}{h - 2} = \frac{2\sin\beta}{2\cos\beta - 2} = \frac{\sin\beta}{\cos\beta - 1} = -\cot\frac{\beta}{2}$

$\frac{\alpha}{2} - \frac{\beta}{2} = \frac{\pi}{4}$

$\tan\left(\frac{\alpha}{2} - \frac{\beta}{2}\right) = \tan\frac{\pi}{4} = 1$

$\frac{\tan\frac{\alpha}{2} - \tan\frac{\beta}{2}}{1 + \tan\frac{\alpha}{2}\tan\frac{\beta}{2}} = 1$

$\frac{\frac{k}{h+2} + \frac{h-2}{k}}{1 + \left(\frac{k}{h+2}\right)\left(\frac{2-h}{k}\right)} = 1$

$\Rightarrow \frac{\frac{k^2 + h^2 - 4}{k(h+2)}}{\frac{4}{h+2}} = 1$

$\Rightarrow \frac{h^2 + k^2 - 4}{4k} = 1$

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

Q16 Solution:
(4)

Statement 1: $f(x) = \frac{x}{1 + |x|}$

$$f(x) = \begin{cases} \frac{x}{1+x} & x \geq 0 \\ \frac{x}{1-x} & x < 0 \end{cases}$$

[IMAGE 291]

f(x) is one-one

Statement 2: $f(x) = \frac{x^2 + 4x - 30}{x^2 - 8x + 18}$, $f\left(0\right) = \frac{-30}{18} = \frac{-5}{3}$

$\frac{-5}{3} = \frac{x^2 + 4x - 30}{x^2 - 8x + 18}$

On solving $x = 0, -1$

$\Rightarrow f\left(0\right) = f\left(-1\right) = \frac{-5}{3}$

$\therefore f\left(x\right)$ is many-one

Q17 Solution:
(3)

[IMAGE 292]

Coordinates of centroid of triangle ABC are

$\frac{2}{3}\left(t_1^2 + t_2^2 + 1\right) = \frac{7}{3} \Rightarrow t_1^2 + t_2^2 = \frac{5}{2}$

$\frac{4}{3}\left(t_1 + t_2\right) = \frac{4}{3} \Rightarrow t_1 + t_2 = 1$

$\left(t_1 + t_2\right)^2 = t_1^2 + t_2^2 + 2t_1t_2 \Rightarrow t_1t_2 = -\frac{3}{4}$

$\left(t_1 - t_2\right)^2 = \left(t_1 + t_2\right)^2 - 4t_1t_2 = 4$

$\left(BC\right)^2 = 4\left(t_1^2 - t_2^2\right)^2 + 16\left(t_1 - t_2\right)^2$

$\Rightarrow \left(BC\right)^2 = 80$

Q18 Solution:
(3)

Equation of hyperbola: $\frac{y^2}{\lambda^2} - \frac{x^2}{16} = 1$

Equation of ellipse: $\frac{x^2}{144} + \frac{y^2}{169} = 1$

$e = \sqrt{1 - \frac{144}{169}} = \frac{5}{13}$

Focus $\Rightarrow \left(0, 5\right)$

$\Rightarrow \lambda\sqrt{1 + \frac{16}{\lambda^2}} = 5$

$\Rightarrow \lambda^2 + 16 = 25 \Rightarrow \lambda = 3$

Eccentricity of hyperbola $= \sqrt{1 + \frac{16}{\lambda^2}} = \frac{5}{3}$

Length of latus rectum of hyperbola $= \frac{2\left(16\right)}{3} = \frac{32}{3}$

$24\left(e + \ell\right) = 24\left(\frac{5}{3} + \frac{32}{3}\right) = 8 \times 37 = 296$

Q19 Solution:
(3)

$S = \frac{6}{3^{26}} + \frac{10}{3^{25}}\left[\frac{6^{25} - 1}{6 - 1}\right]$

$S = \frac{6}{3^{26}} + \frac{10}{3^{25}}\left[\frac{6^{25} - 1}{5}\right]$

$S = \frac{2}{3^{25}} + 2\left[\frac{2^{25}}{3^{25}} - \frac{1}{3^{25}}\right]$

$S = 2^{26}$

Q20 Solution:
(1)

Statement I :

[IMAGE 293]

Statement II: $R = \left(7 + 4\sqrt{3}\right)^{25} = I + f$

$R' = \left(7 - 4\sqrt{3}\right)^{25} = f'$

$\therefore R + R' = 2\left[{}^{25}C_0 7^{25} + {}^{25}C_2 7^{23}\left(4\sqrt{3}\right)^2 + \cdots\right]$

$I + f + f' = \text{even integer}$

$\therefore I = \text{odd integer}$

$\because 0 < f + f' < 2 \Rightarrow f + f' = 1$

$\Rightarrow$ Both the statements are correct

Q21 Solution:
(976)

$S = \sum \frac{r}{(r^2 + r + 1)(r^2 - r + 1)}$

$= \frac{1}{2}\sum_{r=1}^{25}\left(\frac{1}{r^2 - r + 1} - \frac{1}{r^2 + r + 1}\right)$

$= \frac{1}{2}\left[\left(\frac{1}{1} - \frac{1}{3}\right) + \left(\frac{1}{3} - \frac{1}{7}\right) + \cdots + \left(\frac{1}{601} - \frac{1}{651}\right)\right]$

$= \frac{1}{2}\left[1 - \frac{1}{651}\right]$

$= \frac{1}{2}\left[\frac{650}{651}\right] = \frac{325}{651}$

$\frac{p}{q} = \frac{325}{651} \Rightarrow p + q = 976$

Q22 Solution:
(170)

$\frac{x - 43}{3} = \frac{y - \alpha}{-1} = \frac{z - \beta}{0} \Rightarrow P_1\left(43 + 3\lambda, \alpha - \lambda, \beta\right)$

$\frac{x - 4}{2} = \frac{y}{0} = \frac{z + 1}{3} \Rightarrow P_1\left(2\mu + 4, 0, 3\mu - 1\right)$

$\therefore \mu = \frac{3\lambda + 39}{2}, \ \alpha = \lambda, \ \beta = \frac{9\lambda - 115}{2}$

$P\left(43, \alpha, \beta\right), \ P_1\left(43 + 3\alpha, 0, \beta\right)$

$(PP_1)^2 = 1690 = 10\alpha^2 \Rightarrow \alpha = 13,\ \beta = 1$

$\therefore \alpha^2 + \beta^2 = 170$

Q23 Solution:
(0)

$A = I + \begin{bmatrix} 2 & -4 \\ 1 & -2 \end{bmatrix}$, let $M = \begin{bmatrix} 2 & -4 \\ 1 & -2 \end{bmatrix}$

$M^2 = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \Rightarrow M^3 = M^4 = \cdots = M^{100} = 0$

$A^{100} = (I + M)^{100} = \sum_{r=0}^{100} \binom{100}{r} M^r . I$

$A^{100} = I + 100M = I + 100B$

$\therefore M = B \Rightarrow M^{100} = B^{100} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$

Q24 Solution:
(9)

$f(x) = 1 - 2x + e^x \int_0^x e^{-t} f(t)\, dt$

$e^{-x} f(x) = (1 - 2x) e^{-x} + \int_0^x e^{-t} f(t)\, dt$

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

$f'(x) - 2f(x) = 2x - 3$

$\frac{dy}{dx} - 2y = 2x - 3$

$\Rightarrow ye^{-2x} = \int e^{-2x} (2x - 3)\, dx$

On solving we get $f(x) = 1 - x$

$g(x) = \int_0^x (3 - t)^{15} (t - 4)^6 (t + 12)^{17} dt$

$g'(x) = (3 - x)^{15} (x - 4)^6 (x + 12)^{17}$

$= -(x - 3)^{15} (x - 4)^6 (x + 12)^{17}$

[IMAGE 294]

Local maxima $\Rightarrow q = 3$

Local minima $\Rightarrow p = -12 = |p + q| = 9$

Q25 Solution:
(210)

${}^7C_3 \times 3! = \frac{7 \times 6 \times 5}{1 \times 2 \times 3} \times 3! = 210$

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Q26 Solution:
(1)

[IMAGE 295]

$V_A = \frac{V}{2}$

$V_B = \frac{V}{2 \cdot I_R} \times R = \frac{V}{2.1}$

$\therefore V_A - V_B = V\left[\frac{1}{2} - \frac{1}{2.1}\right]$

$V_A - V_B = \frac{0.1}{2 \times 2.1} \times 40$

$V_A - V_B = \frac{4}{4.2} = 0.95$

Q27 Solution:
(3)

$x = 0 \Rightarrow t = 0, \frac{\sqrt{3}}{2}$

$v = 12t^2 - 3$

At turning point, $v = 0$

$t = \frac{1}{2} \Rightarrow x = \frac{4}{8} - \frac{3}{2} = -1$

$a = 24t$ (always positive)

Q28 Solution:
(2)

$R_\alpha = R_0 \alpha^{1/3}$

$R_\beta = R_0 \beta^{1/3}$

$\frac{R_\alpha}{R_\beta} = \left(\frac{\alpha}{\beta}\right)^{1/3} = \frac{1}{2}$

Q29 Solution:
(2)

$\frac{\Delta K}{K} = \frac{2\Delta T}{T} + \frac{\Delta m}{m}$

$T = \frac{60}{50} = 1.2\text{sec}$

$\Delta T = \frac{2}{50}$

$\therefore \frac{\Delta K}{K} = \frac{2 \times 2}{50 \times 1.2} + \frac{10 \times 10^{-3}}{10} = 0.0676$

$\therefore$ % Error $= 6.76\%$

Q30 Solution:
(3)

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$\vec{v} = \frac{d\vec{r}}{dt} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$

$\vec{p} = m\vec{v}$

$\vec{L} = m\left(\vec{r} \times \vec{v}\right)$

$= \left(x\hat{i} + y\hat{j} + z\hat{k}\right) \times m\left(v_x\hat{i} + v_y\hat{j} + v_z\hat{k}\right)$

When sign of $\vec{r}$ changes, $\vec{L}$ remains same.

Q31 Solution:
(2)

$\lambda = \frac{k_B T}{\sqrt{2}\pi\sigma^2 P}$

$= \frac{1.38 \times 10^{-23} \times \left(273 + 41\right) \times 100}{\sqrt{2} \times 3.14 \times \left(5 \times 10^{-10}\right)^2 \times 1.38 \times 10^5}$

$= 2\sqrt{2} \times 10^{-8}$

Q32 Solution:
(2)

Solid cylinder

[IMAGE 296]

B_{max} at surface

B_{min} at axis

Q33 Solution:
(2)

$\delta_{\text{min}} = 2i - A \Rightarrow i = \delta_{\text{min}} = A$

Also, $\mu = \frac{\sin\left(\frac{\delta_{\text{min}} + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$\Rightarrow \mu = \frac{\sin A}{\sin\frac{A}{2}} = 2\cos\left(\frac{A}{2}\right)$

$1 < \mu < 2 \quad ...(1)$

$\delta_{\text{min}} = 2i - A$

$A = 2i - A \Rightarrow i = A$

$i < 90°$ (grazing incidence)

$A < 90°$

$\mu = 2\cos\left(\frac{A}{2}\right),\ A < 90°$

$\mu > \sqrt{2} \quad ...(2)$

from (1) & (2)

$\sqrt{2} < \mu < 2$

Q34 Solution:
(3)

$(A)\ \eta = \frac{Fdr}{Adv} = \frac{\left[MLT^{-2}\right]\left[L\right]}{\left[L^2\right]\left[LT^{-1}\right]} = \left[ML^{-1}T^{-1}\right]$

$(B)\ S = \frac{F}{L} = \frac{\left[MLT^{-2}\right]}{\left[L\right]} = \left[MT^{-2}\right]$

$(C)\ P = \frac{F}{A} = \frac{\left[MLT^{-2}\right]}{\left[L^2\right]} = \left[ML^{-1}T^{-2}\right]$

$(D)\ E = S \times A = [MT^{-2}][L^2] = [ML^2T^{-2}]$

Q35 Solution:
(1)

$\hat{B} = \hat{C} \times \hat{E} = \hat{k} \times \hat{j} = -\hat{i}$

$\therefore \quad \vec{B} = \frac{54}{3 \times 10^8} \sin(kz - \omega t)(-\hat{i})$

$= -1.8 \times 10^{-7} \sin(kz - \omega t)\hat{i}$

Q36 Solution:
(1)

$V_{\text{sound}} = \sqrt{\frac{Y}{\rho}}$

$\frac{\Delta V}{V} \times 100 = \frac{1}{2}\left(\frac{\Delta Y}{Y} \times 100\right) - \frac{1}{2}\left(\frac{\Delta \rho}{\rho} \times 100\right)$

$= \frac{1}{2} \times 1 - \frac{1}{2} \times 0.5$

$\frac{\Delta V}{V} \times 100 = \frac{1}{4}$

$\Delta V = \frac{1}{4} \times \frac{V}{100}$

$\Delta V = 1 \text{m/s}$

$V_{\text{final}} = 400 + 1 = 401 \text{m/s}$

Q37 Solution:
(2)

[IMAGE 297]

$mgsin\theta - ma_0\cos\theta = ma$

$a = g\sin\theta - a_0\cos\theta$

Now using,

$S = ut + \frac{1}{2}a_{\text{down}}t^2$

$\frac{L}{\cos\theta} = \frac{1}{2}\left(g\sin\theta - a_0\cos\theta\right)t^2$

$t = \sqrt{\frac{2L}{g\sin\theta\cos\theta - a_0\cos^2\theta}}$

$t = \sqrt{\frac{4L}{g\sin2\theta - a_0(1 + \cos2\theta)}}$

Q38 Solution:
(1)

For series combination

$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2}$

$\therefore \quad C_{\text{eq}}$ is less than C_1 & C_2.

Note: In statement C, capacitor is assumed to be completely filled with dielectric then on decreasing thickness of dielectric capacitance will increase.

Q39 Solution:
(1)

$P = \frac{nhc}{\lambda}$

$6 \times 10^{-3} = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^{8}}{663 \times 10^{-9}}$

$n = 2 \times 10^{16}$ photons

Q40 Solution:
(2)

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_{\text{net}}} = \frac{1}{f_1} + \frac{1}{f_2}$

$\frac{1}{v} + \frac{1}{30} = \left(1.5 - 1\right)\left(\frac{1}{15} - \frac{1}{\infty}\right) + \left(1.2 - 1\right)\left(\frac{1}{\infty} + \frac{1}{12}\right)$

$\frac{1}{v} + \frac{1}{30} = \frac{1}{30} + \frac{1}{60}$

$v = 60$

$m = \frac{v}{u} = \frac{60}{-30} = -2$

Q41 Solution:
(4)

If either A or B is zero, in that case current flows and $v_c = 0$.

Hence the gate will be AND gate.

Q42 Solution:
(4)

Here from voltage, question refers to potential. We can measure potential difference between two points but not potential at any point.

Note: If the potential of reference point is known then we can measure potential as well.

Q43 Solution:
(2)

Least count will be 0.01 mm.

Q44 Solution:
(1)

$\mu = \frac{m_1 m_2}{m_1 + m_2} = \frac{1 \times 0.2}{1.2}$

$\mu = \frac{1}{6}$

$\omega = \sqrt{\frac{k}{\mu}} = \sqrt{\frac{150}{1/6}} = 30$

Q45 Solution:
(4)

Static electric field lines do NOT from closed loops (they start on positive and end on negative charges), making statement A false.

Q46 Solution:
(30)

[IMAGE 298]

$mg \times 3 = \frac{1}{2} \cdot \frac{mR^2}{2} \cdot \omega^2 + \frac{1}{2}mv^2 \quad ...(i)$

$\& \ v = \omega R \quad ...(ii)$

From equation (i) & (ii)

$g \times 3 = \frac{3}{4}v^2$

K.E. of flywheel $= \frac{1}{2} \times \frac{mR^2}{2} \times \omega^2 = \frac{1}{4}mv^2$

$= \frac{1}{4} \times 3 \times 40 = 30$ Joule

Q47 Solution:
(384)

$|f_A - f_B| = 4$

$|f_A - 380| = 4$

So, $f_A = 384$ Hz or 376 Hz

On loading with wax f_A decreases

So, $f_A = 384$ Hz

Q48 Solution:
(429)

$y = n\frac{\lambda D}{d}$

$y_1 = y_2$

$n_1\lambda_1\frac{D}{d} = n_2\lambda_2\frac{D}{d}$

$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{550}{650} = \frac{11}{13}$

$y = 11 \times \frac{\lambda_1 D}{d} = \frac{11 \times 650 \times 10^{-9} \times 1.2}{2 \times 10^{-3}}$

$y = 429 \times 10^{-5}$

Q49 Solution:
(300)

Work done = Area bounded by cycle

$= \frac{1}{2} \times 3 \times 200 = 300$ J

Q50 Solution:
(314)

$\frac{1}{2}Li_{\text{rms}}^2 = 16 \Rightarrow L = 8$

$i^2R = 32 \Rightarrow R = 8$

$X_L = \omega L = 2 \times 3.14 \times 50 \times 8$

$= 800 \times 3.14$

$R = 8$

$\frac{X_L}{R} = 314$

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Q51 Solution:
(1)

[IMAGE 299]

Q52 Solution:
(1)

Correct order of

(i) Boiling point : HF > HI > HBr > HCl

(ii) Melting point : HI > HF > HBr > HCl

Q53 Solution:
(4)

$\log_{10} K = -\frac{\Delta H°}{2.303RT} + \frac{\Delta S°}{2.303R}$

y-intercept $= \frac{\Delta S°}{2.303R}$

Slope $= -\frac{\Delta H°}{2.303R}$

Ans. (4) is correct.

Q54 Solution:
(4)

$\% S = \frac{32}{233} \times \frac{0.4813}{0.314} \times 100$

$= 21.052\%$

Ans. (4) 21.05%

Q55 Solution:
(2)

XeF_2 & I_3^-: 2 bond pair, 3 lone pair ; Linear

$XeOF_4$ & BrF_5: 5 bond pair, 1 lone pair ; Square pyramidal

XeO_2F_2 & SF_4: 4 bond pair, 1 lone pair ; See-saw

XeO_3 & NH_3: 3 bond pair, 1 lone pair ; Pyramidal

Q56 Solution:
(2)

Density of HCl solution $(d) = 1.13$ g/mL

$V = 300$ mL

Wt. of HCl solution $= 339$ g

Wt. of HCl $= 339 \times \frac{38.55}{100} = 130.68$ g

$$\begin{array}{ccccccccc} (LR) & & & & & & & & \\ CaCO_3 & + & 2HCl & \rightarrow & CaCl_2 & + & H_2O & + & CO_2 \\ \frac{90}{100} & & \frac{130.68}{36.5} & & & & & & \\ = 0.90 \text{ mole} & & = 3.58 \text{ mole} & & & & & & \end{array}$$

Moles of HCl remained $= 1.78$ mole

Mass of HCl remained $= 64.97$ g

Q57 Solution:
(2)

2° Amine are insoluble with Hinsberg reagent.

Ph-NH-CH_3, Me-NH-Me,

Ph-NH-CH_2-CH_2-CH_3, Ph-NH-Ph

Ans. (2) 4

Q58 Solution:
(2)

$$\begin{array}{ccc} A & \rightleftharpoons & B \\ 0.5M & & 0.375M \end{array} \quad (\text{At equilibrium})$$

$K_{eq} = \frac{[B]_{eq}}{[A]_{eq}} = \frac{0.375}{0.5} = 0.75$

Now 0.1 mole of A is added so reaction will move in forward direction.

$$\begin{array}{ccc} A & \rightleftharpoons & B \\ 0.6 - x & & 0.375 + x \end{array}$$

$K_{eq} = 0.75 = \frac{0.375 + x}{0.6 - x}$

$0.45 - 0.75x = 0.375 + x$

$1.75x = 0.075$

$x = \frac{0.075}{1.75} = \frac{3}{70} = 0.043$

Moles of A $= 0.6 - 0.043 = 0.557$

Moles of B $= 0.375 + 0.043 = 0.418$

Ans. (2) is correct.

Q59 Solution:
(4)

[IMAGE 300]

Ans. – (4) A & C

Q60 Solution:
(4)

(1) Wavelength of A $= 400$ nm

(2) Wavelength of B $(\lambda) = \frac{c}{\nu} = \frac{3\times10^{8}}{10^{16}} = 3\times10^{-8} = 30\times10^{-9} = 30$ nm

(3) Wavelength of C $(\lambda) = \frac{1}{\bar{\nu}} = \frac{1}{10^{4}} = 10^{-4}$ cm $= 10^{-6}$ m $= 1000$ nm

Here $\lambda_C > \lambda_A > \lambda_B$

Energy $(E) \propto \frac{1}{\lambda}$

So $E_B > E_A > E_C$

Ans. (4) is correct.

Q61 Solution:
(1)

[IMAGE 301]

Ans. : (1) C, D

Q62 Solution:
(4)

Presence of NO_2 group in benzene ring deactivates the ring towards electrophilic substitution reaction due to –M effect and activates the ring towards nucleophilic substitution.

Ans. → (4) B & C

Q63 Solution:
(2)

[IMAGE 302]

Q64 Solution:
(2)

Structure (1) given is of sucrose which is non reducing.

For non reducing sugar compound should have acetal linkage not hemi acetal linkage.

[IMAGE 303]

Q65 Solution:
(2)

$\Delta T_b = i \cdot k_b \cdot m$

For dilute solution $(M = m)$

	Molarity	$i \times m$
(I)	$M_{\text{glucose}} = \frac{2.2}{180} \times \frac{1000}{125} = 0.098$	0.098×1
(II)	$M_{\text{CaCl}_2} = \frac{1.9}{111} \times \frac{1000}{250} = 0.068$	0.068×3
(III)	$M_{\text{urea}} = \frac{9}{60} \times \frac{1000}{500} = 0.3$	0.3×1
(IV)	$M_{\text{Al}_2(\text{SO}_4)_3} = \frac{20.5}{342} \times \frac{1000}{750} = 0.08$	0.08×5

Order of $\Delta T_b = \text{Al}_2(\text{SO}_4)_3 > \text{Urea} > \text{CaCl}_2 > \text{Glucose}$

So order of $\text{BP} = \text{Al}_2(\text{SO}_4)_3 > \text{Urea} > \text{CaCl}_2 > \text{Glucose}$

So Answer will be $\text{I} < \text{II} < \text{III} < \text{IV}$

Q66 Solution:
(2)

Correct order of acidic strength of major product formed in the given reaction is

[IMAGE 304]

(B) $\text{CH}_3\text{CH}_2 - \text{CHO} \xrightarrow[\Delta]{\text{Ag(NH}_3)_2\text{OH}} \text{CH}_3 - \text{CH}_2 - \text{COOH}$

(C) $\text{CH}_4 + \text{O}_2 \xrightarrow[\text{Na}_2\text{Cr}_2\text{O}_7 / \text{H}^+]{\text{Mo}_2\text{O}_3} \text{HCOOH}$

(D) $\text{Ph - CH}_2\text{MgBr} + \text{CO}_2 \xrightarrow[\text{H}_3\text{O}^{\cdot}]{\text{Dry ether}} \text{Ph - CH}_2\text{ - COOH}$

Ans. (2) C>A>D>B

Q67 Solution:
(2)

Manganate ion $\rightarrow \text{MnO}_4^{2-}$

Permanganate ion $\rightarrow \text{MnO}_4^-$

(A) Both are tetrahedral (d^3s Hybridisation)

(B) MnO_4^- (+7 oxidation state)

MnO_4^{2-} (+6 oxidation state)

(C) $\text{Mn}^{2+} + \text{S}_2\text{O}_8^{2-} \rightarrow \text{MnO}_4^-$ (Permanganate ion)

(D) $\text{MnO}_4^- \rightarrow$ Diamagnetic

$\text{MnO}_4^{2-} \rightarrow$ Paramagnetic

(E) It is oxidising agent

Q68 Solution:
(4)

Least metallic = F, valence electrons = 7

Most metallic = P, valence electrons = 5

Q69 Solution:

(4)

$Mn^{2+}\ 3d^5\ n = 5$

$Cu^{2+}\ 3d^9\ t_{2g}^{2,2,2}\ e_g^{2,1}\ n = 1$

$Ni^{2+}\ 3d^8$ square planar $n = 0$

$Ni^{2+}\ 3d^8$ tetrahedral $e_g^{2,2}\ t_{2g}^{2,1,1}\ n = 2$

Q70 Solution:

(3)

$$Na_2B_4O_7 \xrightarrow{\Delta} \underset{(X)}{(2NaBO_2)} + B_2O_3$$

$$CuSO_4 + B_2O_3 \xrightarrow[\text{Non-luminous flame}]{\Delta} \underset{\substack{\text{(Blue bead)} \\ (Z)}}{\overset{+2}{Cu}(BO_2)_2} + SO_3$$

$$2Cu(BO_2)_2 + 2NaBO_2 + C \xrightarrow[\text{Luminous flame}]{\Delta} \underset{\substack{\text{Colorless} \\ (Q)}}{2\overset{+1}{Cu}BO_2} + Na_2B_4O_7 + CO$$

Q71 Solution:

(4)

Using equation: $\Lambda_m = \Lambda_m^0 - A\sqrt{c}$

$96.1 = \Lambda_m^0 - A\sqrt{0.04}$

$96.1 = \Lambda_m^0 - A \times 0.2\ \ ....(1)$

$95.7 = \Lambda_m^0 - A\sqrt{0.09}$

$95.7 = \Lambda_m^0 - A \times 0.3\ \ ...(2)$

From eq. (1) and eq. (2)

$A = 4$

Q72 Solution:

(2)

$\lambda_d = \frac{h}{\sqrt{2m\text{K.E.}}}$

Here K.E. is same i.e. 200 keV

So $\lambda_d \propto \frac{1}{\sqrt{m}}$

$\frac{(\lambda_d)_{m_1}}{(\lambda_d)_{m_2}} = \sqrt{\frac{m_2}{m_1}} = \sqrt{4} = 2$

$(\lambda_d)_{m_1} = 2(\lambda_d)_{m_2}$

So $x = 2$

Q73 Solution:
(5)

For $A \xrightarrow{k_1} B$

$\ln\left(2\right) = \frac{E_{a1}}{R}\left[\frac{1}{300} - \frac{1}{500}\right]$

$E_{a1} = \frac{\ln 2 \times R \times 1500}{2}$

$E_{a2} = \frac{E_{a1}}{2} = \frac{\ln 2 \times R \times 1500}{4}$

$\left(k_1\right)_{\text{at } 500K} = \frac{\ln 2}{2}$

$\left(k_2\right)_{\text{at } 500K} = \ln 2$

Now for $C \xrightarrow{k_2} D$

$\ln\left[\frac{\left(k_2\right)_{\text{at } 500K}}{\left(k_2\right)_{\text{at } 300K}}\right] = \left(\frac{\ln 2 \times R \times 1500}{4}\right) \times \frac{1}{R} \times \left[\frac{1}{300} - \frac{1}{500}\right]$

$\left(k_2\right)_{\text{at } 300K} = \frac{\ln 2}{\sqrt{2}} = 0.49$

$\left(k_2\right)_{\text{at } 300K} = 4.9 \times 10^{-1}$

Ans is 5.

Q74 Solution:
(6)

Sc^{3+}	18
Cr^{2+}	22
Mn^{3+}	22
Co^{3+}	24
Fe^{3+}	23

Cr^{2+} and Mn^{3+} are isoelectronic

$n = 2$

Complex is: $\left[Co(en)_2NH_3Cl\right]Cl_2$

$\Rightarrow Co^{3+}\ 3d^6\ t_{2g}^{2,2,2}\ e_g^{0,0}$

Q75 Solution:
(78)

We have considered

$E^{\circ}_{\left[Sn\left(OH\right)_6\right]^{2-} / HSnO_2^-} = -0.9V$

$Pt \mid HSnO_2^-\left(aq\right), \left[Sn\left(OH\right)_6\right]^{2-}\left(aq\right), OH^-\left(aq\right) \mid Bi_2O_3\left(s\right) \mid Bi\left(s\right) \mid$

0.5M   0.05M

$E^{\circ}_{cell} = +0.9 - 0.44 = 0.46V$

Oxidation Half:

$$HSnO_2^- + H_2O + 3OH^- \rightarrow \left[Sn(OH)_6\right]^{2-} + 2e^-$$

Reduction half:

$$Bi_2O_3 + 3H_2O + 6e^- \rightarrow 2Bi + 6OH^-$$

$$3HSnO_2^-\left(aq\right) + Bi_2O_3\left(s\right) + 6H_2O + 3OH^-\left(aq\right) \rightarrow 3\left[Sn(OH)_6\right]^{2-}\left(aq\right) + 2Bi\left(s\right)$$

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.059}{6}\log\left(\frac{(0.5)^3}{(0.05)^3 \times [OH^-]^3}\right)$$

$$0.2353 = 0.46 - \frac{0.059}{6} \times 3\log\left(\frac{10}{[OH^-]}\right)$$

$$\log\left(\frac{10}{[OH^-]}\right) = \frac{2 \times 0.2247}{0.059} = 7.6$$

$$1 + pOH = 7.6$$

$$pOH = 6.6$$

$$pH = 14 - 6.6 = 7.4$$

$$pH = pK_{a1} + \log\frac{[HCO_3^-]}{[H_2CO_3]}$$

$$7.4 = 6.11 + \log\left(\frac{5x}{20}\right)$$

$$1.29 = \log\left(\frac{x}{4}\right)$$

$$\frac{x}{4} = 19.5$$

$$x = 78$$