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NATIONAL LEVEL SCIENCE TALENT SEARCH EXAMINATION (UPDATED)

CLASS - 12 (PCM)

Question Paper Code : UN449

KEY

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11. B	12. B	13. B	14. D	15. A	16. D	17. C	18. A	19. D	20. A
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31. C	32. A	33. B	34. C	35. C	36. A	37. C	38. B	39. D	40. D
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SOLUTIONS

MATHEMATICS

1. **(A)** Given, $f(x) = (p-x^n)^{1/n}$, $p > 0$

Now, $f[f(x)] = f[(p-x^n)^{1/n}]$

$= \{p-(p-x^n)^{1/n \times n}\}^{1/n}$

$= (x^n)^{1/n} = x$

2. **(C)** Given, $f(x) = x^2 - 2x + 4$

Now, $f(x-1) = f(x+1)$

$\Rightarrow (x-1)^2 - 2(x-1) + 4 = (x+1)^2 - 2(x+1) + 4$

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

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

$\Rightarrow x^2 - 4x + 7 = x^2 + 3$

$\Rightarrow -4x = -4$

$\Rightarrow x = 1$

$\therefore x = \{1\}$

3. **(C)** $\cos^{-1}\left(\frac{5}{13}\right) + \cos^{-1}\left(\frac{3}{5}\right) = \cos^{-1} x$

$= \cos^{-1}\left[\frac{5}{13}, \frac{3}{5} - \sqrt{1-\frac{25}{169}}.\sqrt{1-\frac{9}{25}}\right] = \cos^{-1} x$

$\Rightarrow \cos^{-1}\left[\frac{3}{13} - \frac{12}{13}.\frac{4}{5}\right] = \cos^{-1} x$

$\Rightarrow \cos^{-1}\left[\frac{15-48}{65}\right] = \cos^{-1} x$

$\therefore \quad x = \frac{-33}{65}$

4. **(A)** Given equation is

$(\tan^{-1} x)^2 + (\cot^{-1} x)^2 = \frac{5\pi^2}{8}$

$(\tan^{-1} x + \cot^{-1} x)^2 - 2\tan^{-1} x.\cot^{-1} x = \frac{5\pi^2}{8}$

$\left[\because \tan^{-1} x + \cot^{-1} x = \frac{\pi}{2}\right]$

$\Rightarrow \frac{\pi^2}{4} - 2\tan^{-1} x\,(\pi/2 - \tan^{-1} x) = \frac{5\pi^2}{8}$

$\Rightarrow -2.\frac{\pi \tan^{-1} x}{2} + 2(\tan^{-1} x)^2 = \frac{5\pi^2}{8} - \frac{\pi^2}{4}$

$\Rightarrow (\tan^{-1} x)^2 - \frac{\pi \tan^{-1} x}{2} = \frac{3\pi^2}{16}$

$\therefore \quad \tan^{-1} x = \frac{\frac{\pi}{2} \pm \sqrt{\frac{\pi^2}{4} + \frac{3\pi^2}{4}}}{2}$

$\Rightarrow \tan^{-1} x = \frac{\frac{\pi}{2} \pm \pi}{2}$

$\Rightarrow \quad = \frac{3\pi}{4}, -\frac{\pi}{4}$

$\Rightarrow \quad x = \tan\left(\frac{3\pi}{4}\right), \tan\left(-\frac{\pi}{4}\right)$

$\Rightarrow \quad x = -1, -1$

5. **(B)** We have,

$A = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 2 & 0 \\ 1 & -1 & 4 \end{bmatrix}$

$A^T = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 2 & -1 \\ 1 & 0 & 4 \end{bmatrix}$

$A + A^T = \begin{bmatrix} 2 & 0 & 2 \\ 0 & 4 & -1 \\ 2 & -1 & 8 \end{bmatrix} A - A^T = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}$

$A = \frac{1}{2}(A + A^T) + \frac{1}{2}(A - A^T)$

$A = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 2 & -0.5 \\ 1 & -0.5 & 4 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0.5 \\ 0 & -0.5 & 0 \end{bmatrix}$

A = B + C

$C = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0.5 \\ 0 & -0.5 & 0 \end{bmatrix} = -C^T$

6. **(B)** Given, $A = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix}$

$\therefore A^2 - 2A = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 2 & 1 \\ 0 & 1 & 1 \end{bmatrix} - \begin{bmatrix} 2 & 0 & 2 \\ 0 & 2 & 2 \\ 0 & 2 & 0 \end{bmatrix}$

$= \begin{bmatrix} -1 & 1 & -1 \\ 0 & 0 & -1 \\ 0 & -1 & 1 \end{bmatrix}$ .... (1)

Now, $|A| = 1(0 - 1) - 0 + 1(0) = -1$

$C_{11} = -1, C_{12} = 0, C_{13} = 0$

$C_{21} = -(-1) = 1, C_{22} = 0, C_{23} = -1$

$C_{31} = -1, C_{32} = -(1), C_{33} = 1$

$\therefore A^{-1} = -1\begin{bmatrix} -1 & 1 & -1 \\ 0 & 0 & -1 \\ 0 & -1 & 1 \end{bmatrix}$ .... (2)

$\therefore$ From Eq. (1) & (2) $A^2 - 2A = -A^{-1}$

7. **(D)** Let $\Delta = \begin{bmatrix} x+2 & x+3 & x+5 \\ x+4 & x+6 & x+9 \\ x+8 & x+11 & x+15 \end{bmatrix}$

Apply operations $R_2 \to R_2 - R_1$, $R_3 \to R_3 - R_1$, we get

Let $\Delta = \begin{bmatrix} x+2 & x+3 & x+5 \\ 2 & 3 & 4 \\ 6 & 8 & 10 \end{bmatrix}$

Again, apply operation $C_2 \to C_2 - C_1$ C3 $\to C_3 - C_1$, we get

$$= \begin{bmatrix} x+2 & 1 & 3 \\ 2 & 1 & 2 \\ 6 & 2 & 4 \end{bmatrix}$$

Expand along R_1, we get

Δ = (x+2) (4–4) – 1 (8 – 12) + 3 (4–6)

= 0 + 4 + 3(–2) = 4 – 6 = – 2

8. **(C)** Let $\Delta = \begin{vmatrix} b^2 - ab & b-c & bc-ac \\ ab - a^2 & a-b & b^2-ab \\ bc-ac & c-a & ab-a^2 \end{vmatrix}$

$$= \begin{vmatrix} b(b-a) & b-c & c(b-a) \\ a(b-a) & a-b & b(b-a) \\ c(b-a) & c-a & a(b-a) \end{vmatrix}$$

Taking common (b – a) from C1 and C_3, respectively

$$= (b-a)(b-a) \begin{vmatrix} b & b-c & c \\ a & a-b & b \\ c & c-a & a \end{vmatrix}$$

$$= (b-a)^2 \begin{vmatrix} b & 0 & c \\ a & 0 & b \\ c & 0 & a \end{vmatrix}$$

= 0

9. **(D)** We have,

$$D = \begin{vmatrix} 4 & 1 & 2 \\ 1 & -6 & 3 \\ 9 & -3 & 7 \end{vmatrix}$$

= 4 (–35 + 9) – 1(7 – 27) + 2(–3 + 45)

= – 104 + 20 + 84 = 0

$$D_1 = \begin{vmatrix} 5 & 1 & 2 \\ 10 & -5 & 3 \\ 20 & -3 & 7 \end{vmatrix}$$

= 5 (–35 + 9) –1 (70 – 60) + 2(–30 + 100)

= – 130 – 10 + 140 = 0

$$D_2 = \begin{vmatrix} 4 & 5 & 2 \\ 1 & 10 & 3 \\ 9 & 20 & 7 \end{vmatrix}$$

= 4(70 – 60)–5(7 – 27) + 2(20 – 90)

= 40 + 100 – 140 = 0

and $D_3 = \begin{vmatrix} 4 & 1 & 5 \\ 1 & -5 & 10 \\ 9 & -3 & 20 \end{vmatrix}$

= 4(–100 + 30) – 1(20– 90) + 5(–3 + 45)

= – 280 + 70 + 210 = 0

So, the given system of equations has infinite number of solutions.

10. **(B)** Given, $f(x) = \begin{cases} \alpha + \frac{\sin[x]}{x} & , \text{ if } x > 0 \\ 2 & , \text{ if } x = 0 \\ \beta + \left[\frac{\sin x - x}{x^3}\right] & , \text{ if } x < 0 \end{cases}$

Since, f is continuous at x = 0,

$\therefore$ LHL = f(0) = RHL

Now, LHL = $\lim_{x\to 0} f(x)$

$$= \lim_{x\to 0}\left[\beta + \left(\frac{\sin x - x}{x^3}\right)\right]$$

$$= \lim_{h\to 0}\left[\beta + \left(\frac{\sin h - h}{h^3}\right)\right]$$

$$= \beta + 0$$

RHL = $\lim_{x\to 0^+}\left[\alpha + \frac{\sin[x]}{x}\right]$

$$= \lim_{x\to 0^+}\left[\alpha + \frac{\sin[h]}{h}\right]$$

$$= \alpha + 1$$

and f(0) = 2

$\therefore$ From eq. (i), we get

$$\beta + 0 = 2 = \alpha + 1$$

$$\Rightarrow \quad \beta - \alpha = 1$$

11. **(B)**

LHL	RHL	f(1)
$\lim_{x\to1^-} x$	$\lim_{x\to1^+} 2-x$	$2-1$
$\lim_{h\to0} (1-h)$	$\lim_{h\to0} 2-(1-h)$	$= 1$
$= 1$	$= 1$	

$\therefore$ LHL = RHL = f(1)

Hence, f(x) is continuous at x = 1.

LHD	RHD
$\lim_{x\to1^-} \frac{f(x)-f(1)}{x-1}$	$\lim_{x\to1^+} \frac{f(x)-f(1)}{x-1}$
$\lim_{x\to1^-} \frac{x-1}{x-1}$	$\lim_{x\to1^+} \frac{(2-x)-1}{x-1}$
$=1$	$=1$

$\therefore$ LHD $\neq$ RHD

Hence, f(x) is not differentiable at x = 1

12. **(B)** Given,

$$y = \tan^{-1}\left[\frac{5\cos x - 12\sin x}{12\cos x + 5\sin x}\right]$$

$$y = \tan^{-1}\left[\frac{\frac{5}{12} - \tan x}{1 + \frac{5}{12}\tan x}\right]$$

[divide by 12 cos x in denominator and numerator]

$$\tan y = \tan\left(\frac{5}{12} - x\right)$$

$$y = \frac{5}{12} - x$$

Differentiating both sides w.r.t. x

$$\frac{dy}{dx} = -1$$

13. **(B)** Given, $\frac{dV}{dt} = 2\pi\ cm^3/s$

$\because$ Volume of sphere, $V = \frac{4}{3}\pi r^3$

On differentiating w.r.t. t, we get

$$\frac{dV}{dt} = \frac{4}{3}\pi \times 3r^2\frac{dr}{dt}$$

$$\Rightarrow \quad 2\pi = 4\pi r^2\frac{dr}{dt}$$

$$\Rightarrow \quad \frac{dr}{dt} = \frac{1}{2r^2} = \frac{1}{2\times6^2} = \frac{1}{72}\ cm/s$$

$$\left[\because V = 288\pi = \frac{4}{3}\pi r^3 \Rightarrow 216\ r^3 \Rightarrow r = 6\right]$$

14. **(D)** Given, $\Delta r = \pm\frac{0.04}{2} = 0.02$

Volume of sphere

$$V = \frac{4}{3}\pi r^3$$

On differentiating w.r.t. r, we get

$$\frac{dU}{dr} = \frac{4}{3}\pi\times3r^2 = 4\pi r^2$$

$$\therefore \quad \Delta V = \frac{dU}{dr}\Delta r = 4\pi r^2\ \Delta r$$

$\therefore$ Relative per cent error

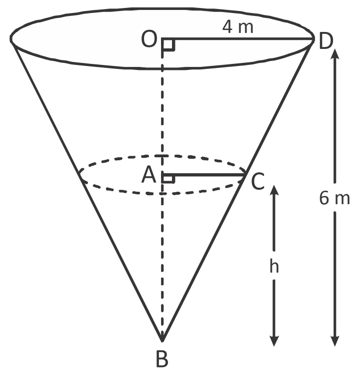
$$\frac{\Delta V}{V}\times100 = \frac{4\pi r^2\ \Delta r}{\frac{4}{3}\pi r^3}\times100$$

$$= \frac{3\ \Delta r}{r}\times100$$

$$= \frac{3\times(\pm0.02)}{10}\times100$$

$$= \pm\frac{6}{10} = \pm0.6$$

15. **(A)** Let V be the volume, r be the radius and h be the height of cone at any time t. Then



We have, $\frac{dv}{dt} = 3m^3/min$

We have to find : $\frac{dh}{dt}$ when h = 3 m

Clearly, $V = \frac{1}{3}\pi r^2 h$ ..... (i)

Since, $\Delta BOD \sim \Delta BAC$

[By AA-similarity criterion]

$$\therefore \quad \frac{BO}{BA} = \frac{OD}{AC}$$

$$\Rightarrow \quad \frac{6}{h} = \frac{4}{r}$$

$$\Rightarrow \quad r = \frac{2}{3}h$$

Now, from Eq. (1), we get

$$V = \frac{1}{3}\pi\left(\frac{2}{3}h\right)^2 h = \frac{4}{27}\pi h^3$$

$$\Rightarrow \quad \frac{dv}{dt} = \frac{4}{27}\pi\, 3h^2 \frac{dh}{dt}$$

$$\Rightarrow \quad 3 = \frac{4}{27}\pi\, 3h^2 \frac{dh}{dt}$$

$$\Rightarrow \quad \frac{dh}{dt} = \frac{3 \times 27}{4\pi 3h^2}$$

$$\Rightarrow \quad \left.\frac{dh}{dt}\right|_{h=3} = \frac{3 \times 27}{4\,\pi\, 27} = \frac{3}{4\,\pi}\ m/min$$

16. **(D)** Let $i = \int e^x \left(\frac{2 + \sin 2x}{1 + \cos 2x}\right) dx$

$$= \int e^x \left\{\frac{2}{1 + \cos 2x} + \frac{\sin 2x}{1 + \cos 2x}\right\} dx$$

$$= \int e^x \left\{\frac{2}{2\cos^2 x} + \frac{2 \sin x \cos x}{2\cos^2 x}\right\} dx$$

$$= \int e^x \left(\sec^2 x + \tan x\right) dx$$

$$= \int e^x \sec^2 x\, dx + \int e^x \tan x\, dx$$

$$= e^x \tan x - \int e^x \tan x\, dx + \int e^x \tan x\, dx$$

$$= e^x \tan x + C$$

17. **(C)** Let $f(x) = \frac{\sqrt{1+x+x^2} - \sqrt{1-x+x^2}}{\sqrt{1+x+x^2} + \sqrt{1-x+x^2}}$

Now, $f(-x) = \frac{\sqrt{1-x+x^2} - \sqrt{1+x+x^2}}{\sqrt{1-x+x^2} + \sqrt{1+x+x^2}}$

$$= -\left(\frac{\sqrt{1+x+x^2} - \sqrt{1-x+x^2}}{\sqrt{1+x+x^2} + \sqrt{1-x+x^2}}\right) = -f(x)$$

So, f(x) is an odd function

$$\therefore \quad \int_{-1}^{1} f(x)\, dx = 0$$

18. **(A)** Let $I = \int \frac{dx}{\sqrt{x - x^2}}$

$$= \int \frac{1}{\sqrt{x}} \times \frac{dx}{\sqrt{1-x}}$$

Put $\sqrt{x} = \sin\theta$

$$\Rightarrow \quad \frac{1}{2\sqrt{x}} dx = \cos\theta\, d\theta$$

$$\therefore \quad I = \int \frac{2\cos\theta\, d\theta}{\sqrt{1 - \sin^2\theta}}$$

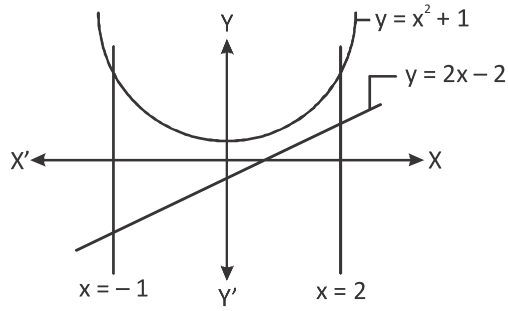
$$= \int \frac{2\cos\theta}{\cos\theta} d\theta$$

$$= \int 2\, d\theta = 2\theta + C$$

$$= 2\sin^{-1}\sqrt{x} + C$$

19. **(D)** Given curve is $y = x^2 + 1 \Rightarrow x^2 = y - 1$

and line $y = 2x - 2$



The intersection point of curve and line is

$$x^2 = 2x - 2 - 1$$

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

Now, $b^2 - 4ac = 4 - 12 < 0$

Hence, there is no point of intersection

$$\therefore \text{ Required area} = \int_{-1}^{2} (y_2 - y_1)\, dx$$

$$= \int_{-1}^{2} [(x^2 + 1) - (2x - 2)]\, dx$$

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

$$= \left[\frac{8}{3} + 2 - \left(-\frac{1}{3} - 1\right)\right] - [4 - 4 - (1+2)]$$

$$= \frac{14}{3} + \frac{4}{3} - [-3]$$

$= 6 + 3 = 9$

20. **(A)** $I = \int_0^{\pi/4} \sqrt{\tan x} + \sqrt{\cot x}\, dx$

$$= \int_0^{\pi/4} \left(\frac{\sqrt{\sin x}}{\sqrt{\cos x}} + \frac{\sqrt{\cos x}}{\sqrt{\sin x}}\right) dx$$

$$= \int_0^{\pi/4} \frac{\sin x + \cos x}{\sqrt{\sin x \cos x}} dx$$

$$= \int_0^{\pi/4} \frac{\sqrt{2}\,(\sin x + \cos x)}{\sqrt{2 \sin x \cos x}} dx$$

$$= \sqrt{2} \int_0^{\pi/4} \frac{\sin x + \cos x}{\sqrt{1 - (\sin x - \cos x)^2}} dx$$

Let $\sin x - \cos x = t$

$\Rightarrow (\cos x + \sin x)\, dx = dt$

$$\therefore I = \sqrt{2} \int_0^{\pi/4} \frac{dt}{\sqrt{1 - t^2}}$$

$$= \sqrt{2}\, [\sin^{-1} t]_0^{\pi/4}$$

$$= \sqrt{2}\, [\sin^{-1} (\sin x - \cos x]_0^{\pi/4}$$

$$= \sqrt{2}\left[\sin^{-1}\left(\sin\frac{\pi}{4} - \cos\frac{\pi}{4}\right) - \sin^{-1}(\sin 0° - \cos 0°)\right]$$

$$= \sqrt{2}\, [\sin^{-1} 0 - \sin^{-1}(-1)]$$

$$= \sqrt{2}\left[0 + \frac{\pi}{2}\right] = \sqrt{2}\,\frac{\pi}{2} = \frac{\pi}{\sqrt{2}}$$

21. **(D)** Given differential equation is

$$x\frac{dy}{dx} = y + xe^{y/x}$$

$$\frac{dy}{dx} = \frac{y}{x} + e^{y/x}$$

It is a homogeneous differential equation.

$\therefore$ Put $y = vx \Rightarrow \frac{dy}{dx} = v + x\frac{dv}{dx}$

$$\therefore\ v + X\frac{dv}{dx} = \frac{vx}{x} + e^{vx/x}$$

$$\Rightarrow\ v + X\frac{dv}{dx} = v + e^{v}$$

$$\Rightarrow\ X\frac{dv}{dx} = e^{v}$$

$$\Rightarrow\ e^{-v} dv = \frac{1}{x} dx$$

On integrating both sides, we get

$-e^{-v} = \log x + c$

$-e^{-y/x} = \log x + c$

Given, $y(1) = 0$

$\therefore\ e^{-0/1} = \log 1 + c$

$-1 = 0 + c \Rightarrow c = -1$

$\therefore\ -e^{-y/x} = \log x - 1$

$\Rightarrow\ 1 = \log x + e^{-y/x}$

22. **(B)** We have, $\frac{dy}{dx} = \frac{1}{ax + by + c}$

$$\Rightarrow \frac{dx}{dy} = ax + by + c$$

$$\Rightarrow \frac{dx}{dy} - ax = by + c$$

Hence, the above equation is a linear differential euqation in x.

23. **(B)** Let the coordinates of four points P, Q, R and S be (3, –4, 5), (0, 0, 4), (–4, 5, 1) and (–3, 4, 3) respectively.

Now, equation of line PQ is

$$\frac{x-3}{0-3} = \frac{y+4}{0+4} = \frac{z-5}{4-5}$$

$$\Rightarrow \frac{x-3}{-3} = \frac{y+4}{4} = \frac{z-5}{-1} = r_1 \text{ (say) .... (i)}$$

Equation of line RS is

$$\frac{x+4}{-3+4} = \frac{y-4}{4-5} = \frac{z-1}{3-1}$$

$$\Rightarrow \frac{x+4}{1} = \frac{y-5}{-1} = \frac{z-1}{2} = r_2 \text{ (say) ....(ii)}$$

Let $(-3r_1 + 3, 4r_1 - 4, r_1 + 5)$ and $(r_2 - 4, + 5, 2r_2 + 1)$ be the points on line (i) and (ii), respectively. Since, both lines intersect at a common point, then

$-3r_1 + 3 = r_2 - 4$

$\Rightarrow\ 3r_1 + r_2 = 7$ .... (iii) and $-r_2 + 5 = 4r_1 - 4$

$\Rightarrow$ 4r1 + r2 = 9 .... (iv)

On subtracting Eq. (iv) from Eq. (iii), we get

$$r_1 = 2$$

On putting the value of r1 in Eq. (iii), we get

$3(2) + r_2 = 7 \Rightarrow r_2 = 1$

So, required point of intersection is (–3, 4, 3) i.e.,

$$-3i + 4j + 3k$$

24. **(B)** Given, a = i + j – 2k

$$\therefore \sum[(a \times i) \times j]^2 = \sum[(a.j)i]^2$$

$$= a^2 = |i + j - 2k|^2$$

$$= \sqrt{(1+1+4)^2} = 6$$

25. **(C)** Let a = 2i + 3j + 4k = OA

b = 3i + 4j + 2k = OB

and c = 4i + 2j + 3k = OC

AB = OB – OA = i + j – 2k

BC = OC – OB = i – 2j + k

and CA = OA – OC = – 2i + j + k

Now, AB = $\sqrt{1+1+4} = \sqrt{6}$

BC = $\sqrt{1+4+1} = \sqrt{6}$

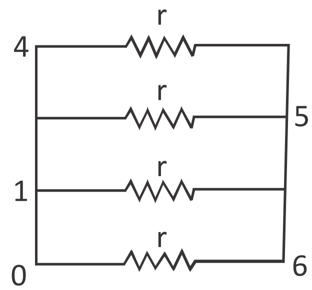
and CA = $\sqrt{4+1+1} = \sqrt{6}$

Since, the length of all three sides are equal.

So, the traingle is an equilateral triangle.

PHYSICS

26. **(D)** The points 0, 1 and 4 have same potential and the points 5 and 6 have same potential. Therefore, the circuit may be reduced as shown below.



Thus, $R_{16} = \frac{r}{4}$

27. **(B)** Magnitude of the other field

$$= \frac{1.2 \times 10^{-2} \times \sin 15^\circ}{\sin 45^\circ} = 4.4 \times 10^{-3}\,T$$

28. **(D)** Speed of infrared radiation in vacuum = 3×10^8 m s^{-1}

v = fl

3×10^8 f(2×10^{-5})

f = 1.5×10^{13} Hz

29. **(C)** Intensity at the centre of bright fringe,

$$I_0 = I + I + 2\sqrt{I\,I}\cos 0^\circ$$

$$I_0 = 2I + 2I$$

$$I_0 = 4I$$

Intensity at a point distant b/4 (with a phase difference = 2p/4 = p/2) is

$$I' = I + I + 2\sqrt{I\,I}\cos\frac{\pi}{2}$$

$$I' = 2I + 2\sqrt{I\,I} \times 0$$

$$I' = 2I$$

$$\therefore \frac{I_0}{I'} = \frac{4I}{2I} = 2$$

30. **(D)** The energy of the incident photons is

$E = hf = (4.14 \times 10^{-15}$ eV . s) $(7.2 \times 10^{15}$ Hz) = 30 eV

Since E > f, photoelectrons will be produced, with maximum kinetic energy

K_{max} = E – f = 30 eV – 6 eV = 24 eV

31. **(C)** No.emf is induced in the parallel horizontal wires. Equal emf of same polarity is induced in the two parallel vertical wires. Hence, induced current is zero as two equal and opposite emf's are present in the loop.

32. **(A)** R_1 = 30 W, R_2 = 70 W

E_0 = 20 V,

$$E_{rms} = \frac{E_0}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.14 \text{ V}$$

$$I_{rms} = \frac{E_{rms}}{\text{Total resistance}}$$

$$= \frac{14.14}{30+70} = 0.1414 \text{ A}$$

Power developed across R_2

= $I_{rms}^2 \times R_2$ $(0.1414)^2 \times 70$ = 1.4 W.

33. **(B)** Magnetic field due to ADB is

$$B_1 = \left(\frac{\theta}{2\pi}\right)\frac{\mu_0 i}{2a}$$

(Perpendicular to paper outwards)

and magnetic field due to ACB is

$$B_2 = \left(\frac{2\pi - \theta}{2\pi}\right)\frac{\mu_0 i}{2a}$$

(Perpendicular to paper inwards)

$$\therefore B_{net} = B_2 - B_1 = \left(\frac{\pi - \theta}{\pi}\right)\frac{\mu_0 i}{2a}$$

(Perpendicular to paper inwards)

34. **(C)** $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$ or $q_1 q_2 = 4\pi\varepsilon_0 F r^2$

Setting F = 0.075 N and r = 3 m, we get $q_1 q_2 = 7.5 \times 10^{-11}$ .... (i)

Also, $q_1 + q_2$ = 20 mC = 20×10^{-6} C ..(ii)

From the equations (i) and (ii), it can be obtained that

$q_1 = 15 \times 10^{-6}$ C and $q_2 = 5 \times 10^{-6}$ C

35. **(C)** m = 0.254 kg, I = 100 A, t = ?

$$t = \frac{m}{z.I}, \quad z = \frac{E}{F} = \frac{M}{pF}$$

Atomic mass of copper = M = 63.5×10^{-3} kg

Valency = p = 2

1 Faraday = F = 96500 C

$$z = \frac{M}{pF} = \frac{63.5 \times 10^{-3}}{2 \times 96500} = 3.29 \times 10^{-7} \text{ kg C}^{-1}$$

$$t = \frac{m}{z.I} = \frac{0.254}{3.29 \times 10^{-7} \times 100} = 7720.3 \text{ second.}$$

36. **(A)** $R = \rho(4l / \pi d^2)$

Therefore, R μ l/d^2

Hence, $R_1 : R_2 : R_3$

$$= \frac{2}{3^2} : \frac{3}{4^2} : \frac{4}{5^2} : = \frac{2}{9} : \frac{3}{16} : \frac{4}{25}$$

Currents are in the inverse ratio of resistances.

$$i_1 : i_2 : i_3 = \frac{9}{2} : \frac{16}{3} : \frac{25}{4} = 54 : 64 : 75$$

or i_1 = 54k, i_2 = 64k and i_3 = 75k

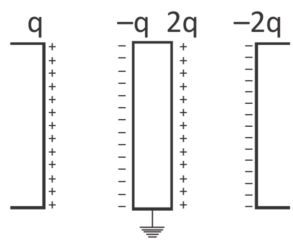
Where k is the common ratio.

But $i_1 + i_2 + i_3 = 5$

54k + 64k + 75k = 5 or k = 5/193

$$i_1 = \frac{270}{193}\text{A}, i_2 = \frac{320}{193}\text{A}, i_3 = \frac{375}{193}\text{A}$$

37. **(C)** In steady state the following charges will appear on different faces of the plates.



Netcharge on central plate is +q. Thus, +q charge will flow through the switch.

38. **(B)** The distance of closest approach is given by $r_0 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2Ze^2}{\frac{1}{2}mu^2}$

Here, Z = 79; $\frac{1}{2}mu^2$ = 5 MeV = 5 × 1.6 × 10^{-13} J

We know, e = 1.6 × 10^{-19} C

$$\therefore r_0 = 9\times10^9\times\frac{2\times79\times(1.6\times10^{-19})^2}{5\times1.6\times10^{-13}}$$

= 4.55 ×10^{-14} m

39. **(D)** The lens maker's formula is :

$$\frac{1}{f}\left(\frac{n_L}{n_m}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

Where n_L =Refractive index of lens and n_m = Refractive index of medium.

In case of double concave lens, R_1 is negative and R_2 is positive. Therefore, $\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ will be negative.

For the lens to be diverging in nature, focal length 'f' should be negative or $\left(\frac{n_L}{n_m}-1\right)$ should be positive or $n_L > n_m$

but since $n_2 > n_1$ (given), therefore the lens should be filled with L_2 and immersed in L_1.

40. **(D)** Series $\frac{1}{C_S}=\frac{1}{C_1}+\frac{1}{C_2}+.....$

Effective capacitance

$$=C_S=\frac{C}{n}=\frac{5\mu F}{5}=1\,\mu F$$

Parallel C_P = C_1 + C_2 + ...

Effective capacitance = C_P = nC

= 5 × 5 mF = 25 mF.

CHEMISTRY

41. **(D)** 4Zn + 10HNO_3 ® 4Zn $(NO_3)_2$ + NH_4NO_3 + 3H_2O.

42. **(A)** Here, Mn is in +7 state. The atomic number of Mn is 25. So, the electronic configuration of Mn^{7+} is $1s^2\ 2s^2\ 3s^2\ 3p^6$. Thus, there is no electron in its d orbital.

43. **(D)** Difluoroacetic acid is the strongest acid out of the given acids. Hence, it ionizes maximum and therefore, has highest electrical conductivity.

44. **(C)** Ethyl chloride and acetyl chloride react with alc. KCN by nucleophilic substitution reaction while benzaldehyde undergoes benzoin condensation.

$C_2H_5Cl \xrightarrow{\text{KCN (alc.)}} C_2H_5CN + KCl$

$CH_3COCl \xrightarrow{\text{KCN (alc.)}} CH_3COCN + KCl$

$2C_6H_5CHO \xrightarrow{\text{KCN (alc.)}} C_6H_5CHOHCOC_6H_5$

Thus, only chlorobenzene does not react.

45. **(A)** NaCl changes into CsCl type (6:6 to 8:8) on applying pressure.

46. **(C)** Addition of an electron to a negatively charged species is not a favourable process. So, energy is absorbed in such a step.

47. **(A)** Only Na reacts with both ethanol and phenol. In contrast, $NaOH/I_2$ reacts only with ethanol while neutral $FeCl_3$ and Br_2/H_2O react in the presence of conc. H_2SO_4 with phenol only.

48. **(A)** Number of moles of acetic acid

$$=\frac{0.6\text{ mL}\times1.06\text{g mL}^{-1}}{60\text{ g mol}^{-1}}$$

= 0.0106 mol = n

$$\text{Molality} = \frac{0.0106\text{ mol}}{1000\text{ mL}\times1\text{ g mL}^{-1}}$$

= 0.0106 mol kg^{-1}

DT_f = 1.86 K kg mol^{-1} × 0.0106 mol kg^{-1}

= 0.0197 K

van't Hoff factor (i)

$$=\frac{\text{Observed freezing point}}{\text{Calculated freezing point}}=\frac{0.0205\text{ K}}{0.0197\text{ K}}$$

= 1.041

49. **(C)** Heats of adsorption in physisorption lie in the range 10 – 40 kJ mol^{-1}.

50. **(C)** $C_6H_5CH = O + H_2N-C_6H_5 \xrightarrow[\text{Reaction}]{\text{Condensation}}$
$C_6H_5CH = NC_6H_5 + H_2O$
(Benzylideneaniline)

51. **(A)** Both Zn and Hg react with air (oxygen) on heating to form ZnO and HgO. All other properties are shown by Zn but not Hg.

52. **(B)** S_N1 reaction leads to racemisation.

53. **(B)** Rate = rate of disappearance of A per mole.

$$= -\frac{1}{2}\frac{\Delta[A]}{\Delta t} = -\frac{1}{2}\frac{(0.5-0.4)}{10} = -\ 0.005$$

The negative sign simply indicates the fall in concentration of A. Thus ignoring the negative sign, the rate of the reaction is 0.005 mole/litre/minute.

54. **(A)** $SO_2 + O_2 + 2H_2O + \underset{\text{Catalyst}}{NO} \rightarrow 2H_2SO_4 + \underset{\text{Catalyst}}{NO}$

55. **(D)** $CH_3-\overset{O}{\overset{\|}{C}}-O-H + \underset{\text{Sod. bicarbonate}}{Na^+\ {}^-O-\overset{O}{\overset{\|}{C}}-OH} \rightarrow$

$$CH_3-\overset{O}{\overset{\|}{C}}-O^-Na^+ + [H-O-\overset{O}{\overset{\|}{C}}-OH] \rightarrow CO_2 + H_2O$$

Thus, C of CO_2 comes from bicarbonate.

CRITICAL THINKING

56. **(D)**

57. **(D)** If Geetha is older than Manish and Rohan is older than Geetha, then Manish has to be the youngest of the three. Choice b is clearly wrong because Rohan is the oldest. There is no information in the paragraph to support either choice a or choice c.

58. **(B)** Clearly, damage to crops due to high temperature may have resulted in a short supply fo vegetables and hence an increase in their prices.

59. **(D)** The women is the mother of sharikh granddaughter. Hence, the woman is the daughter-in-law of sharukh.

60. **(Delete)**

THE END