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NATIONAL LEVEL SCIENCE TALENT SEARCH EXAMINATION

Paper Code: UN439 (UPDATED)

Solutions for Class : 11_PCM

MATHEMATICS

1. **(B)** Since $x^2+1=0 \Rightarrow x=\pm i$.

2. **(A)** Let N be the number of one – one functions from {1, 2, 3} into {a, b, c}.

$\Rightarrow \; N={}^3P_3$

$\therefore \; N = \underline{|3} = 6$

3. **(B)** $8\sin\frac{x}{8}\cos\frac{x}{2}\cos\frac{x}{4}\cos\frac{x}{8}$

$=\left(2\sin\frac{x}{8}\cos\frac{x}{8}\right)\left(4\cos\frac{x}{4}\cos\frac{x}{2}\right)$

$=\left(\sin\frac{2x}{8}\right)\left(4\cos\frac{x}{4}\cos\frac{x}{2}\right)$

$=\left(2\sin\frac{x}{4}\cos\frac{x}{4}\right)\left(2\cos\frac{x}{2}\right)$

$=\left(\sin\frac{2x}{4}\right)\left(2\cos\frac{x}{2}\right)$

$=\sin\frac{2x}{4}=\sin x$

4. **(B)** Let P (n): $\frac{1^3}{1}+\frac{1^3+2^3}{1+3}+\frac{1^3+2^3+3^3}{1+3+5}$ ....n terms)

$\Rightarrow$ P (n): $\sum\frac{1^3+2^3+.....+n^3}{1+3+5...(n \text{ terms})}$

$\Rightarrow$ P (n): $\sum\left\{\frac{\sum n^3}{n^2}\right\}$

$\Rightarrow$ P (n): $\sum\left\{\frac{1}{4}\frac{n^2\,(n+1)^2}{n^2}\right\}$

$\Rightarrow$ P (n): $\frac{1}{4}\sum(n^2+2n+1)$

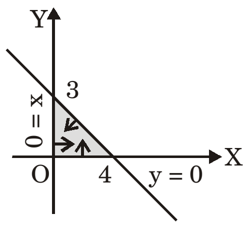
$\Rightarrow$ P (n): $\frac{1}{4}\left\{\sum n^2+2\sum n+\sum 1\right\}$

$\Rightarrow$ P (n): $\frac{1}{4}\left\{\frac{n(n+1)}{2}+\frac{1}{3}n\,(n+1)\,(2n+1)+n\right\}$

$\Rightarrow$ P (n): $\frac{1}{24}$ n {3 (n + 1) + 2 (n + 1) (2n + 1) + 6}

$\therefore$ P (n): $\frac{1}{24}n\,(2n^2+9n+13)$

5. **(B)** (B)



Therefore, the graph is the interior of a triangle including the points on the sides.

6. **(A)** We have, $\frac{1}{2}|z|^2 = a\,|z|^2 \Rightarrow$ a = 1/2

7. **(C)** The graph of given inequalities is common to the graphs of $x \geq -2$, $x \leq 2$, $y \geq -2$, $y \leq 2$.

8. **(A)** 6 bananas can be dealt with in 7 ways as we can choose 1 or 2 or 3 or 4 or 5 or 6 or none.

Similarly 5 oranges can be dealt with in 6 ways and 4 apples can be dealt in 5 ways.

$\therefore$ The number of ways = 5 x 6 x 7 = 210. But these ways also include the case in which none of the fruit is selected.

$\therefore$ 210 - 1 = 209 is the required number of ways.

9. **(D)** The result (D) is incorrect as
$^{n}C_r + {}^{n}C_{r-1} \neq {}^{n}C_{r+1}$

10. **(D)** $(1 + x2)^5 \times (1 + x)^4$
$= (1 + 5x^2 + 10x^4 + 10^6 + 5x^8 + x^{10}) \times$
$(1 + 4x + 6x^2 + 4x^3 + x^4)$
$= \ldots + (5x^2)(4x^3) + (10x^4)(4x) + \ldots..$
Hence the coefficient of $x^5 = 20 + 40 = 60$

11. **(B)** a, A_1, A_2, b are in AP.(since. A_1, A_2 are A.M's between a & b)

$$\Rightarrow A_1 - a = A_2 - A_1 = b - A_2$$

$$\Rightarrow A_1 - a = A_2 - A_1 \text{ and } A_2 - A_1 = b - A_2$$

$$\Rightarrow 2A_1 - A_2 = a \text{ and } 2A_2 = A_1 = b$$

$$\Rightarrow (2A_1 - A_2)(2A_2 - A_1) = ab$$

12. **(B)** Letter the GP be a, ar, ar^2,....., where $0 < r < 1$. Then, $a + ar + ar^2 + \ldots = 3$ and $a^2 + a^2r^2 + a^2r^4 + \ldots = 9/2$.

$$\Rightarrow \frac{a}{1-r} = 3 \text{ and } \frac{a^2}{1-r^2} = \frac{9}{2}$$

$$\Rightarrow \frac{9(1-r)^2}{1-r^2} = \frac{9}{2}$$

$$\Rightarrow \frac{1-r}{1+r} = \frac{1}{2} \quad \Rightarrow \quad r = \frac{1}{3}$$

Putting $r = \frac{1}{3}$ in $\frac{a}{1-r} = 3$, we get $a = 2$.

Now, the required sum of the cubes is

$$a^3 + a^3r^3 + a^3r^6 + \ldots = \frac{a^3}{1-r^3}$$

$$= \frac{8}{1-(1/27)} = \frac{108}{13}$$

13. **(A)** Here, $|F_1F_2| = \sqrt{(3-0)^2 + (4-0)^2} = 5$

$$\Rightarrow |PF_1| + |PF_2| = 10 > 5$$

$\Rightarrow \Rightarrow |PF_1| + |PF_2| = a$ constant greater than $|F_1F_2|$, therefore, locus of P is an ellipse with foci at F_1 and F_2.

14. **(C)** The centre of the circle is the point of outersection of the diameters $2x - 3y = 5$ and $3x - 4y = 7$, i.e., the point $(1, -1)$.
If r is the radius of the circle, then its area $\pi r^2 = 154$ (Given)

$$\Rightarrow \frac{22}{7} \times r^2 = 154 \Rightarrow r = 7.$$

$\therefore$ Equation of the circle is
$(x - 1)^2 + (y + 1)^2 = 7^2$
or $x^2 + y^2 - 2x + 2y = 47$.

15. **(B)** Length of the diagonal of the square

$$= \sqrt{(1-2)^2 + (-2+3)^2 + (3-5)^2} = \sqrt{6}$$

$\therefore$ Length of its side $= \frac{\sqrt{6}}{\sqrt{2}} = \sqrt{3}$

16. **(C)** Required number $= 8 \times 9 \times 9$
$= 8 \times 81 = 648$

17. **(A)** $\lim_{x \to \frac{\pi}{4}} \frac{2\sqrt{2} - (\cos x + \sin x)^3}{1 - \sin 2x} \quad \left(\frac{0}{0}\text{form}\right)$

Using L' Hospital's rule,

$$= \lim_{x \to \frac{\pi}{4}} \frac{-3(\cos x + \sin x)^2(-\sin x + \cos x)}{-2\cos 2x}$$

$$= \lim_{x \to \frac{\pi}{4}} \frac{-3(\cos x + \sin x)(\cos^2 x - \sin^2 x)}{-2\cos 2x}$$

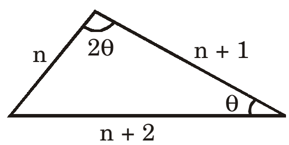
$$= \lim_{x \to \frac{\pi}{4}} \frac{-3(\cos x + \sin x)\cos 2x}{-2\cos 2x}$$

$$= \lim_{x \to \frac{\pi}{4}} \frac{3(\cos x + \sin x)}{2} = \frac{3}{2}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) = \frac{3}{\sqrt{2}}$$

18. **(B)** $(x + y)^9 = x^9 + 9x^8y + 36x^7y^2 + \ldots + y^9$
Given, $9p^8q = 36p^7q^2$ and $p + q = 1$
Dividing by $9p^7q$, we get
$p = 4q$
Substituting $1 - p$ for q, we get
$p = 4(1 - p)$

$$\Rightarrow p = \frac{4}{5}$$

19. **(A)** In the adjoining fig, 'n' denotes the length of the shortest side and 'θ' denotes the smallest angle.



Using law of sines, and writing $2\sin\theta.\cos\theta$ for $\sin 2\theta$, we obtain

$$\frac{\sin\theta}{n} = \frac{2\sin\theta.\cos\theta}{n+2}$$

$$\Rightarrow \cos\theta = \frac{n+2}{2n}$$

Equating $\frac{n+2}{2n}$ to the expression of $\cos\theta$ obtained from the law of cosines, we get

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

$$= \frac{(n+1)(n+5)}{2(n+1)(n+2)} = \frac{n+5}{2(n+2)}$$

Thus, n = 4 and $\cos\theta = \frac{4+2}{2(4)} = \frac{3}{4}$

20. **(D)** The smallest possible value of $\overline{AC} + \overline{BC}$ is obtained when C is the intersection of the y-axis, with the line that leads from A to the mirror image of B i.e., B^1 (–2, 1) (Here mirror image is being y-axis). This is true because $\overline{CB^1} = \overline{CB}$ and a straight line is the shortest path between two points.

The line through A and B^1 is given by,

$y = \frac{5-1}{5+2}x + k = \frac{4}{7}x + k$

Since it passes through A (5, 5)

We have, $5 = \frac{4}{7}.5 + k$

$\Rightarrow k = 5 - \frac{20}{7} = \frac{15}{7} = 2\frac{1}{7}$

21. **(A)** Let the edges be $\frac{a}{r}$ a.ar = 216, i.e.,

$a^3 = 216$, i.e., a = 6 and

$2\left(\frac{a}{r}.a + a.ar + \frac{a}{r}.ar\right) = 252;$

$\therefore \frac{1}{r} + r + 1 = \frac{7}{2} \Rightarrow r = \frac{1}{2}, 2$

$\therefore$ a = 6, r = 2, so the longest side = ar = 12.

22. **(D)** $A1\ B1 = \sqrt{4+4} = 2\sqrt{2}$

$AB = 2\sqrt{2} - 2 = 2\left(\sqrt{2}-1\right)$

Thus equation of required circle is

$x^2 + y^2 = \left(\sqrt{2}-1\right)^2 = 3 - 2\sqrt{2}$

23. **(B)** Normal at (at2, 2at) on the parabola y2 = 4ax is y + tx = 2at + at3

Suppose normal equation (i) cuts the curve again at $\left(at_1^2, 2at_1\right)$, then

$2at_1 + att_1^2 = 2at + at^3$

$\Rightarrow 2a(t - t^1) + at(t^2 - t_1^2) = 0$

or $2 + t(t + t_1) = 0$

$\left(\because a\left(t - t_1\right) \neq 0\right)$

$\therefore t_1 = -t - \frac{2}{t}$

$= -\left(t + \frac{2}{t}\right)$

24. **(A)** Let A(5,2,4), B(6,–1,2), C(8,–7,k) be the given points

Direction ratios of AB are

6 – 5, –1 –2, 2 – 4 (i.e.) 1, –3, –2

Direction ratios of BC are

8–6, –7 + 1, k –2 (i.e.) 2, –6, k–2

Since A, B, C are collinear

$\frac{2}{1} = \frac{-6}{-3} = \frac{k-2}{-2}$

$k - 2 = -4 \Rightarrow k = 2 - 4 = -2$

25. **(A)** Squaring and adding both the given equations, we get 24 sin(A + B) = 12

Thus, $\sin C = \sin(180 - A - B) = \sin(A + B)$

$= \frac{1}{2}$

So, $\angle C = 30°$ or 150°

$\angle C = 150°$ is impossible because it would imply that A < 30° and consequently that

$3\sin A + 4\cos B < 3.\frac{1}{2} + 4 < 6$, a contradiction.

$\therefore$ $\angle C = 30°$ only

26. **(A)** Let p(n): $\frac{n^7}{7} + \frac{n^5}{5} + \frac{2n^3}{3} - \frac{n}{105}$

$\Rightarrow$ $p(1) = \frac{1}{7} + \frac{1}{5} + \frac{2}{3} - \frac{1}{105} = 1$

and $p(2) = 8\left(\frac{16}{7} + \frac{4}{5} + \frac{2}{3}\right) - \frac{2}{105} = 15$

$\therefore$ By induction p(n) is an integer $\forall\ n \in N$

27. **(C)** There are a total of 2^{100} subsets.

The number of subsets containing 0, 1, 2, 3, ... 49 elements is exactly the same as those containing 100, 99, 98, 97, ... 51 elements.

Since the number of subsets with 50 elements is ${}^{100}C_{50}$, the answer is:

$\frac{2^{100} - {}^{100}C_{50}}{2} + {}^{100}C_{50} = 2^{99} + \frac{{}^{100}C_{50}}{2}$

28. **(A)** $x^2 + y^2 - 10x + 6y + 9 = 0$

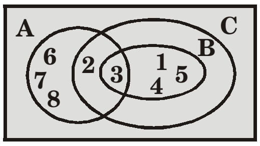
$\Rightarrow (x - 5)^2 + (y + 3)^2 = 25.$

So, L passes through the centre (5, –3) and (7, 1) and has slope $m = \frac{-3-1}{5-7} = 2$ and the equation L is y = 2x – 13.

$\therefore$ The only choice that lies on the line is (8, 3).

29. **(C)** If B = {1, 3, 4, 5} and A = {2, 3, 6, 7, 8}, then the total values in A is 2 + 3 + 6 + 7 + 8 = 26

Which is twice the total of the value in B i.e. 1 + 3 + 4 + 5 = 13



30. **(D)** $\frac{2\sin x.\cos x}{\cos^2 x - \sin^2 x} = \frac{\cos x}{\sin x}$

$\Rightarrow 2\sin^2x.\cos x = \cos^3x - \sin^2x.\cos x$

$\Rightarrow \cos x(3\sin^2x - \cos^2x) = 0$

$\Rightarrow \cos x = 0 \text{ or } \tan^2x = \frac{1}{3}$

Which give two solutions and four solutions respectively.

31. **(B)** To obtain the elements of RoR, we proceed as follows. Since (1, 4) and ∈ R we have (1, 5) ∈ RoR. Again , since (1,4) ∈ R and (4, 6) ∈ R we have (1, 6) ∈ RoR.

Similarly, (3, 6) ∈ RoR since (3, 7) ∈ R and (7, 6) ∈ R.

Hence, RoR = {(1, 5), (1, 6), (3, 6)}

32. **(A)** The equation represented by $z\bar{z} + a\bar{z} + \bar{a}z + b = 0$ is a circle centered at "–a" and radius $\sqrt{|a|^2 - b}$.

∴ The radius of given circle

$= \sqrt{25-5} = \sqrt{20}$

$= 2\sqrt{5}$

33. **(B)** Given digits 0, 1, 2, 3, 4.

1,2,3	0,1,2,3,4	0,1,2,3,4	0,1,2,3,4

3 × 5 × 5 × 5 = 375

34. **(A)** Each of the three persons can leave the lift at one of the ten floors (other than 2nd storey and one at which they enter the lift).

Since they leave the lift at different storeys.

∴ Number of ways = $^{10}P_3$ = 10 × 9 × 8 = 720

35. **(B)** Length of the diagonal of the square

$= \sqrt{(1-2)^2 + (-2+3)^2 + (3-5)^2} = \sqrt{6}$

∴ Length of its side $= \frac{\sqrt{6}}{\sqrt{2}} = \sqrt{3}$

36. **(C)** Equation of the tangent at point "θ" is:

$\frac{x}{a}\cos\theta + \frac{y}{b}\sin\theta = 1$ . . . (1)

Given line is, $\frac{x}{a}.\frac{1}{\sqrt{2}} + \frac{y}{b}.\frac{1}{\sqrt{2}} = 1$ . . . (2)

Since (2) touches the ellipse (1),

we have $\cos\theta = \frac{1}{\sqrt{2}}$ and $\sin\theta = \frac{1}{\sqrt{2}}$

∴ θ = 45°

37. **(A)** Let "r" be the common ratio.

Then $x_2 = x_1r$, $x_3 = x_2r = x_1r^2$, $y_2 = y_1r$, $y_3 = y_1r^2$

$Q = (x_2, y_2) = (x_1r, y_1r)$

$R = (x_3, y_3)\ (x_1r^2, y_1r^2)$

We observed that PQ + QR = PR

∴ P, Q, R are collinear.

38. **(C)** Let $f(x) = 2ax^3 + 3bx^2 + 6cx$

Clearly f(x) is continuous on [0, 1], derivable on (0, 1) and f(0) = 0, f(1) = 2a + 3b + 6c = 0

Also $f^1(x) = 6ax^2 + 6bx + 6c$

∴ By Rolle's theorem,

∃ α ∈ (0, 1) such that $f^1(\alpha) = 0$

$\Rightarrow 6a\alpha^2 + 6b\alpha + 6c = 0$

$\Rightarrow a\alpha^2 + b\alpha + c = 0$

∴ $ax^2 + bx + c = 0$ has a root in (0, 1)

39. **(A)** If $P(x_1, y_1)$ is the middle point of the chord, then the equation of the chord is,

$3xx_1 - 2yy_1 + 2(x + x_1) - 3(y + y_1) = 3x_1^2 - 2y_1^2 + 4x_1 - 6y_1$

If this chord is parallel to y = 2x, then

$\frac{3x_1+2}{2} = \frac{2y_1+3}{1} \Rightarrow 3x_1 + 2 = 4y_1 + 6$

$\Rightarrow 3x_1 - 4y_1 = 4$

∴ The equation to the locus of P is 3x – 4y = 4

40. **(A)** $\cot(\alpha+\beta) = 0 \Rightarrow \cos(\alpha+\beta) = 0$

$\Rightarrow \cos\alpha.\cos\beta - \sin\alpha.\sin\beta = 0$

$\Rightarrow \cos\alpha.\cos\beta = \sin\alpha.\sin\beta$

Now $\sin(\alpha+2\beta) = \sin(\alpha+\beta+\beta)$

$= \sin(\alpha+\beta).\cos\beta + \cos(\alpha+\beta).\sin\beta$

$= \sin(\alpha+\beta).\cos\beta$ $[\because \cos(\alpha+\beta) = 0]$

$= (\sin\alpha.\cos\beta + \cos\alpha.\sin\beta).\cos\beta$

$= \sin\alpha.\cos^2\beta + \sin\beta.\cos\alpha.\cos\beta$

$= \sin\alpha.\cos^2\beta + \sin\beta.\sin\alpha.\sin\beta$

$= \sin\alpha\,[\cos^2\beta + \sin^2\beta]$

$= \sin\alpha(1) = \sin\alpha$

PHYSICS

41. **(C)** It falls with terminal velocity. (i.e., acquires a constant velocity)

42. **(B)** Rise of cold drink in a straw is an example of atmospheric pressure.

43. **(C)** The dimensions of K are same as that of pressure, which are same as that for modulus of elasticity.

Modulus of elasticity Y = $\frac{\text{Stress}}{\text{Strain}} = \frac{N}{m^2}$

44. **(C)** The pressure inside the soap bubble is more than that outside it.

45. **(C)** The total momentum of the ball and the earth is conserved.

46. **(A)** $p_1V_1 = p_2V_2$

When radius is doubled, volume becomes 8 times.

Hence $(p + H) V_1 = H \times 8V_1$

That is, p = 7H.

47. **(B)** Statements (i) and (iii) are not correct. Instantaneous speed is equal to the magnitude of instantaneous velocity.

48. **(B)** Acceleration due to gravity on planet

$= \frac{\text{Gravitational potential difference}}{\text{Distance between two points}}$

$= \frac{4}{10} = 0.4\ ms^{-2}$

Work done = 4 × 0.4 × 2.5 = 4 J

49. **(B)** $C_m = \frac{3}{2}R,\ C_{di} = \frac{5}{2}R$. If change in temperature is ΔT, then

$1 \times \frac{3}{2}R\Delta T + 1 \times \frac{5}{2}R\Delta T = 2 \times C_v \times \Delta T.$

This gives $C_v = 2R$

50. **(D)** The acceleration acting on both the bodies is due to gravity.

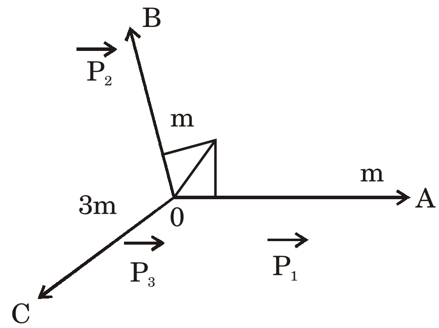
51. **(B)** Let the mass of the three fragments be m kg, m kg and 3m kg

Total mass = 1 kg

⇒ m + m + 3m = 1kg

⇒ 5m = 1 kg

⇒ m = $\frac{1}{5}$ kg



Momentum along OA is P_1

= mass × velocity = $\frac{1}{5} \times 30$

P_2 = 6 kg m s^{-1} = 6 kg m s^{-1}

P_3 = 3 m × V

Total momentum after collision

= Total momentum before collision.

$\vec{P}_1 + \vec{P}_2 + \vec{P}_3 = 0$

$\vec{P}_3 = (\vec{P}_1 + \vec{P}_2)\ ;\ |\vec{P}_3| = \sqrt{P_1^2 + P_2^2}$

$\sqrt{6^2 + 6^2} = \sqrt{72} = 6\sqrt{2}$ kg m s^{-1}

3 m V = $6\sqrt{2}$

$V = \frac{6\sqrt{2}}{3 \times \frac{1}{5}} = 10\sqrt{2}$

= 14.14 ms^{-1}

52. **(A)** Here, v = $7\sqrt{3}$ m s^{-1}; r = $5\sqrt{3}$ m.

Let θ be the inclination of the cyclist with the vertical.

Then, $\tan\theta = \frac{v^2}{rg} = \frac{(7\sqrt{3})^2}{5\sqrt{3} \times 9.8} = \sqrt{3}$

⇒ θ = 60°

53. **(D)** Let the angle between vectors P and Q be θ.

$(P + Q)^2 + (P - Q)^2 + 2 (P + Q) (P - Q) \times \cos\theta$

$= P^2 + Q^2$

which gives $\cos\theta = (P^2 + Q^2)/2(Q^2 - P^2)$

(or) $\theta = \cos^{-1}\left[\frac{(P^2 + Q^2)}{2(Q^2 - P^2)}\right]$

54. **(D)** As oxygen and hydrogen are diatomic gases, their specific heat is the same.

∴ 1 × C × (100 – θ) = 1 × C × (θ –10)

2θ = 110° ⇒ θ = 55°.

55. **(B)** Impulse = change in momentum

= mv – mu = m(v – u)

= 0.1[30 – (–20)] = 5 N s

56. **(C)** V = (100 ± 5) V

I = (10 ± 0.2) A

$$R = \frac{V}{I} = \frac{100}{10} = 10 \text{ ohm}$$

$$\frac{\Delta R}{R} = \pm\left(\frac{\Delta V}{V} + \frac{\Delta I}{I}\right)$$

$$= \pm\left(\frac{5}{100} + \frac{0.2}{10}\right) = \pm\frac{7}{100}$$

$$\frac{\Delta R}{R} \times 100 = \pm\frac{7}{100} \times 100 = \pm 7\%$$

57. **(B)** The downward force on the elevator is

$F = mg + F_f = 3600 \times 10 + 8000 = 44000$ N

The motor must supply enough power to balance this force. Hence,

P = F.v = 44000 × 4 = 176000 W = 236 hp

58. **(A)** The set of quantities with the same dimensional formula ML^2T^{-3} are luminous intensity and radiant flux.

59. **(C)** From the law of conservation of linear momentum,

$MV = m_1v_1 + m_2v_2$

or $m_1v_1 + m_2v_2 = 0$ (Because $V = 0$.)

or $m_1v_1 = -m_2v_2$

or $v_1 = \frac{-m_2v_2}{m_1}$

Substituting m_2 = 8 kg; $v_2 = 6\ m\ s^{-1}$, m_1 = 4kg, we get

$v_1 = 12\ m\ s^{-1}$ (neglecting –ve sign).

Hence, kinetic energy is given by

$K = (1/2)m_1v_1^2 = (1/2) \times 4 \times (12)^2 = 288$ J.

60. **(D)** dQ = 400 cal. dW = –105 J

= –105 / 4.2 cal = –25 cal.; dU = ?

dU = dQ – dW

dU = 400 – (–25) = 425 cal

Note dW is negative because work is done on the system.

61. **(B)** Energy stored per unit volume

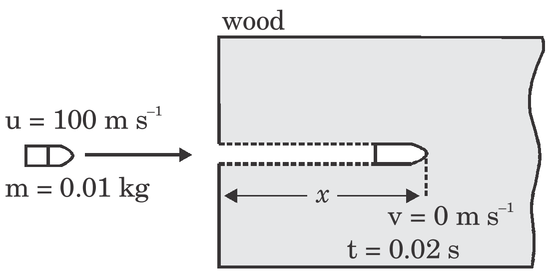
$$U = \frac{1}{2}\text{stress} \times \text{strain}$$

$$= \frac{1}{2}\text{stress} \times \frac{\text{strain}}{Y}$$

$$= \frac{1}{2}S \times \frac{S}{Y} = \frac{1}{2}\frac{S^2}{Y}$$

62. **(C)** On the surface of the earth, the atmospheric pressure is quite high. The astronauts will feel great discomfort if they move on the earth immediately after coming back from the moon. To avoid it, they need to get used to normal air pressure gradually. That is why, they have to live for some days in a caravan with the air pressure lower than outside.

63. **(B)**



$u = 100\ m\ s^{-1}$ $v = 0\ m\ s^{-1}$

a = ? t = 0.02 s

v = u + at

0 = 100 + a × 0.02

0.02 a = – 100

a = – 100 / 0.02

$a = -5000\ m\ s^{-2}$

A bullet penetrating a wooden block

F = ? m = 0.01 kg $a = -5000\ m\ s^{-2}$

F = ma

F = 0.01 × (– 5000)

The average retarding force exerted by the wood is – 50 N.

64. **(A)** Relative velocity of overtaking =

$40\ m\ s^{-1} - 30\ m\ s^{-1} = 10\ m\ s^{-1}$.

Total distance covered with this relative velocity during overtaking will be =

100 m + 200 m = 300 m.

Time taken $t = 300\ m/10\ m\ s^{-1} = 30$ s

65. **(C)** $$\upsilon = \frac{m_1u_1 + m_2u_2}{m_1 + m_2} = \frac{40 \times 4 + 60 \times 2}{40 + 60}$$

$= 2.8\ m\ s^{-1}$

Loss in K.E. =

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1 + m_2)\upsilon^2$$

$$\frac{1}{2}\left[40 \times 16 + 60 \times 4 - 100 \times 2.8^2\right] = 48 \text{ J}$$

<u>**CHEMISTRY**</u>

66. **(C)** In borax, two boron atoms are in triangular geometry and two boron atoms are in tetrahedral geometry. The ion is $[B_4O_5(OH)_4]^{2-}$ and the remaining 8 water molecules are associated with 2 sodium ions and borax is formulated as $Na_2[B_4O_5(OH)_4]\cdot 8H_2O$.

67. **(D)** Chromatography may be used for the purification/separation of the constituents of a mixture consisting of :

(i) gases, (ii) liquids, (iii) solids

68. **(B)** $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

At STP $\rightarrow$ 65 g Zn liberates $\rightarrow$ 22.4 litre of hydrogen.

3.25 g of Zn liberated $\rightarrow$? litre of hydrogen.

$$\Rightarrow \frac{3.25\,g \times 22.4\,l}{65\,g} = 1.12\,\text{litre}.$$

69. **(D)** The favourable conditions are :

(i) Low temperature, (ii) Catalyst

(iii) High pressure

70. **(B)** Tertiary carbonium ion is more stable as the positive charge on the carbon can be neutralized by positive I effect of 3 methyl radicals.

71. **(D)** Inert gases do not form any compounds. Therefore, the distance between two adjacent atoms is considered for the calculation of atomic radius. As two adjacent atoms are bound by non-bonded forces of attraction called Vander Waal's forces the atomic radius is called Vander Waal's radius. Inert gases belong to zero group.

72. **(D)** All the given mixtures form buffer solutions. In case of (II) sodium acetate reacts with HC*l* to form CH_3COOH and NaC*l*.

73. **(B)** For the given reaction,

(i) ΔH is negative

(ii) ΔS is negative

74. **(C)** Mass of 1 drop or 0.05 ml of H_2O = 0.05 g (1 g = 1 m*l*)

No. of moles in 0.05 g = $\frac{0.05}{18}$

One mole contains 6.02×10^{23} molecules

$\therefore$ No. of water molecules in one drop

$= \frac{0.05}{18} \times 6.02 \times 10^{23} = 1.67 \times 10^{21}$ molecules

75. **(A)** Exhaust system in limekilns drive away CO_2 formed so that the equilibrium shifts towards forward reaction.

76. **(B)** Na_2ZnO_2 and H_2 are produced on dissolving metallic zinc in excess of NaOH.

2 NaOH + Zn $\rightarrow$ $Na_2ZnO_2 + H_2$

77. **(A)** If S is the solubility product of AX_2.

$$AX_2(aq) \rightleftharpoons \underset{S}{A^{+2}}(aq) + \underset{2S}{2X^-}(aq)$$

Then, $K_{sp} = [A^{+2}][X^-] = S \times (2S^2) = 4S^3$

$= 4 \times (1.0 \times 10^{-5}\ mol\ L^{-1})^3$

$= 4 \times 10^{-15}\ mol^3\ L^{-3}$

78. **(A)** In potassium dichromate titrations the most commonly employed indicators are diphenylamine or N – phenylanthranilic acid.

79. **(D)** When KC*l* is dissolved in water, heat is absorbed. Thus, the enthalpy of solution of KC*l* is positive. For a dilution of 200, the enthalpy of KC*l* is + 18.6 kJ mol^{-1}

80. **(D)** Total no. of moles of CO_2

$= \frac{wt. in\ g}{1000g} = \frac{200}{1000} = 0.2\,g$

No. of moles of CO_2 = $\frac{wt. in\ g}{mol. wt. of\ CO_2}$

$= \frac{0.2}{44} = 0.00454$

No. of moles removed

$= \frac{10^{21}}{6.022 \times 10^{23}} = 0.00166$

No. of moles of CO_2 left = 0.00454 – 0.00166

= 0.00288.

81. **(B)** $C(s) + O_2(g) \rightarrow CO_2(g)$

1 mol (= 44 g)

Amount of CO_2 in 35.2 g

$= \frac{1\,\text{mol}}{44\,\text{g}} \times 35.2$ g = 0.8 mol

Heat released during the formation of 35.2 g CO_2 = – 393.5 kJ mol^{-1} × 0.8 mol = – 314.8 kJ

82. **(C)** Molar mass of sodium nitrate ($NaNO_3$) = (23 + 14 + 48) g mol = 85 g mol

Mass of 1 dm^3 (or 1 litre) of the solution = Volume × Density

= 1000 cm^3 × 1.25 g cm^{-3} = 1250 g

Therefore,

Mass of the water containing

85 g of $NaNO_3$ = (1250 – 85) g = 1165 g

= 1.165 kg

So, Molality (m) of the solution

$= \frac{1\,\text{mol}}{1.165\,\text{kg}}$ = 0.86 mol kg^{-1}

83. **(C)** From the given data, 2.0 × 10^{-50}

$$= \frac{[O_3]^2}{[O_2]^3} = \frac{[O_3]^2}{(1.6\times10^{-2})^3}$$

This gives, $[O_3]^2$ = 2.0 × 10^{-50}(1.6 × 10^{-2})^3

= 8.2 × 10^{-56}

or $[O_3] = \sqrt{8.2\times10^{-56}}$

= 2.86 × 10^{-28} mol L^{-1}

84. **(A)**

(i) The similarity between lithium and magnesium is striking particularly in their similar sizes of atomic, ionic radii etc.

(ii) They are harder and lighter than other elements in their respective groups.

(iii) They form nitrides by direct combination with nitrogen.

(iv) Their chlorides are soluble in ethanol.

(v) Oxides and hydroxides of both Li and Mg are much less soluble and their hydroxides decompose on heating.

85. **(A)** The given characteristics belong to borazine, a compound of boron with the formula $B_3N_3H_6$.

(i) It is a colourless liquid with an aromatic smell and is also called inorganic benzene.

(ii) It has alternate BH and NH groups in its ring structure.

(iii) It is isoteric because it has the same number of atoms and electrons as that of benzene.

(iv) On heating or by passing silent electric discharge through borazine, it forms a product similar to naphthalene which is also known as inorganic naphthalene.

86. **(B)** HNO_3 is added to decompose Na_2S and NaCN otherwise Na_2S will give black ppt. of Ag_2S and NaCN will give white ppt. of AgCN which would interfere with the test of halogens.

87. **(C)** $BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$

In this reaction, none of the elements undergo, a change in oxidation number or valency.

88. **(A)** Structure of B_2H_6 contains four 2c - 2e bonds and two 3c – 2e bonds.

89. **(B)** % of S = $\frac{32}{233}\times\frac{0.233}{0.32}\times100 = 10$

90. **(B)** Rise in temperature,

Δt = (300.78 K – 294.05 K) = 6.73 K

Heat capacity of the calorimeter =

8.93 kJ K^{-1}

Then,

Heat transferred to calorimeter =

Heat capacity of calorimeter × Rise in temperature

= 8.93 kJ K^{-1} × 6.73 K = 60.1 kJ

GENERAL AWARENESS

91. **(B)** 92. **(A)** 93. **(D)** 94. **(C)**

95. **(B)** 96. **(A)** 97. **(D)** 98. **(C)**

99. **(B)** 100. **(A)**