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NATIONAL LEVEL SCIENCE TALENT SEARCH EXAMINATION

CLASS - 12 (PCM)

Question Paper Code : UN478

KEY

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11. A	12. B	13. D	14. A	15. B	16. D	17. B	18. B	19. A	20. D
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SOLUTIONS

MATHEMATICS

1. (D) $P = \{(a, b): \sec^2 a - \tan^2 b = 1\}$

For reflexive :

$\sec^2 a - \tan^2 a = 1$ (true $\forall$ a)

For symmetric :

$\sec^2 b - \tan^2 a = 1$

L.H.S

$1 + \tan^2 b - (\sec^2 a - 1)$

$= 1 + \tan^2 b - \sec^2 a + 1$

$= -(\sec^2 a - \tan^2 b) + 2$

$= -1 + 2 = 1$

So, Relation is symmetric

For transitive :

if $\sec^2 a - \tan^2 b = 1$ and

$\sec^2 b - \tan^2 c = 1$

$\sec^2 a - \tan^2 c$

$= (1 + \tan^2 b) - (\sec^2 b - 1)$

$= - \sec^2 b + \tan^2 b + 2$

$= - 1 + 2 = 1$

So, Relation is transitive

Hence, Relation P is an equivalence relation

2. (D) $f(g(x)) = x$

$\Rightarrow f(3^{10}x - 1)$

$= 2^{10}(3^{10}x - 1) + 1 = x$

$\Rightarrow 2^{10}(3^{10}x - 1) + 1 = x$

$\Rightarrow x(6^{10} - 1) = 2^{10} - 1$

$$\Rightarrow x = \frac{2^{10}-1}{6^{10}-1} = \frac{1-2^{-10}}{3^{10}-2^{-10}}$$

3. (C) $$2\pi - \left(\sin^{-1}\frac{4}{5} + \sin^{-1}\frac{5}{13} + \sin^{-1}\frac{16}{65}\right)$$

$$= 2\pi - \left(\tan^{-1}\frac{4}{3} + \tan^{-1}\frac{5}{12} + \tan^{-1}\frac{16}{63}\right)$$

$$\left[\because \sin^{-1}\frac{4}{5} = \tan^{-1}\frac{4}{3}\right]$$

$$= 2\pi - \left\{\tan^{-1}\left(\frac{\frac{4}{3}+\frac{5}{12}}{1-\frac{4}{3}.\frac{5}{12}}\right) + \tan^{-1}\frac{16}{63}\right\}$$

$$= 2\pi - \left\{\tan^{-1}\frac{63}{16} + \tan^{-1}\frac{16}{63}\right\}$$

$$= 2\pi - \left\{\tan^{-1}\frac{63}{16} + \cot^{-1}\frac{63}{16}\right\}$$

$$= 2\pi - \frac{\pi}{2} = \frac{3\pi}{2}$$

4. (D) $$\because A = \begin{bmatrix} \cos\theta & i\sin\theta \\ i\sin\theta & \cos\theta \end{bmatrix}$$

$$\therefore A^n = \begin{bmatrix} \cos n\theta & i\sin n\theta \\ i\sin n\theta & \cos n\theta \end{bmatrix}, n \in N$$

$$\therefore A^5 = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

$$\therefore A^5 = \begin{bmatrix} \cos 5\theta & i\sin 5\theta \\ i\sin 5\theta & \cos 5\theta \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

$\therefore$ a = $\cos 5\theta$, b = i $\sin 5\theta$ = c,

d = $\cos 5\theta$

$\therefore a^2 - b^2 = \cos^2 5\theta + \sin^2 5\theta = 1$

$a^2 - c^2 = \cos^2 5\theta + \sin^2 5\theta = 1$

$a^2 - d^2 = \cos^2 5\theta - \cos^2 5\theta = 0$

$a^2 + b^2 = \cos^2 5\theta - \sin^2 5\theta$

$$= \cos 10\theta = \cos\frac{10\pi}{24}$$

and $0 < \cos\frac{5\pi}{12} < 1 \Rightarrow$

$0 \le a^2 + b^2 \le 1$

$\therefore a^2 - b^2 = \frac{1}{2}$ is wrong

5. (C) $$\Delta = \begin{vmatrix} x-2 & 2x-3 & 3x-4 \\ 2x-3 & 3x-4 & 4x-5 \\ 3x-5 & 5x-8 & 10x-17 \end{vmatrix}$$

$$\Rightarrow \Delta = \begin{vmatrix} x-2 & x-1 & x-1 \\ 2x-3 & x-1 & x-1 \\ 3x-5 & 2x-3 & 5x-9 \end{vmatrix}$$

$$\begin{bmatrix} C_3 \to C_3 - C_2 \\ C_2 \to C_2 - C_1 \end{bmatrix}$$

$$\Rightarrow \Delta = \begin{vmatrix} x-2 & x-1 & x-1 \\ x-1 & 0 & 0 \\ 3x-5 & 2x-3 & 5x-9 \end{vmatrix}$$

$$[R_2 \to R_2 - R_1]$$

$\Rightarrow \Delta = -(x - 1)[(x - 1)(5x - 9)$

$- (x - 1)(2x - 3)]$

$\Rightarrow \Delta = -(x - 1)[(5x^2 - 14x + 9)$

$- (2x^2 - 5x + 3)]$

$= -3x^3 + 12x^2 - 15x + 6$

So, B + C = –3

6. (A) $\because \begin{vmatrix} 2 & -4 & \lambda \\ 1 & -6 & 1 \\ \lambda & -10 & 4 \end{vmatrix} = 0$

$\Rightarrow 3\lambda^2 - 7\lambda - 12 = 0$

$\Rightarrow \lambda = 3 \text{ (or) } -\frac{2}{3}$

$D_1 = \begin{vmatrix} 1 & -4 & \lambda \\ 2 & -6 & 1 \\ 3 & -10 & 4 \end{vmatrix} = 2(3 - \lambda)$

$\therefore$ When $\lambda = -\frac{2}{3}$, $D_1 \neq 0$

Hence, equations will be inconsistent when $\lambda = \frac{-2}{3}$

7. (D) R.H.L $\lim\limits_{x\to 5^+} b|(x-\pi)| + 3 = (5-\pi)b + 3$

f(5) = L.H.L

$\lim\limits_{x\to 5^-} a|(\pi - x)| + 1 = a(5-\pi) + 1$

$\because$ function is continuous at $x = 5$

$\therefore$ LHL = RHL

$(5 - \pi)b + 3 = (5 - \pi)a + 1$

$\Rightarrow 2 = (a - b)(5 - \pi) \Rightarrow a - b = \frac{2}{5-\pi}$

8. (D) Let $u = \tan^{-1}\left(\frac{\sqrt{1+x^2}-1}{x}\right)$

Put $x = \tan\theta \Rightarrow \theta = \tan^{-1}x$

$\therefore \quad u = \tan^{-1}\left(\frac{\sec\theta - 1}{\tan\theta}\right) = \tan^{-1}\left(\tan\frac{\theta}{2}\right)$

$= \frac{\theta}{2} = \frac{1}{2}\tan^{-1}x$

$\therefore \quad \frac{du}{dx} = \frac{1}{2} \times \frac{1}{(1+x^2)}$

Let $v = \tan^{-1}\left(\frac{2x\sqrt{1-x^2}}{1-2x^2}\right)$

Put $x = \sin\phi \Rightarrow \phi = \sin^{-1}x$

$v = \tan^{-1}\left(\frac{2\sin\phi\cos\phi}{\cos 2\phi}\right) = \tan^{-1}(\tan 2\phi)$

$= 2\phi = 2\sin^{-1}x$

$\frac{dv}{dx} = 2\frac{1}{\sqrt{1-x^2}}$

$\frac{du}{dv} = \frac{du/dx}{dv/dx} = \frac{\sqrt{1-x^2}}{4(1+x^2)}$

$\therefore \left(\frac{du}{dv}\right)_{\left(x=\frac{1}{2}\right)} = \frac{\sqrt{3}}{10}$

9. (D) Let the side of cube be a

$S = 6a^2 \Rightarrow \frac{dS}{dt} = 12a\frac{da}{dt} \Rightarrow 3.6 = 12a\frac{da}{dt}$

$\Rightarrow 12(10)\frac{da}{dt} = 3.6 \Rightarrow \frac{da}{dt} = 0.03$

$V = a^3 \Rightarrow \frac{dV}{dt} = 3a^2\frac{da}{dt}$

$= 3(10)^2\left(\frac{3}{100}\right) = 9$

10. (A) $I = \int \sin^{-1}\left(\frac{\sqrt{x}}{\sqrt{1+x}}\right)dx = \int \tan^{-1}\sqrt{x}.1dx$

$= x\tan^{-1}\sqrt{x} - \int \frac{1}{1+x}\frac{1}{2\sqrt{x}}xdx + C$

$= x\tan^{-1}\sqrt{x} - \frac{1}{2}\int \frac{t\,2t\,dt}{1+t^2} + C$

(Put $x = t^2 \Rightarrow dx = 2t\,dt$)

$= x\tan^{-1}\sqrt{x} - \int \frac{t^2}{1+t^2}dt + C$

$= x\tan^{-1}\sqrt{x} - t + \tan^{-1}t + C$

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

$= (x+1)\tan^{-1}\sqrt{x} - \sqrt{x} + C$

$\Rightarrow A(x) = x + 1 \Rightarrow B(x) = -\sqrt{x}$

11. (A) $\int \frac{x^2}{(x\sin x + \cos x)^2}\,dx$

$\because \frac{d}{dx}(x\sin x + \cos x) = x\cos x$

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

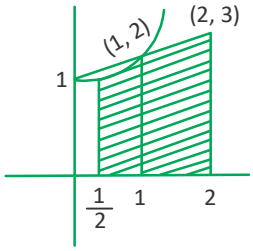
$= \frac{x}{\cos x}\left[\frac{-1}{x\sin x + \cos x}\right]$

$-\int \frac{x\sin x + \cos x}{\cos^2 x}\left[\frac{-1}{x\sin x + \cos x}\right]dx$

$= \frac{x}{\cos x}\left[\frac{-1}{x\sin x + \cos x}\right] + \int \sec^2 x\,dx$

$= \frac{-x\sec x}{x\sin x + \cos x} + \tan x + C$

12. (B)



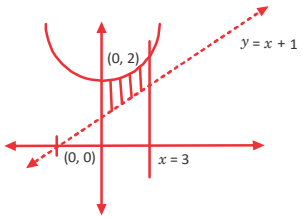
Required area

$= \int_{\frac{1}{2}}^{1}(x^2+1)dx + \int_{1}^{2}(x+1)dx$

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

$= \left[\frac{4}{3} - \frac{13}{24}\right] + \frac{5}{2} = \frac{79}{24}$

13. (D)



Area of the bounded region

$\int_0^3 \left[(x^2+2) - (x+1)\right]dx$

$= \left[\frac{x^3}{3} - \frac{x^2}{2} + x\right]_0^3$

$= 9 - \frac{9}{2} + 3 = \frac{15}{2}$

14. (A) Since, $x^2 = 4b(y + b)$

$x^2 = 4by + 4b^2$

$2x = 4by'$

$\Rightarrow b = \frac{x}{2y'}$

So, differential equation is

$x^2 = \frac{2x}{y'}y + \left(\frac{x}{y'}\right)^2$

$x(y')^2 = 2yy' + x$

15. (B) It is given that $\vec{u} = \hat{i} + \hat{j} + \lambda\hat{k}$, $\vec{v} = \hat{i} + \hat{j} + 3\hat{k}$

and $\vec{w} = 2\hat{i} + \hat{j} + \hat{k}$

Volume of parallelopiped = $\left[\vec{u}.\vec{v}.\vec{w}\right]$

$\Rightarrow \pm = \begin{vmatrix} 1 & 1 & \lambda \\ 1 & 1 & 3 \\ 2 & 1 & 1 \end{vmatrix} \Rightarrow -\lambda + 3 = \pm 1$

$\lambda = 2$ or $\lambda = 4$

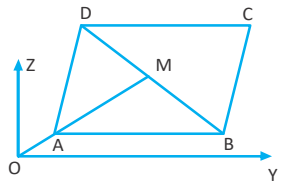
For $\lambda = 2$

$$\cos\theta = \frac{2+1+2}{\sqrt{6}\sqrt{6}} = \frac{5}{6}$$

For $\lambda = 4$

$$\cos\theta = \frac{2+1+4}{\sqrt{6}\sqrt{18}} = \frac{7}{6\sqrt{3}}$$

16. (D)



In a parallelogram, diagonals bisect each other. So, mid point of DB is also the mid-point of AC.

Mid-point of M = $2\hat{i} - \hat{j}$

Direction ratio of OC = (1, –5, –5)

Direction ratio of OM = (2, –1, 0)

Angle θ between OM and OC is given by

$$\cos\theta = \frac{(1\times 2)+(-5)(-1)+(-5)(0)}{\sqrt{2^2+(-1)^2}\sqrt{(1)^2+(-5)^2+(-5)^2}}$$

$$= \frac{2+5}{\sqrt{5}\sqrt{51}} = \frac{7}{\sqrt{5}\sqrt{51}}$$

Projection of $\overrightarrow{OM}$ on $\overrightarrow{OC}$ is given by

$$|OM|\cos\theta = \sqrt{5}\times\frac{7}{\sqrt{5}\times\sqrt{51}} = \frac{7}{\sqrt{51}}$$

17. (B) For line of intersection of planes

$x + y + z + 1 = 0$ and

$2x - y + z + 3 = 0$

$$\vec{b}_2 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 2 & -1 & 1 \end{vmatrix} = 2\hat{i} + \hat{j} - 3\hat{k}$$

Put $y = 0$, we get $x = -2$ and $z = 1$

$$L_2 : \bar{r} = \left(-2\hat{i} + \hat{k}\right) + \lambda\left(2\hat{i} + \hat{j} - 3\hat{k}\right) \text{ and}$$

$$L_1 : \bar{r} = \left(\hat{i} - \hat{j}\right) + \mu\left(-\hat{j} + \hat{k}\right) \text{ (Given)}$$

Now, $\overline{b_1} \times \overline{b_2} = -2\left[\hat{i} + \hat{j} + \hat{k}\right]$

and $\overline{a_2} - \overline{a_1} = -3\hat{i} + \hat{j} + \hat{k}$

$\therefore$ Shortest distance = $\frac{1}{\sqrt{3}}$

18. (B) P(second A – card appears before the third B – card)

= P(AA) + P(ABA) + P(BAA) + P(ABBA) + P(BBAA) + P(BABA)

$$= \frac{1}{4} + \frac{1}{8} + \frac{1}{8} + \frac{1}{16} + \frac{1}{16} + \frac{1}{16} = \frac{11}{16}$$

19. (A) Required probability = when no machine has fault + when only one machine has fault + when only two machines have fault.

$$= {}^5C_0\left(\frac{3}{4}\right)^5 + {}^5C_1\left(\frac{1}{4}\right)\left(\frac{3}{4}\right)^4 + {}^5C_2\left(\frac{1}{4}\right)^2\left(\frac{3}{4}\right)^3$$

$$= \frac{243}{1024} + \frac{405}{1024} + \frac{270}{1024}$$

$$= \frac{918}{1024} = \frac{459}{512} = \frac{27\times 17}{64\times 8}$$

$$= \left(\frac{3}{4}\right)^3 \times k = \left(\frac{3}{4}\right)^3 \times \frac{17}{8}$$

$\therefore$ k = $\frac{17}{8}$

20. (D) Given f(x) = $\tan^{-1}\left(\frac{2x}{1-x^2}\right) = 2\tan^{-1}x$

for $x \in (-1, 1)$

If $x \in (-1, 1) \Rightarrow \tan^{-1}x \in \left(\frac{-\pi}{4}, \frac{\pi}{4}\right)$

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

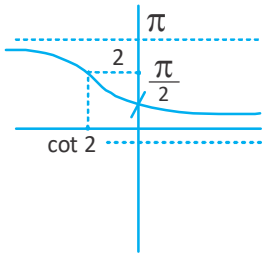
Clearly, range of f(x) = $\left(-\frac{\pi}{2},\frac{\pi}{2}\right)$

For f to be onto, codomain = range

$\therefore$ Co-domain of function

= B = $\left(-\frac{\pi}{2},\frac{\pi}{2}\right)$

21. (B)



$(\cot^{-1} x)^2 - 7(\cot^{-1} x) + 10 > 0$

$(\cot^{-1} x - 5)(\cot^{-1} - 2) > 0$

$\cot^{-1} x \in (-\infty, 2) \cup (5, \infty) \rightarrow (1)$

But $\cot^{-1} x$ lies on $(0, \pi)$

Now, from equation (1)

$\cot^{-1} x \in (0, 2)$

Now, it is clear from the graph

$x \in (\cot 2, \infty)$

22. (D) $\Delta_1 = \begin{vmatrix} x & \sin\theta & \cos\theta \\ -\sin\theta & -x & 1 \\ \cos\theta & 1 & x \end{vmatrix}$

$= (x - x^2 - 1) - \sin\theta(-x\sin\theta - \cos\theta)$

$+ \cos\theta(-\sin\theta + x\cos\theta)$

$= -x^3 - x + x\sin^2\theta + \sin\theta\cos\theta$

$- \cos\theta\sin\theta + x\cos^2\theta$

$= -x^3 - x + x = -x^3$

Similarly, $\Delta_2 = -x^3$ Then,

$\Delta_1 + \Delta_2 = -2x^3$

23. (C) $y^2 + 2\log_e(\cos x) = y$

$\Rightarrow 2yy' - 2\tan x = y'$

From (i), $y(0) = 0$ or 1

$\therefore y'(0) = 0$

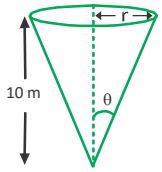
Again differentiating (ii) we get,

$2(y')^2 + 2yy'' - 2\sec^2 x = y''$

Put $x = 0$, $y(0) = 0$, 1 and $y'(0) = 0$,

we get, $|y''(0)| = 2$

24. (D)



Given that water is poured into the tank at a constant rate of 5 m^3/minute

$\therefore \frac{dv}{dt} = 5$ m^3/minute

Volume of the tank is,

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

where r is radius and h is height at any time.

By the diagram,

$\tan\theta = \frac{r}{h} = \frac{1}{2}$

$\Rightarrow h = 2r \Rightarrow \frac{dh}{dt} = \frac{2dr}{dt} \rightarrow$(ii)

Differentiate equ (i) write the 't', we get

$\frac{dV}{dt} = \frac{1}{3}\left(\pi 2r\frac{dr}{dt}h + \pi r^2\frac{dh}{dt}\right)$

Putting h = 10, r = 5 and $\frac{dV}{dt}$ = 5 in the above equation

$5 = \frac{75\pi}{3}\frac{dh}{dt} \Rightarrow \frac{dh}{dt} = \frac{1}{5\pi}$ m/minute

25. (A) $\sqrt{1+x^2}\sqrt{1+y^2} = -xy\frac{dy}{dx}$

$$\int \frac{\sqrt{1+x^2}}{x}dx = -\int \frac{y}{\sqrt{1+y^2}}dy$$

Let $x = \tan\theta \Rightarrow dx = \sec^2\theta d\theta$

$$\Rightarrow \int \frac{\sec^3\theta d\theta}{\tan\theta} = -\int \frac{2y}{2\sqrt{1+y^2}}dy$$

$$\Rightarrow \int \frac{\sin^2\theta+\cos^2\theta}{\sin\theta\cos^2\theta}d\theta = -\sqrt{1+y^2}$$

$$\Rightarrow \int (\tan\theta\sec\theta + \operatorname{cosec}\theta)d\theta = -\sqrt{1+y^2}$$

$$\Rightarrow \sec\theta + \log_e|\operatorname{cosec}\theta - \cot\theta| = -\sqrt{1+y^2}+C$$

$$\therefore \sqrt{1+x^2} + \log_e\left|\frac{\sqrt{1+x^2}-1}{x}\right| = -\sqrt{1+y^2}+C$$

$$\Rightarrow \sqrt{1+y^2}+\sqrt{1+x^2} = \frac{1}{2}\ln\left(\frac{\sqrt{1+x^2}+1}{\sqrt{1+x^2}-1}\right)+C$$

PHYSICS

26. (B) No. of free electrons per unit volume

$$n = \frac{N}{M}\rho = \frac{6.023\times10^{23}}{63.5\times10^{-3}}\times9\times10^3$$

$$\therefore v_d = \frac{1}{nAe}$$

$$= \frac{1.5\times635\times10^{-3}}{6.023\times10^{23}\times9\times10^3\times10^{-7}\times1.6\times10^{-19}}$$

$$= 1.1\times10^{-3} m\ s^{-1}$$

27. (C) When switch S is turned off; Bulb B_1 dies out promptly, but B_2 dies out with some delay because of self-induced e.m.f. across L.

28. (D) Magnetic field induction at the centre of circular coil carrying current is

$B = \frac{\mu_0}{4\pi}\frac{2\pi ni}{r}$ i.e., $B \propto n/r$.

But $2\pi r = 3\times2\pi r_1$ or $r_1 = r/3$

So, $\frac{B_1}{B} = \frac{n_1}{r_1}\times\frac{r}{n} = \frac{3\times r}{(r/3)\times1} = 9$

29. (B) As 1 mole, i.e., 63.5 g of copper contains 6×10^{23} atoms, the number of atoms in 10 g copper will be

$$\frac{6\times10^{23}\times10}{63.5} = 9.45\times10^{22}$$

and as out of 1000 atoms, 1 electron is transferred from one piece of copper to the other, the total electrons transferred from one piece to the other will be

$$(1/1000)\times9.45\times10^{22} = 9.45\times10^{19}$$

Due to transfer of these electrons, one piece will become negative while the other positive with magnitude of charge

$$q = ne = (9.45\times10^{19})\times(1.6\times10^{-19})$$

$$= 15.12\ C$$

So, treating each piece of copper as point charge, electric force between them from Coulomb's law when they are 10 cm apart will be

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = 9\times10^9 \frac{15.12\times15.12}{\left(10\times10^{-2}\right)^2}$$

$$= 2.06\times10^{14}\,N$$

30. (B) $eV_s = E - \phi_0$; $V_s \propto E$

Since energy E of ultraviolet light is greater than that of visible light, hence stopping potential is more for ultraviolet light than that for visible light.

31. (A) Resistance of each bulb R = V^2/P

When connected in series

Total resistance of bulbs = 2 R

Current in each bulb, I = V'/ 2 R

Power generated by each bulb = $I^2 R$

$$= \left(\frac{V'}{2R}\right)^2 \times R = \frac{V'^2}{4R} = \frac{V'^2}{4\times\left(V^2/P\right)}$$

$$= \frac{(110)^2\times500}{4\times(220)^2} = 31.25 \text{ watt}$$

32. (A) Infrared radiations are of higher wavelength than that of visible light. They arise due to minor electron transitions in atoms.

33. (A) K.E. of particle, $E = \frac{1}{2}mv^2$ or

$mv = \sqrt{2mE}$

Also, $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$

$E = \frac{h^2}{2\lambda^2 m}$ i.e., $E \propto \frac{1}{m}$

Since, the mass of photon is least as compared to electron and helium nucleus, so kinetic energy of photon is maximum.

34. (C) As $f_1 = -20$ cm and $f_2 = 20$ cm

$\therefore$ F = ∞ The combination behaves as a plane refracting surface. Hence, image is erect and of same size.

35. (D) Total magnetic moment at temperature 4.2 K is M_1

M_1 = 15% of $(2\times10^{24}\times1.5\times10^{-23})$

= 4.5 JT^{-1}

From Curie's law, the susceptibility $\psi = \frac{C}{T}$ where C is a constant and T is the temperature.

But $\psi = \frac{I}{H}$, where I is the magnetisation and $I = \frac{M}{V}$ and V is the volume of the specimen.

$\psi = \frac{M}{VH} = \frac{C}{T}, \frac{M_1}{M_2} = \frac{H_1}{H_2}\frac{T_2}{T_1}$ because V and C are constants

$$M_2 = M_1 \times \frac{H_2}{H_1}\times\frac{T_1}{T_2}$$

$$= 4.5\times\frac{0.98}{0.84}\times\frac{4.2}{2.8} = 7.9\ JT^{-1}$$

36. (A) Through L, when current is maximum, voltage is minimum.

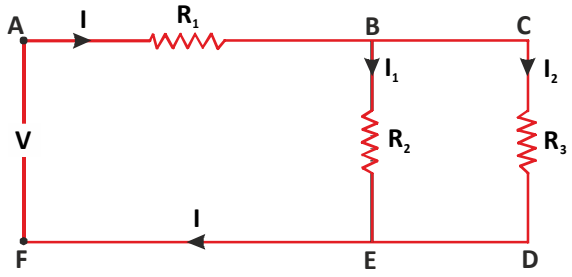
37. (B) Let nth fringe of 2500 Å coincide with $(n-2)^{th}$ fringe of 3500 Å.

$\therefore$ 3500 (n – 2) = 2500 × n

1000 n = 7000, n = 7

$\therefore$ 7^{th} order fringe of 1^{st} source will coincide with 5^{th} order fringe of 2^{nd} source

38. (C) As voltage across the resistors R_2 and R_3 is same and they show same dissipation of energy, so using the relation for energy, $H = \frac{V^2}{R}t$, we have R_2 = R_3. Thus, the current in each resistor R_2 and R_3 will be 1/2.



i.e., $I_1 = 1/2$ and $I_2 = 1/2$

Since the energy dissipation is same in all the three resistors, so

$I^2R_1t = I_1^2 R_2t$

or $I^2 R_1t = (I/2)^2 R_2t$

or $R_1 = R_2/4$

39. (B) From $s = ut + \frac{1}{2}at^2 = \frac{1}{2}at^2 \quad (\because u = 0)$

$t = \sqrt{\frac{2s}{a}}$ As s is same, $\therefore t \propto \frac{1}{\sqrt{a}}$

$$\frac{t_2}{t_1} = \sqrt{\frac{a_1}{a_2}} = \sqrt{\frac{q_e/M_e}{q_p/M_p}} = \sqrt{\frac{M_p}{M_e}}$$

40. (A) $q_1 = 10 \times 50 = 500\ \mu C$,

$C_1 = 10\ \mu F$, $C_2 = ?$

$q_2 = 0$ As $V = \frac{q_1 + q_2}{C_1 + C_2}$

$$\therefore\ C_1 + C_2 = \frac{q_1 + q_2}{V} = \frac{500 + 0}{20} = 25\ \mu F$$

$C_2 = 25 - C_1 = 25 - 10 = 15\ \mu F$

CHEMISTRY

41. (D) Oxidation of potential of Sn ($E°_{Sn/Sn^{2+}}$) = + 0.136 V. It can reduce the substance having lower oxidation potential viz. Pb.

42. (C) CO is neutral whereas SO_3 is acidic. Also Al_2O_3 and ZnO are amphoteric in nature.

43. (C)

$$C_3H_7I \xrightarrow{KOH\ alc.} CH_3CH = CH_2 \xrightarrow{NBS,\ hv}$$

$$BrCH_2CH = CH_2 \xrightarrow{KCN\ alc.} NC - CH_2CH = CH_2$$

44. (A) Amount of NaCl $= \frac{1.00\ g}{58.5\ g/mol}$

No. of unit cells in 1.00 g of NaCl

$$= \frac{6.02 \times 10^{23}\ mol^{-1}}{4} \times \frac{1.00\ g}{58.5\ g\ mol^{-1}} = 2.57 \times 10^{21}$$

45. (D) Na_2S is quite soluble - alkali metal salts are more soluble.

The K_{sp} values for ZnS and CuS are 2.5×10^{-24} and 8.5×10^{-45}

46. (C) $C_6H_5CH\boxed{O+H_2}CHCOCH_3 \xrightarrow{Aq\ NaOH}$

$C_6H_5CH = CHCOCH_3 + H_2O$.

47. (D) Mass of the solute, $w_2 = 3.5$ g

Mass of water, $w_1 = 125$ g = 0.125 kg

Elevation of boiling point,

$\Delta T_b = (373.52 - 373.0)$ K = 0.52K

Molar mass of the solute = M (?)

We know that,

$$\Delta T_b = \frac{K_b n_2}{w_1} = \frac{K_b (w_2/M)}{w_1}$$

$$= \frac{0.52\ K\ kg\ mol^{-1} \times 3.5\ g}{M \times 0.125\ kg}$$

$$0.52\ K = \frac{0.52 \times 3.5\ K\ kg\ mol^{-1}\ g}{M \times 0.125\ kg}$$

$$\text{or } M = \frac{0.52 \times 3.5 \text{ K kg mol}^{-1}\text{ g}}{0.52 \text{ K} \times 0.125 \text{ kg}}$$

$$= \frac{3.5}{0.125} \text{ g mol}^{-1} = 28 \text{ g mol}^{-1}$$

48. (D) Urea contains 46.6% N and $(NH_4)_2SO_4$ contains 20% N.

49. (C) $2NH_3 \xrightarrow{Pt} N_2 + 3H_2$

$$\text{Rate} = -\frac{1}{2}\frac{d[NH_3]}{dt} = \frac{d[N_2]}{dt}$$

$$= \frac{1}{3}\frac{d[H_2]}{dt} = k = 2.5 \times 10^{-4} \text{mol L}^{-1}\text{s}^{-1}$$

Rate of production of H_2,

$$\frac{d[H_2]}{dt} = 3 \times 2.5 \times 10^{-4}$$

$$= 7.5 \times 10^{-4} \text{mol L}^{-1}\text{s}^{-1}$$

50. (A) In acidic solution, NH_3 forms a bond with H^+ to give NH_4^+ ion which does not have a lone pair on N to act as a ligand.

51. (C) $RCOCl \xrightarrow[Pd-BaSO_4]{H_2} \underset{(P)}{RCHO} + HCl$

52. (C) Doping of Si with P gives extra electrons while doping with Al gives rise to holes.

53. (B) HCl gas in the presence of moisture in air forms droplets of liquid solution in the form of cloudy smoke.

54. (D) $CH_3CHOHCH_2CH_3 \xrightarrow{[O]} CH_3COCH_2CH_3$

$\xrightarrow{[O]} CH_3COOH + CH_3CH_2COOH$

55. (D) Greater is the critical temp. of a gas, greater is the adsorption. Critical temp. (K) are NH_3 (406), CO_2(304), CH_4 (190) H_2(33). Thus, adsorption decreases from NH_3 to H_2 in this order.

CRITICAL THINKING

56. (B) The bar will expand as it is heated so the pins will be pushed away from the blocks;

57. (A) In this question, all of the inputs (Red, Yellow, Green, Blue) are on.

When these inputs pass through the first switch, all colours are allowed to pass if the switch is working and only red is allowed to pass if the switch is at fault.

This modified input passes through the second switch which allows only red and yellow to pass if the switch is working and only green and blue to pass if the switch is at fault.

This modified input passes through the third switch which turns on red and green if the switch is working and turns on yellow and blue if the switch is at fault.

Once again, you need to compare the input and output and determine which of the switches is at fault. In this case, it is switch 'A' (the first switch) which allows all colours to pass when working but allows only red to pass when at fault.

58. (D) Some people eating vitamin-fortified foods exceed the daily intake for vitamin C that is recommended by the National Academy of Sciences

Explanation:

This question stem is asking you to form a conclusion based on the information given, so you must pick the one answer that is guaranteed. As is true for all inference style questions, you should use process of elimination by evaluating each potential conclusion

For "Most people eating vitamin-fortified foods are consuming dangerous amounts of vitamin C.", you do know that "most consumers overestimate the amount of one serving for these foods, ingesting two to four times what is considered one serving by the manufacturer" so it is safe to say that most people get more than their daily intake as recommended by the NAS.

However, to be dangerous the recommended amounts must be “greatly exceeded” and we have no idea if “two to four times” meets that threshold. As a result this is not a proper inference.

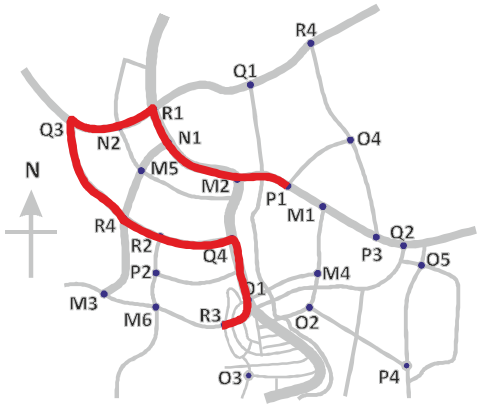
For "Manufacturers need to change the amount listed as one serving on the packaging for vitamin-fortified foods.", there is no proof given in the stimulus that manufacturers need to do anything. While it is true that many consumers overestimate the amount of one serving, this does not allow you to conclude that manufacturers need to make a change (maybe the consumers just need to get better at estimating!). This type of prescription is virtually impossible to prove in an inference style question.

For "Any person eating vitamin-fortified foods will receive the daily intake for vitamin C that is recommended by the National Academy of Sciences.", the word “any” makes this easy to eliminate. We know that many, but not necessarily all, vitamin fortified foods contain 100% of the recommended vitamin C and that “most” consumers overestimate a serving. However, this still leaves open the possibility that some people are eating vitamin-fortified foods that do not contain vitamin C or that they are not getting a full serving’s worth.

For "Some people eating vitamin-fortified foods exceed the daily intake for vitamin C that is recommended by the National Academy of Sciences.", you know with certainty that most consumers are eating 2-4 servings of vitamin-fortified foods containing vitamin C, which provides more than 100% of the recommended amount. Since you only need to prove one person has consumed more than a serving of these foods to be sure of this conclusion, it must be true and "Some people eating vitamin-fortified foods exceed the daily intake for vitamin C that is recommended by the National Academy of Sciences." is correct.

For "People should avoid taking supplemental vitamin C if they are eating vitamin-fortified foods.", this is a similar prescription to what you saw in "Manufacturers need to change the amount listed as one serving on the packaging for vitamin-fortified foods.". There might be many reasons why someone wants or needs to take a vitamin C supplement even if they are eating the vitamin-fortified foods. Maybe their doctor wants them to have lots of extra vitamin C or maybe they are eating the vitamin-fortified foods that do not contain 100% of the recommended amount. This is not a proper inference.

59. (D)



The courier boy ends his ride at R3.

60. (A) As India is democratic country and every person has its right about where he wants to work and singing such bonds does not esure the correct use of talent of a country. So, argument I is strong but argument II and III are weak also argument IV is a vague and hence is weak argument.