



1. Let $\omega = -\frac{1}{2} + i\frac{\sqrt{3}}{2}$.

Then the value of the determinant $\begin{vmatrix} 1 & 1 & 1 \\ 1 & -1-\omega^2 & \omega^2 \\ 1 & \omega^2 & \omega^4 \end{vmatrix}$ is

- (A) 3ω (B) $3\omega(\omega - 1)$
(C) $3\omega^2$ (D) $3\omega(1 - \omega)$

Ans: Since $1 + \omega + \omega^2 = 0$, the given determinant

$$\begin{aligned} &= \begin{vmatrix} 1 & 1 & 1 \\ 1 & \omega & \omega^2 \\ 1 & \omega^2 & \omega \end{vmatrix} = \begin{vmatrix} 3 & 0 & 0 \\ 1 & \omega & \omega^2 \\ 1 & \omega^2 & \omega \end{vmatrix} \\ &= 3(\omega^2 - \omega^4) = 3(\omega^2 - \omega) = 3\omega(\omega - 1) \end{aligned}$$

2. For all complex numbers z_1, z_2 satisfying $|z_1| = 12$ and $|z_2 - 3 - 4i| = 5$, the minimum value of $|z_1 - z_2|$ is

- (A) 0 (B) 2
(C) 7 (D) 17

Ans: $5 = |z_2 - 3 - 4i| \geq ||z_2| - 5| \Rightarrow |z_2| \leq 10 \Rightarrow |z_1 - z_2| \geq ||z_1| - |z_2|| = 12 - 10 = 2$.

3. If a_1, a_2, \dots, a_n are positive real numbers whose product is a fixed number c , then the minimum value of $a_1 + a_2 + \dots + a_{n-1} + 2a_n$ is

- (A) $n(2c)^{1/n}$ (B) $(n+1)c^{1/n}$
(C) $2nc^{1/n}$ (D) $(n+1)(2c)^{1/n}$

Ans: We have $\frac{a_1 + a_2 + \dots + a_{n-1} + 2a_n}{n} \geq (a_1 \cdot a_2 \cdot \dots \cdot a_{n-1} \cdot 2a_n)^{1/n}$
 $\Rightarrow a_1 + a_2 + a_3 + \dots + a_{n-1} + 2a_n \geq n(2c)^{1/n}$

4. Suppose a, b, c are in A.P. and a^2, b^2, c^2 are in G.P. If $a < b < c$ and $a + b + c = 3/2$, then the value of a is

- (A) $\frac{1}{2\sqrt{2}}$ (B) $\frac{1}{2\sqrt{3}}$
(C) $\frac{1}{2} - \frac{1}{\sqrt{3}}$ (D) $\frac{1}{2} - \frac{1}{\sqrt{2}}$

Ans: Since $a + c = 2b$, $b = 1/2$. Also $b^2 = \pm ac \Rightarrow ac = \pm 1/4$ and $a + c = 1$
Hence a, c are the roots of the equation $x^2 - x \pm 1/4 = 0$
 $\Rightarrow a = \frac{1}{2} - \frac{1}{\sqrt{2}}$.

5. The number of arrangements of the letters of the word BANANA in which the two N's do not appear adjacently is

- (A) 40 (B) 60
(C) 80 (D) 100

Ans: Total number of ways of arranging the letters of the word BANANA is

$$\frac{6!}{2!3!} = 60.$$

Number of words in which 2 N's come together is $5!/3!$. Hence the required number
 $= 60 - 20 = 40$.

6. The sum $\sum_{i=0}^m \binom{10}{i} \binom{20}{m-i}$ (where $\binom{p}{q} = 0$ if $p < q$) is maximum when m is
- (A) 5 (B) 10
(C) 15 (D) 20

Ans: The sum $\sum_{i=0}^m {}^{10}C_i \cdot {}^{20}C_{m-i} = {}^{10+20}C_{m-i+i} = {}^{30}C_m$
which is maximum for $m = 15$.

7. The number of values of k for which the system of equations
 $(k+1)x + 8y = 4k$
 $kx + (k+3)y = 3k-1$
 has infinitely many solutions is
- (A) 0 (B) 1
(C) 2 (D) infinite

Ans: Here $\Delta = 0$ for $k = 3, 1$, $\Delta_x = 0$ for $k = 2, 1$, $\Delta_y = 0$ for $k = 1$.
 Hence $k = 1$. Alternatively, for infinitely many solutions the two equations become identical
 $\Rightarrow \frac{k+1}{k} = \frac{8}{k+3} = \frac{4k}{3k-1} \Rightarrow k = 1$

8. The set of all real numbers x for which $x^2 - |x+2| + x > 0$, is
- (A) $(-\infty, -2) \cup (2, \infty)$ (B) $(-\infty, -\sqrt{2}) \cup (\sqrt{2}, \infty)$
 (C) $(-\infty, -1) \cup (1, \infty)$ (D) $(\sqrt{2}, \infty)$

Ans: For $x \geq -2$, $x^2 - x - 2 + x > 0 \Rightarrow x^2 > 2 \Rightarrow x \in (-\infty, -\sqrt{2}) \cup (\sqrt{2}, \infty)$
 $\Rightarrow x \in [-2, -\sqrt{2}) \cup (\sqrt{2}, \infty)$
 For $x < -2$, $x^2 + x + 2 + x > 0$ or $x^2 + 2x + 2 > 0$ which is true for all x .
 Hence $x \in (-\infty, -\sqrt{2}) \cup (\sqrt{2}, \infty)$.

9. The length of a longest interval in which the function $3 \sin x - 4 \sin^3 x$ is increasing, is
- (A) $\pi/3$ (B) $\pi/2$
(C) $3\pi/2$ (D) π

Ans: $3 \sin x - 4 \sin^3 x = \sin 3x$ which increases for $3x \in (-\pi/2, \pi/2)$
 $\Rightarrow x \in (-\pi/6, \pi/6)$ whose length is $\pi/3$.

10. Which of the following pieces of data does **NOT** uniquely determine an acute-angled triangle ABC (R being the radius of the circumcircle)?
- (A) $a, \sin A, \sin B$ (B) a, b, c
(C) $a, \sin B, R$ (D) $a, \sin A, R$

Ans: With a, b, c given, the angles are obtained uniquely by the cosine rule.
 By sine rule $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = 2R$,
 we find that $a, \sin A, R$ do not fix the triangle uniquely.

11. The number of integral values of k for which the equation $7 \cos x + 5 \sin x = 2k + 1$ has a solution is
- (A) 4 (B) 8
(C) 10 (D) 12

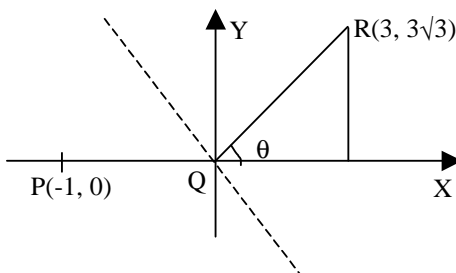
Ans: $-\sqrt{74} \leq 2k + 1 \leq \sqrt{74} \Rightarrow -8 \leq 2k + 1 \leq 8 \Rightarrow k$ can take 8 integral values.

12. Let $0 < \alpha < \pi/2$ be a fixed angle. If $P = (\cos \theta, \sin \theta)$ and $Q = (\cos (\alpha-\theta), \sin (\alpha-\theta))$ then Q is obtained from P by
 (A) clockwise rotation around origin through an angle α
 (B) anticlockwise rotation around origin through an angle α
 (C) reflection in the line through origin with slope $\tan \alpha$
 (D) reflection in the line through origin with slope $\tan(\alpha/2)$

Ans: Clearly Q is the mirror reflection of P in the line $y = \tan (\alpha/2) x$.

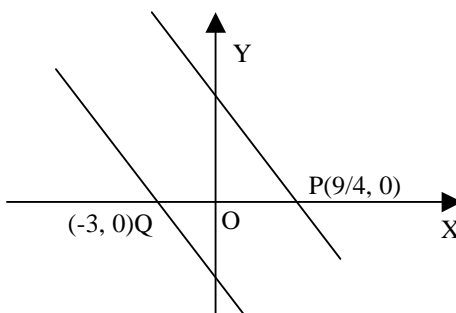
13. Let $P = (-1, 0)$, $Q = (0, 0)$ and $R = (3, 3\sqrt{3})$ be three points. Then the equation of the bisector of the angle PQR is
 (A) $(\sqrt{3}/2)x + y = 0$ (B) $x + \sqrt{3} y = 0$
 (C) $\sqrt{3}x + y = 0$ (D) $x + (\sqrt{3}/2)y = 0$

Ans: $\tan \theta = \sqrt{3} \Rightarrow \theta = 60^\circ$
 $\Rightarrow \angle PQR = 120^\circ$
 \Rightarrow bisector will have slope $\tan 120^\circ$
 \Rightarrow equation of bisector is $\sqrt{3}x + y = 0$.



14. A straight line through the origin O meets the parallel lines $4x + 2y = 9$ and $2x + y + 6 = 0$ at points P and Q respectively. Then the point O divides the segment PQ in the ratio
 (A) 1 : 2 (B) 3 : 4
 (C) 2 : 1 (D) 4 : 3

Ans: $\frac{OP}{OQ} = \frac{9}{4 \times 3} = \frac{3}{4}$



15. If the tangent at the point P on the circle $x^2 + y^2 + 6x + 6y = 2$ meets the straight line $5x - 2y + 6 = 0$ at a point Q on the y-axis, then the length of PQ is
 (A) 4 (B) $2\sqrt{5}$
 (C) 5 (D) $3\sqrt{5}$

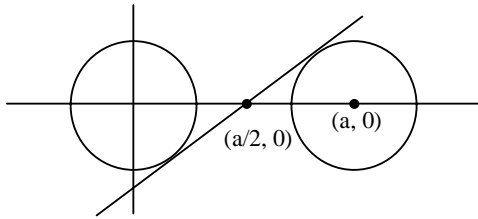
Ans: Co-ordinates of Q $\equiv (0, 3)$

PQ will be length of the tangent $= \sqrt{0^2 + 3^2 + 0 + 6 \times 3 - 2} = \sqrt{25} = 5$

16. If $a > 2b > 0$ then the positive value of m for which $y = mx - b\sqrt{1+m^2}$ is a common tangent to $x^2 + y^2 = b^2$ and $(x-a)^2 + y^2 = b^2$ is
 (A) $\frac{2b}{\sqrt{a^2 - 4b^2}}$ (B) $\frac{\sqrt{a^2 - 4b^2}}{2b}$
 (C) $\frac{2b}{a - 2b}$ (D) $\frac{b}{a - 2b}$

Ans: Clearly line $y = mx - b\sqrt{1+m^2}$ will pass from point $(a/2, 0)$ (mid-point of the centres of the circles)

$\Rightarrow m = \frac{2b}{\sqrt{a^2 - 4b^2}}$

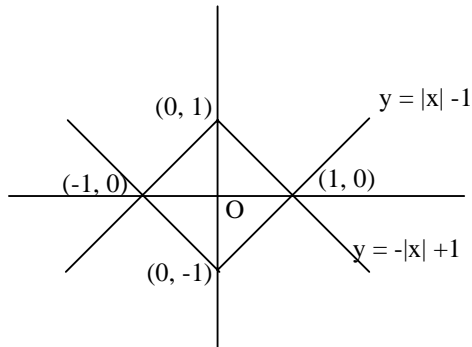


17. The locus of the mid-point of the line segment joining the focus to a moving point on the parabola $y^2 = 4ax$ is another parabola with directrix
 (A) $x = -a$ (B) $x = -a/2$
 (C) $x = 0$ (D) $x = a/2$

Ans: Let (α, β) be the mid-point of the line joining $(a, 0)$ and $(at^2, 2at)$
 $\Rightarrow 2\alpha = a(1 + t^2)$ and $2\beta = 2at$
 \therefore locus will be $y^2 = 2a(x - a/2)$
 \therefore equation of directrix is $x - (a/2) = -a/2 \Rightarrow x = 0$.

18. The area bounded by the curves $y = |x| - 1$ and $y = -|x| + 1$ is
 (A) 1 (B) 2
 (C) $2\sqrt{2}$ (D) 4

Ans: Required area = $(1/2) \times 2 \times 2$ sq. units



19. Suppose $f(x) = (x + 1)^2$ for $x \geq -1$. If $g(x)$ is the function whose graph is the reflection of the graph of $f(x)$ with respect to the line $y = x$, then $g(x)$ equals
 (A) $-\sqrt{x} - 1, x \geq 0$ (B) $\frac{1}{(x+1)^2}, x > -1$
 (C) $\sqrt{x+1}, x > -1$ (D) $\sqrt{x} - 1, x \geq 0$

Ans: Clearly $g(x)$ will be inverse of $f(x)$
 $\Rightarrow g(x) = \sqrt{x} - 1$

20. Let function $f: \mathbb{R} \rightarrow \mathbb{R}$ be defined by $f(x) = 2x + \sin x$ for $x \in \mathbb{R}$. then f is
 (A) one-to-one and onto (B) one-to-one but NOT onto
 (C) onto but NOT one-to-one (D) neither one-to-one nor onto

Ans: $f'(x) = 2 + \cos x > 0 \quad \forall x \in \mathbb{R}$. Also $f(x)$ tends to ∞ as $x \rightarrow \infty$ and $f(x) \rightarrow -\infty$ as $x \rightarrow -\infty$. Thus $f(x)$ is one-one and onto.

21. The domain of the derivative of the function

$$f(x) = \begin{cases} \tan^{-1} x & \text{if } |x| \leq 1 \\ \frac{1}{2}(|x| - 1) & \text{if } |x| > 1 \end{cases} \text{ is}$$

- (A) $\mathbb{R} - \{0\}$ (B) $\mathbb{R} - \{1\}$
 (C) $\mathbb{R} - \{-1\}$ (D) $\mathbb{R} - \{-1, 1\}$

Ans: $f(x)$ is discontinuous at $x = 1, -1$, hence non-differentiable

22. The integer n for which $\lim_{x \rightarrow 0} \frac{(\cos x - 1)(\cos x - e^x)}{x^n}$ is a finite non zero number is
- (A) 1 (B) 2
(C) 3 (D) 4

Ans:
$$\lim_{x \rightarrow 0} \frac{(\cos x - 1)(\cos x - e^x)}{x^n} = \lim_{x \rightarrow 0} \frac{2\sin^2(x/2)(e^x - 1 + 1 - \cos x)}{x^n}$$

$$= \lim_{x \rightarrow 0} \frac{2\sin^2(x/2)(e^x - 1 + 2\sin^2 x/2)}{x^n} = \lim_{x \rightarrow 0} \frac{1}{2} \left(\frac{\sin x/2}{x/2} \right)^2 \frac{(e^x - 1 + 2\sin^2 x/2)}{x^{n-2}}$$

It is non-zero if $n - 2 = 1 \Rightarrow n = 3$.

Alternate:

$$\lim_{x \rightarrow 0} \frac{(\cos x - 1)(\cos x - e^x)}{x^n} = \lim_{x \rightarrow 0} \frac{\left(-\frac{x^2}{2!} + \frac{x^4}{4!} + \dots \right) \left(-x - x^2 + \dots \right)}{x^n}$$

$\Rightarrow n = 3$.

23. Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be such that $f(1) = 3$ and $f'(1) = 6$.

Then $\lim_{x \rightarrow 0} \left(\frac{f(1+x)}{f(1)} \right)^{1/x}$ equals

- (A) 1 (B) $e^{1/2}$
(C) e^2 (D) e^3

Ans:
$$\lim_{x \rightarrow 0} \left(\frac{f(1+x)}{f(1)} \right)^{1/x} = e^{\lim_{x \rightarrow 0} \frac{1}{x} \left(\frac{f(1+x) - f(1)}{f(1)} \right)} = e^{\frac{f'(1)}{f(1)}} = e^2$$

24. The point(s) on the curve $y^3 + 3x^2 = 12y$ where the tangent is vertical, is (are)

- (A) $\left(\pm \frac{4}{\sqrt{3}}, -2 \right)$ (B) $\left(\pm \sqrt{\frac{11}{3}}, 1 \right)$
(C) $(0, 0)$ (D) $\left(\pm \frac{4}{\sqrt{3}}, 2 \right)$

Ans: $y^3 + 3x^2 = 12y$

$$\Rightarrow \frac{dy}{dx} = \frac{6x}{3(4 - y^2)}$$

For vertical tangents,

$y = \pm 2$. But for $y = -2$, we get x^2 to be negative. For $y = 2$, $x^2 = 16/3$.

Hence points are $\left(\pm \frac{4}{\sqrt{3}}, 2 \right)$

25. The equation of the common tangent to the curves $y^2 = 8x$ and $xy = -1$ is

- (A) $3y = 9x + 2$ (B) $y = 2x + 1$
(C) $2y = x + 8$ (D) $y = x + 2$

Ans: Any tangent to $y^2 = 8x$ is $y = mx + 2/m$. It will also touch $xy = -1$ if $x(mx + 2/m) = -1$ has equal roots. $\Rightarrow 4/m^2 = 4m \Rightarrow m = 1$.
Hence tangent is $y = x + 2$.

26. Let $f(x) = \int_1^x \sqrt{2 - t^2} dt$.

Then the real roots of the equation $x^2 - f'(x) = 0$ are

- (A) ± 1 (B) $\pm 1/\sqrt{2}$
(C) $\pm 1/2$ (D) 0 and 1

Ans: $f'(x) = \sqrt{2-x^2}$; $x^2 = f'(x) \Rightarrow x^4 = 2 - x^2 \Rightarrow x^2 = 1 \Rightarrow x = 1, -1$

27. Let $T > 0$ be a fixed real number. Suppose f is a continuous function such that for all $x \in \mathbb{R}$,

$f(x+T) = f(x)$. If $I = \int_0^T f(x) dx$ then the value of $\int_3^{3+3T} f(2x) dx$ is

- (A) $(3/2) I$ (B) $2 I$
(C) $3 I$ (D) $6 I$

Ans: $\int_3^{3+3T} f(2x) dx = \int_6^{6+6T} f(t) \frac{dt}{2} = \frac{1}{2} \int_6^{6+6T} f(t) dt = 3 \int_0^T f(t) dt = 3I$

28. The integral $\int_{-1/2}^{1/2} \left([x] + \ln \left(\frac{1+x}{1-x} \right) \right) dx$ equals to

- (A) $-1/2$ (B) 0
(C) 1 (D) $2 \ln(1/2)$

Ans: $\int_{-1/2}^{1/2} \left([x] + \ln \left(\frac{1+x}{1-x} \right) \right) dx = \int_{-1/2}^{1/2} ([x]) dx = -\frac{1}{2}$

29. If \vec{a} and \vec{b} are two unit vectors such that $\vec{a} + 2\vec{b}$ and $5\vec{a} - 4\vec{b}$ are perpendicular to each other then the angle between \vec{a} and \vec{b} is

- (A) 45° (B) 60°
(C) $\cos^{-1}(1/3)$ (D) $\cos^{-1}(2/7)$

Ans: We have $(\vec{a} + 2\vec{b}) \cdot (5\vec{a} - 4\vec{b}) = 0$

$$\Rightarrow 5|\vec{a}|^2 - 8|\vec{b}|^2 + 6\vec{a} \cdot \vec{b} = 0$$

$$\Rightarrow \vec{a} \cdot \vec{b} = \frac{1}{2}$$

$$\Rightarrow \cos \theta = 1/2 \Rightarrow \theta = \pi/3.$$

30. Let $\vec{V} = 2\vec{i} + \vec{j} - \vec{k}$ and $\vec{W} = \vec{i} + 3\vec{k}$. If \vec{U} is a unit vector, then the maximum value of the scalar triple product $[\vec{U} \vec{V} \vec{W}]$ is

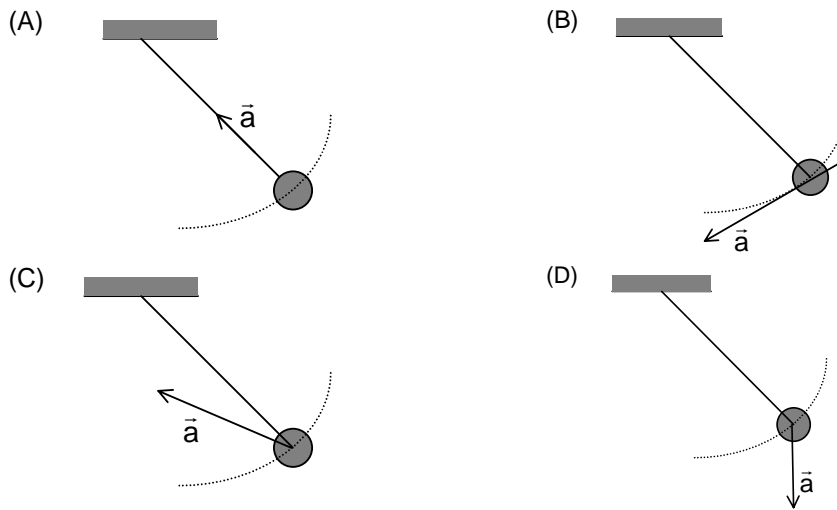
- (A) -1 (B) $\sqrt{10} + \sqrt{6}$
(C) $\sqrt{59}$ (D) $\sqrt{60}$

Ans: $[\vec{U} \vec{V} \vec{W}] = \vec{U} \cdot (\vec{V} \times \vec{W}) \leq |\vec{U}| |\vec{V} \times \vec{W}| = |\vec{V} \times \vec{W}|$

$$\text{Now } \vec{V} \times \vec{W} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 1 & -1 \\ 1 & 0 & 3 \end{vmatrix} = 3\hat{i} - 7\hat{j} - \hat{k} \Rightarrow |\vec{V} \times \vec{W}| = \sqrt{59}$$

$$\Rightarrow [\vec{U} \vec{V} \vec{W}] \leq \sqrt{59}$$

31. A simple pendulum is oscillating without damping. When the displacement of the bob is less than maximum, its acceleration vector \vec{a} is correctly shown in :

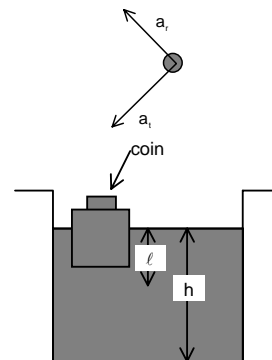


The components of acceleration are as shown.

Ans: $\vec{a} = \vec{a}_r + \vec{a}_t$

32. A wooden block, with a coin placed on its top, floats in water as shown in figure. The distance ℓ and h are shown there. After some time the coin falls into the water. Then

- (A) ℓ decreases and h increases
 (B) ℓ increases and h decreases
 (C) both ℓ and h increase
 (D) both ℓ and h decrease



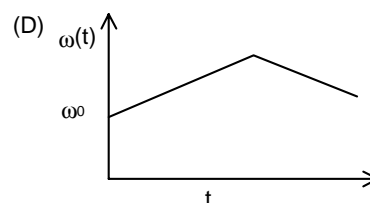
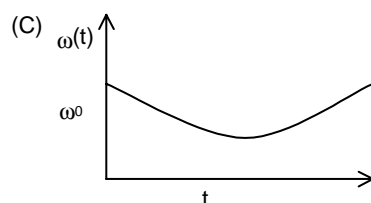
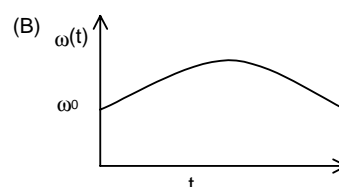
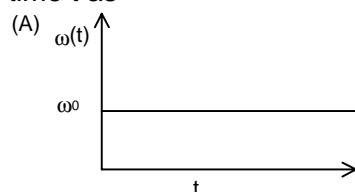
Ans: ℓ decreases as the block moves up. h will also decrease because when the coin is in the water it will displace equal volume of water, whereas when it is on the block an equal weight of water is displaced.

33. A cylinder rolls up an inclined plane, reaches some height, and then rolls down (without slipping throughout these motions). The directions of the frictional force acting on the cylinder are:

- (A) up the incline while ascending and down the incline descending.
 (B) up the incline while ascending as well as descending.
 (C) down the incline while ascending and up the incline while descending.
 (D) down the incline while ascending as well as descending.

Ans: Torque due to friction has the same sense as the angular acceleration.

34. A circular platform is free to rotate in a horizontal plane about a vertical axis passing through its centre. A tortoise is sitting at the edge of the platform. Now, the platform is given an angular velocity ω_0 . When the tortoise move along a chord of the platform with a constant velocity (with respect to the platform), the angular velocity of the platform $\omega(t)$ will vary with time t as



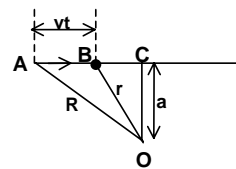
Ans: Since there is no external torque, angular momentum remains conserved. As moment of inertia initially decreases and then increases, so ω will increase initially and then decrease.

Moment of inertia when tortoise is at B,

$$I = mr^2 + \frac{MR^2}{2}; \text{ where } r^2 = a^2 + [\sqrt{R^2 - a^2} - vt]^2$$

m = mass of tortoise; M = mass of disc

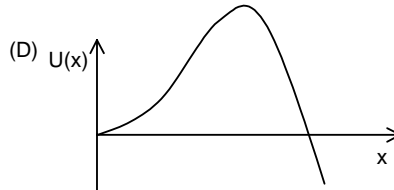
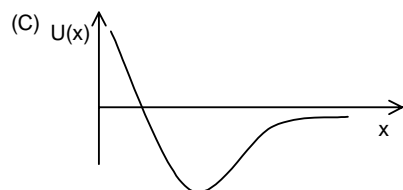
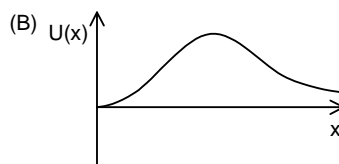
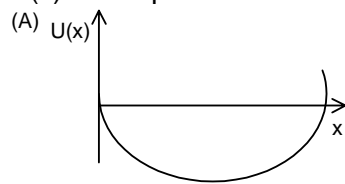
\therefore So the variation of ω is nonlinear.



35. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of 14 m/s to the heavier block in the direction of the lighter block. The velocity of the centre of mass is
 (A) 30 m/s (B) 20 m/s
 (C) 10 m/s (D) 5 m/s

Ans: $v_c = \frac{10 \times 14 + 4 \times 0}{10 + 4} = 10 \text{ m/s}$; since spring force is internal force.

36. A particle, which is constrained to move along the x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here k and a are positive constants. For $x \geq 0$, the functional form of the potential energy $U(x)$ of the particle is



Ans: $dU_{(x)} = -Fdx$

$$\therefore U_{(x)} = - \int_0^x Fdx = \frac{kx^2}{2} - \frac{ax^4}{4}$$

$U=0$ at $x=0$ and at $x = \sqrt{\frac{2k}{a}}$; also at $x=0$, F is zero.

37. A siren placed at a railway platform is emitting sound of frequency 5 kHz. A passenger sitting in a moving train A records a frequency of 5.5 kHz while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of the velocity of train B to that train A is
 (A) 242/252 (B) 2
 (C) 5/6 (D) 11/6

Ans: $\frac{v_A + v}{v} = \frac{5.5}{5}$ and $\frac{v_B + v}{v} = \frac{6}{5} \Rightarrow \frac{v_B}{v_A} = 2$

38. A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9 kg is suspended from the wire. When this mass is replaced by a mass M , the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The value of M is
 (A) 25 kg (B) 5 kg
 (C) 12.5 kg (D) 1/25 kg

Ans: $f_o = \frac{5}{2\ell} \sqrt{\frac{9g}{\mu}} = \frac{3}{2\ell} \sqrt{\frac{Mg}{\mu}} \Rightarrow M = 25\text{kg}$

39. An ideal spring with spring-constant k is hung from the ceiling and a block of mass M is attached to its lower end. The mass is released with the spring initially unstretched. Then the maximum extension in the spring is

- (A) $\frac{4Mg}{k}$ (B) $\frac{2Mg}{k}$
(C) $\frac{Mg}{k}$ (D) $\frac{Mg}{2k}$

Ans: From Work-energy theorem; $W_g + W_s = 0 \Rightarrow mgx - (1/2)kx^2 = 0 \Rightarrow x = 2mg/k$

40. A geo-stationary satellite orbits around the earth in a circular orbit of radius 36000km. Then, the time period of a spy satellite orbiting a few hundred km above the earth's surface ($R_{\text{earth}} = 6400\text{km}$) will approximately be

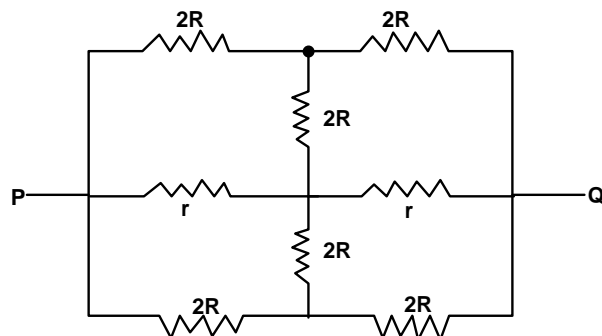
- (A) $\frac{1}{2}$ hr. (B) 1hr
(C) 2hr (D) 4hr

Ans: $T^2 \propto R^3$; with $R_e = 6400$ km,
 $\frac{T^2}{(24)^2} = \left(\frac{6400}{36000}\right)^3 \Rightarrow T \approx 1.7\text{hr}$

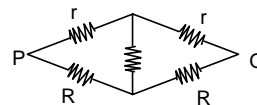
For spy satellite R is slightly greater than $R_e \Rightarrow T_s > T, \therefore T_s = 2\text{hr}$

41. The effective resistance between points P and Q of the electrical circuit shown in the figure is

- (A) $\frac{2Rr}{R+r}$
(B) $\frac{8R(R+r)}{3R+r}$
(C) $2r + 4R$
(D) $\frac{5R}{2} + 2r$



Ans: The circuit can be reduced to the following balanced Wheatstone bridge



42. A particle of mass m and charge q moves with a constant velocity v along the positive x direction. It enters a region containing a uniform magnetic field B directed along the negative z direction, extending from $x = a$ to $x = b$. The minimum value of v required so that the particle can just enter the region $x > b$ is

- (A) $\frac{qbB}{m}$ (B) $\frac{q(b-a)B}{m}$
(C) $\frac{qaB}{m}$ (D) $\frac{q(b+a)B}{2m}$

Ans: Width of the magnetic field region $(b - a) \leq R$; where ' R ' is its radius of curvature inside magnetic field.

$$\therefore R = \frac{mv}{qB} = (b - a)$$

$$\Rightarrow v = \frac{(b - a)qB}{m}$$

43. Two equal point charges are fixed at $x = -a$ and $x = +a$ on the x-axis. Another point charge Q is placed at the origin. The change in the electrical potential energy of Q , when it is displaced by a small distance x along the x-axis, is approximately proportional to
 (A) x (B) x^2
 (C) x^3 (D) $\frac{1}{x}$

Ans: $U_i = \frac{2Qq}{4\pi\epsilon_0(a)}; U_f = \frac{2Qq}{4\pi\epsilon_0(a)}$
 $\therefore \Delta U = U_i - U_f = (Qqx^2)/(2\pi\epsilon_0 a^3); \text{ (for } x \ll a \text{)}$

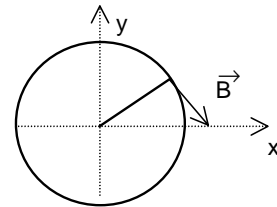
44. A long straight wire along the z-axis carries a current I in the negative z direction. The magnetic vector field \vec{B} at a point having coordinates (x, y) in the $z = 0$ plane is

- (A) $\frac{\mu_0 I}{2\pi} \frac{(y\hat{i} - x\hat{j})}{(x^2 + y^2)}$ (B) $\frac{\mu_0 I}{2\pi} \frac{(x\hat{i} + y\hat{j})}{(x^2 + y^2)}$
 (C) $\frac{\mu_0 I}{2\pi} \frac{(x\hat{j} - y\hat{i})}{(x^2 + y^2)}$ (D) $\frac{\mu_0 I}{2\pi} \frac{(x\hat{i} - y\hat{j})}{(x^2 + y^2)}$

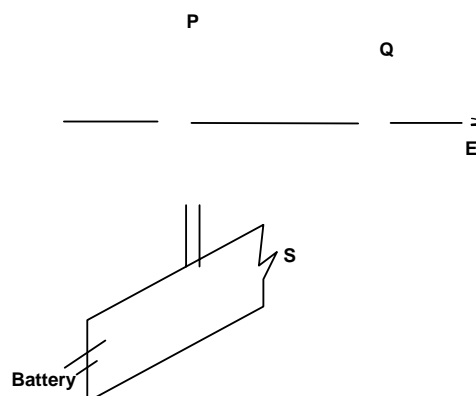
Ans : Magnetic field $|\vec{B}| = \frac{\mu_0 I}{2\pi\sqrt{x^2 + y^2}};$

Unit vector perpendicular to the position vector is
 $\frac{(y\hat{i} - x\hat{j})}{\sqrt{x^2 + y^2}}$

$\therefore \vec{B} = \frac{\mu_0 I}{2\pi(x^2 + y^2)} (y\hat{i} - x\hat{j})$

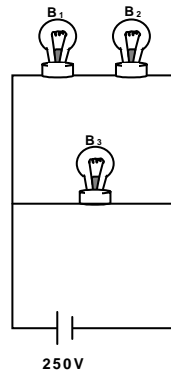


45. As shown in the figure, P and Q are two coaxial conducting loops separated by some distance. When the switch S is closed, a clockwise current I_P flows in P (as seen by E) and an induced current I_{Q1} flows in Q. The switch remains closed for a long time. When S is opened, a current I_{Q2} flows in Q. Then the direction I_{Q1} and I_{Q2} (as seen by E) are:
 (A) respectively clockwise and anti-clockwise.
 (B) both clockwise.
 (C) both anti-clockwise.
 (D) respectively anti-clockwise and clockwise.



Ans: Apply Lenz's law

46. A 100W bulb B_1 , and two 60W bulbs B_2 and B_3 , are connected to a 250V source, as shown in the figure. Now W_1 , W_2 and W_3 are the output powers of the bulbs B_1 , B_2 and B_3 , respectively. Then
- (A) $W_1 > W_2 = W_3$
 (B) $W_1 > W_2 > W_3$
 (C) $W_1 < W_2 = W_3$
 (D) $W_1 < W_2 < W_3$



Ans : $R_1 = \frac{V^2}{100}$; $R_2 = \frac{V^2}{60} = R_3$

$$\therefore W_3 = \frac{(250)^2}{R_1}; W_2 = \frac{(250)^2}{(R_1 + R_2)^2} R_2; W_1 = \frac{(250)^2}{(R_1 + R_2)^2} R_1$$

$$W_3 : W_2 : W_1 = 64 : 25 : 15$$

47. Two identical capacitors, have the same capacitance C . One of them is charged to potential V_1 and the other to V_2 . The negative ends of the capacitors are connected together. When the positive ends are also connected, the decrease in energy of the combined system is

(A) $\frac{1}{4}C(V_1^2 - V_2^2)$

(B) $\frac{1}{4}C(V_1^2 + V_2^2)$

(C) $\frac{1}{4}C(V_1 - V_2)^2$

(D) $\frac{1}{4}C(V_1 + V_2)^2$

Ans: $\Delta U = \text{Initial Energy} - \text{Final energy}$

$$= \frac{1}{2}C(V_1^2 + V_2^2) - \frac{1}{2}(2C)\left(\frac{V_1 + V_2}{2}\right)^2 = \frac{1}{4}C(V_1 - V_2)^2$$

48. A short-circuited coil is placed in a time-varying magnetic field. Electrical power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled and the wire radius halved, the electrical power dissipated would be

(A) halved

(B) the same.

(C) doubled

(D) quadrupled

Ans : $P = \frac{\epsilon^2}{R}$; where $\epsilon = \text{induced emf} = -\frac{d\phi}{dt}$

$$\Rightarrow \phi = NBA; \epsilon = -NA \frac{dB}{dt}$$

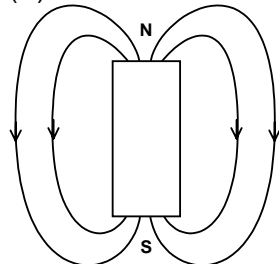
also $R \propto \frac{\ell}{r^2}$

$R = \text{Resistance and } r = \text{radius of the wire.}$

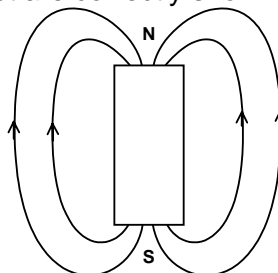
$$\Rightarrow P \propto \frac{N^2 r^2}{\ell} \Rightarrow \frac{P_1}{P_2} = 1$$

49. The magnetic field lines due to a bar magnet are correctly shown in

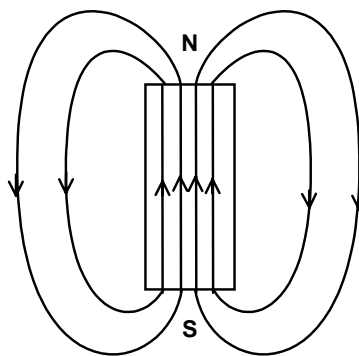
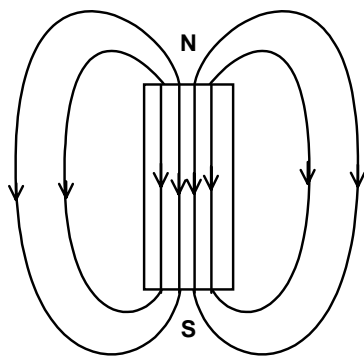
(A)



(C)



(D)

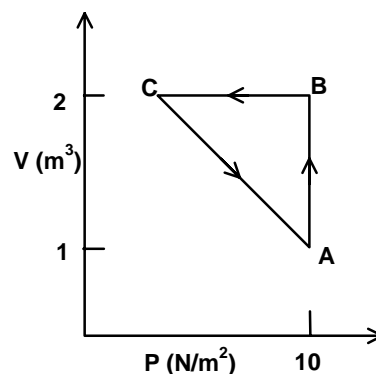


Ans: Magnetic lines of force form closed loops. Inside magnet, these are directed from south to north pole.

50. An ideal gas is taken through the cycle $A \rightarrow B \rightarrow C \rightarrow A$, as shown in the figure. If the net heat supplied to the gas in the cycle is 5J, the work done by the gas in the process $C \rightarrow A$ is

(A) -5J
(C) -15J

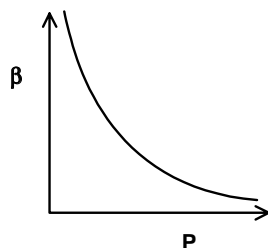
(B) -10J
(D) -20J



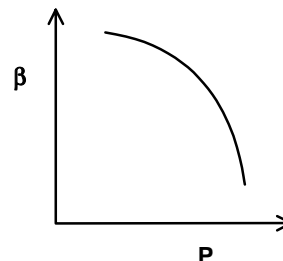
Ans: For cyclic process; $Q_{\text{cyclic}} = W_{AB} + W_{BC} + W_{CA} = 10\text{J} + 0 + W_{CA} = 5\text{J}$

51. Which of the following graphs correctly represents the variation of $\beta = -\frac{dV/dP}{V}$ with P for an ideal gas at constant temperature?

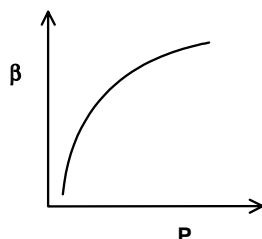
(A)



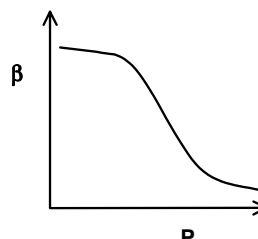
(B)



(C)



(D)



Ans: $PV = \text{Const.}$ differentiating, $PdV/dP = -V/P$; $\beta = -(1/V)(dV/dP) = (1/P)$

52. The potential difference applied to an X-ray tube is 5kV and the current through it is 3.2mA. Then the number of electrons striking the target per second is

(A) 2×10^{16}

(B) 5×10^6

(C) 1×10^{17}

(D) 4×10^{15}

Ans: No. of electrons striking the target per second $= i/e = 2 \times 10^{16}$.

53. An ideal black - body at room temperature is thrown into a furnace. It is observed that

(A) initially it is the darkest body and at later times the brightest.

(B) it is the darkest body at all times.

- (C) it cannot be distinguished at all times.
 (D) initially it is the darkest body and at later times it cannot be distinguished.

Ans: Black body is the brightest object at a given temperature.

54. A Hydrogen atom and a Li^{++} ion are both in the second excited state. If ℓ_H and ℓ_{Li} are their respective electronic angular momenta, and E_H and E_{Li} their respective energies, then

- (A) $\ell_H > \ell_{\text{Li}}$ and $|E_H| > |E_{\text{Li}}|$ (B) $\ell_H = \ell_{\text{Li}}$ and $|E_H| < |E_{\text{Li}}|$
 (C) $\ell_H = \ell_{\text{Li}}$ and $|E_H| > |E_{\text{Li}}|$ (D) $\ell_H < \ell_{\text{Li}}$ and $|E_H| < |E_{\text{Li}}|$

Ans: $L = nh/2\pi$, $|E| = Z^2 R h c / n^2$; $n = 3 \Rightarrow L_H = L_{\text{Li}}$ and $|E_H| < |E_{\text{Li}}|$.

55. The half-life of ^{215}At is $100\mu\text{s}$. The time taken for the radioactivity of a sample of ^{215}At to decay to $\frac{1}{16}$ th of its initial value is

- (A) $400\mu\text{s}$ (B) $6.3\mu\text{s}$
 (C) $40\mu\text{s}$ (D) $300\mu\text{s}$

Ans: $A = A_0 (1/2)^n$ n = no. of half lives.

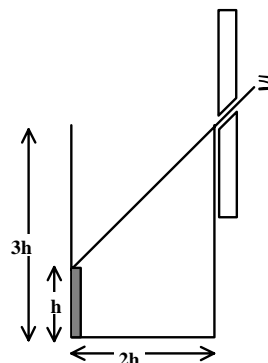
56. Which of the following processes represents a γ -decay?

- (A) ${}^A\text{X}_Z + \gamma \longrightarrow {}^A\text{X}_{Z-1} + a + b$. (B) ${}^A\text{X}_Z + {}^1_0\text{n} \longrightarrow {}^{A-3}\text{X}_{Z-2} + c$
 (C) ${}^A\text{X}_Z \longrightarrow {}^A\text{X}_Z + f$. (D) ${}^A\text{X}_Z + e_{-1} \longrightarrow {}^A\text{X}_{Z-1} + g$.

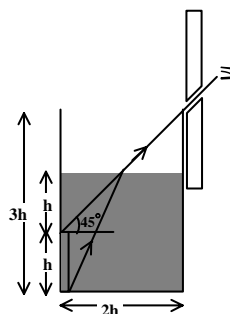
Ans: In γ -decay, the atomic number and mass number does not change.

57. An observer can see through a pin-hole the top end of a thin rod of height h , placed as shown in the figure. The beaker height is $3h$ and its radius h . When the beaker is filled with a liquid up to a height $2h$, he can see the lower end of the rod. Then the refractive index of the liquid is

- (A) $\frac{5}{2}$ (B) $\sqrt{\frac{5}{2}}$
 (C) $\sqrt{\frac{3}{2}}$ (D) $\frac{3}{2}$

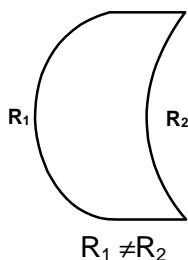


Ans: $\sin i / \sin r = 1/\mu$; $r = 45^\circ$;
 $\sin i = 1/\sqrt{5} \Rightarrow \mu = (5/2)^{1/2}$.



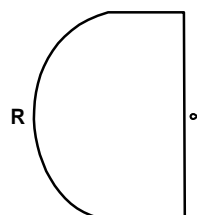
58. Which one of the following spherical lenses does not exhibit dispersion? The radii of curvature of the surfaces of the lenses are as given in the diagrams.

(A)

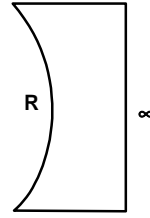
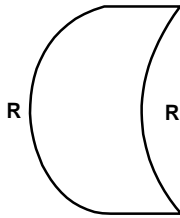


(C)

(B)



(D)



Ans : $\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right) \quad \dots(1)$

For no dispersion; $d\left(\frac{1}{f}\right) = 0$

Diff. equation (1);

$d\left(\frac{1}{f}\right) = d\mu \left(\frac{1}{R_1} - \frac{1}{R_2} \right) = 0 \Rightarrow R_1 = R_2$

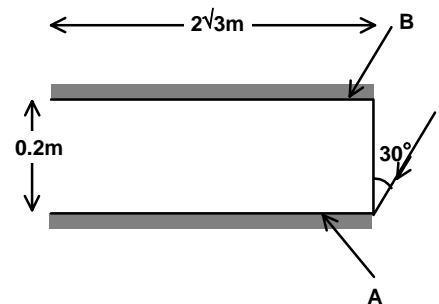
59. In the ideal double-slit experiment, when a glass-plate (refractive index 1.5) of thickness t is introduced in the path of one of the interfering beams (wave-length λ), the intensity at the position where the central maximum occurred previously remains unchanged. The minimum thickness of the glass-plate is

- (A) 2λ (B) $\frac{2\lambda}{3}$
(C) $\frac{\lambda}{3}$ (D) λ

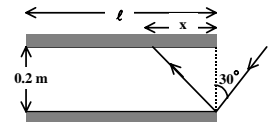
Ans: Path difference $= (\mu - 1)t = n\lambda$; For minimum t , $n = 1$; $\therefore t = 2\lambda$

60. Two plane mirrors A and B are aligned parallel to each other, as shown in the figure. A light ray is incident at an angle 30° at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is

- (A) 28 (B) 30
(C) 32 (D) 34



Ans: Maximum no. of reflections $= [\ell/x]$
where $[]$ represents greatest integer function. where $x = 0.2 \cdot \tan 30^\circ$



61. How many moles of electron weigh one kilogram

- (A) 6.023×10^{23} (B) $\frac{1}{9.108} \times 10^{31}$
(C) $\frac{6.023}{9.108} \times 10^{54}$ (D) $\frac{1}{9.108 \times 6.023} \times 10^8$

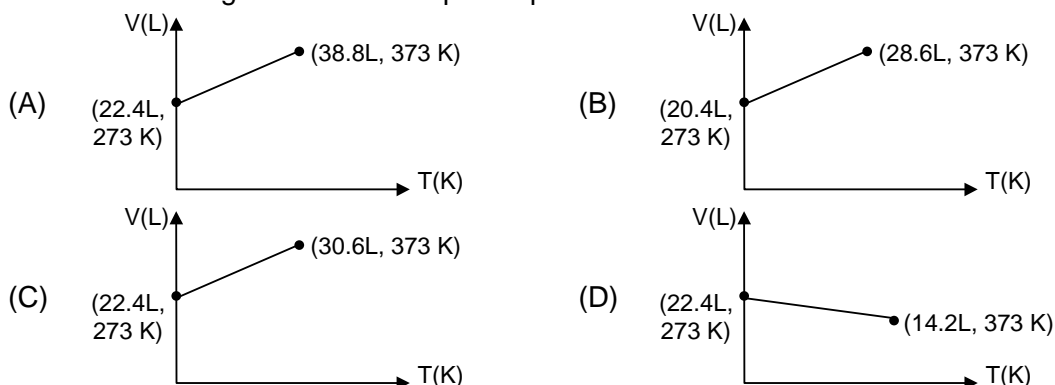
Ans: 1 mole of electron weighs $9.108 \times 10^{-31} \times 6.023 \times 10^{23} \text{ kg}$

So number of moles of electron in 1 Kg is

$$\frac{1}{9.108 \times 10^{-31} \times 6.023 \times 10^{23}}$$

$$= \frac{1}{9.108 \times 6.023} \times 10^8$$

62. Which of the following volume (V) – temperature (T) plots represents the behaviour of one mole of an ideal gas at one atmospheric pressure?



Ans: Volume of 1 mole of an ideal gas at 273K and 1 atm is 22.4 L and that at 373 K and 1 atm pressure is calculated as ;

$$V = \frac{RT}{P} = \frac{0.082 \times 373}{1} = 30.58 \text{ L}$$

63. A substance A_xB_y crystallizes in a face centred cubic (FCC) lattice in which atoms 'A' occupy each corner of the cube and atoms 'B' occupy the centers of each face of the cube. Identify the correct composition of the substance A_xB_y

- (A) AB_3 (B) A_4B_3
(C) A_3B (D) Composition cannot be specified

Ans: Effective number of corner atom i.e. $A = 8 \times 1/8 = 1$
Effective number of face centered atoms $B = 1/2 \times 6 = 3$
Thus, the composition will be AB_3

64. When the temperature is increased, surface tension of water
(A) increases (B) decreases
(C) remains constant (D) shows irregular behaviour

Ans: Upon increase of temperature the internal energy of water or any system increases resulting into decrease in intermolecular force and hence surface tension.

65. Rutherford's experiment, which established the nuclear model of the atom, used a beam of
(A) β -particles, which impinged on a metal foil and got absorbed
(B) γ -rays, which impinged on a metal foil and ejected electrons
(C) helium atoms, which impinged on a metal foil and got scattered
(D) helium nuclei, which impinged on a metal foil and got scattered

Ans: Rutherford's experiment was actually α - particle scattering experiment. α - particle is doubly positively charged helium ion i.e., He – nucleus.

66. If the Nitrogen atom had electronic configuration $1s^7$, it would have energy lower than that of the normal ground state configuration $1s^22s^22p^3$, because the electrons would be closer to the nucleus. Yet $1s^7$ is not observed because it violates.

- (A) Heisenberg uncertainty principle (B) Hund's rule
(C) Pauli exclusion Principle (D) Bohr postulate of stationary orbits

Ans: As per Pauli Exclusion Principle "no two electrons in the same atom can have all the four Quantum numbers equal or an orbital cannot contain more than two electrons and it can accommodate two electrons only when their directions of spins are opposite".

67. Specify the coordination geometry around and hybridisation of N and B atoms in a 1 : 1 complex of BF_3 and NH_3

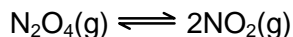
- (A) N : tetrahedral, sp^3 ; B : tetrahedral, sp^3 (B) N : pyramidal, sp^3 ; B : pyramidal, sp^3
(C) N : pyramidal, sp^3 ; B : planar, sp^2 (D) N : pyramidal, sp^3 ; B : tetrahedral, sp^3

Ans: $\text{H}_3\text{N} \rightarrow \text{BF}_3$ where both N, B are attaining tetrahedral geometry.

68. One mole of a non-ideal gas undergoes a change of state (2.0 atm, 3.0 L, 95 K) \rightarrow (4.0 atm, 5.0 L, 245 K) with a change in internal energy, $\Delta U = 30.0 \text{ L atm}$. The change in enthalpy (ΔH) of the process in L atm is
(A) 40.0
(B) 42.3
(C) 44.0
(D) not defined, because pressure is not constant

Ans: $H_2 - H_1 = (U_2 - U_1) + P_2V_2 - P_1V_1 = 30 + 4 \times 5 - 2 \times 3 = 44 \text{ L atm}$

69. Consider the following equilibrium in a closed container:



At a fixed temperature, the volume of the reaction container is halved. For this change, which of the following statements holds true regarding the equilibrium constant (K_p) and degree of dissociation (α)?

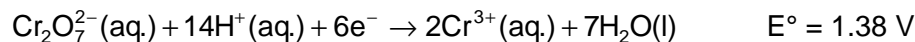
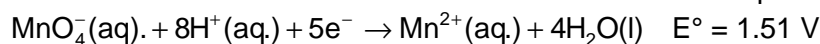
- (A) neither K_p nor α changes
(B) both K_p and α change
(C) K_p changes, but α does not change
(D) K_p does not change, but α changes

Ans: For the equilibria: $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$

$$K_p = K_c \times (RT)^{\Delta n}$$

Since temperature is constant so K_c or K_p will remain constant. Further since volume is halved, the pressure will be doubled so α will decrease so as to maintain the constancy of K_c or K_p .

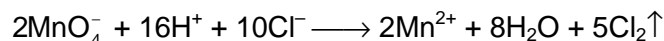
70. Standard electrode potential data are useful for understanding the suitability of an oxidant in a redox titration. Some half cell reactions and their standard potentials are given below:



Identify the only incorrect statement regarding the quantitative estimation of aqueous $\text{Fe}(\text{NO}_3)_2$

- (A) MnO_4^- can be used in aqueous HCl
(B) $\text{Cr}_2\text{O}_7^{2-}$ can be used in aqueous HCl
(C) MnO_4^- can be used in aqueous H_2SO_4
(D) $\text{Cr}_2\text{O}_7^{2-}$ can be used in aqueous H_2SO_4

Ans: MnO_4^- will oxidise Cl^- ion according to the equation



The cell corresponding to this reaction is as follows:



$$E^\circ_{\text{cell}} = 1.51 - 1.40 = 0.11 \text{ V}$$

E°_{cell} being +ve, ΔG° will be -ve and hence the above reaction is feasible.

MnO_4^- will not only oxidise Fe^{2+} ion but also Cl^- ion simultaneously.

71. Consider the chemical reaction, $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$. The rate of this reaction can be expressed in terms of time derivative of concentration of $\text{N}_2(\text{g})$, $\text{H}_2(\text{g})$ or $\text{NH}_3(\text{g})$. Identify the correct relationship amongst the rate expressions.

- (A) Rate = $-\text{d}[\text{N}_2]/\text{dt} = -1/3\text{d}[\text{H}_2]/\text{dt} = 1/2\text{d}[\text{NH}_3]/\text{dt}$
(B) Rate = $-\text{d}[\text{N}_2]/\text{dt} = -3\text{d}[\text{H}_2]/\text{dt} = 2\text{d}[\text{NH}_3]/\text{dt}$
(C) Rate = $\text{d}[\text{N}_2]/\text{dt} = 1/3\text{d}[\text{H}_2]/\text{dt} = 1/2\text{d}[\text{NH}_3]/\text{dt}$
(D) Rate = $-\text{d}[\text{N}_2]/\text{dt} = -\text{d}[\text{H}_2]/\text{dt} = \text{d}[\text{NH}_3]/\text{dt}$

Ans: Individual rates become equal when each of these is divided by their respective stoichiometric coefficient. Further the rate of the consumption of the reactant goes on decreasing and the rate of formation of the product goes on increasing, hence –ve and +ve sign, respectively.

72. Anhydrous ferric chloride is prepared by
 (A) heating hydrated ferric chloride at a high temperature in a stream of air
 (B) heat metallic iron in a stream of dry chlorine gas
 (C) reaction of metallic iron with hydrochloric acid
 (D) reaction of metallic iron with hydrochloric acid

Ans: $2\text{Fe} + 3\text{Cl}_2 \rightarrow 2\text{FeCl}_3$

73. Identify the correct order of solubility of Na_2S , CuS and ZnS in aqueous medium
 (A) $\text{CuS} > \text{ZnS} > \text{Na}_2\text{S}$ (B) $\text{ZnS} > \text{Na}_2\text{S} > \text{CuS}$
 (C) $\text{Na}_2\text{S} > \text{CuS} > \text{ZnS}$ (D) $\text{Na}_2\text{S} > \text{ZnS} > \text{CuS}$

Ans: Na salts are highly soluble

74. Which of the following process is used in the extractive metallurgy of magnesium?
 (A) fused salt electrolysis (B) self reduction
 (C) aqueous solution electrolysis (D) thermite reduction

Ans: $\text{MgCl}_2 \rightarrow \text{Mg}^{+2} + 2\text{Cl}^-$
 At cathode: $\text{Mg}^{+2} + 2\text{e}^- \rightarrow \text{Mg}$;
 At anode: $2\text{Cl}^- - 2\text{e}^- \rightarrow \text{Cl}_2\uparrow$

75. An aqueous solution of substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulfide is passed through the hot acidic solution, a black precipitate is obtained. The substance is a
 (A) Hg_2^{2+} salt (B) Cu^{2+} salt
 (C) Ag^+ salt (D) Pb^{2+} salt

Ans: $\text{Pb}^{+2} + 2\text{HCl} \longrightarrow \underset{\substack{\text{White ppt.} \\ \text{dissolves on} \\ \text{boiling}}}{\text{PbCl}_2\downarrow} \xrightarrow{\text{H}_2\text{S}} \underset{\text{Black ppt.}}{\text{PbS}\downarrow}$

76. A gas 'X' is passed through water to form a saturated solution. The aqueous solution on treatment with silver nitrate gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with evolution of a colourless gas 'Y'. Identify 'X' and 'Y'.
 (A) $\text{X} = \text{CO}_2$, $\text{Y} = \text{Cl}_2$ (B) $\text{X} = \text{Cl}_2$, $\text{Y} = \text{CO}_2$
 (C) $\text{X} = \text{Cl}_2$, $\text{Y} = \text{H}_2$ (D) $\text{X} = \text{H}_2$, $\text{Y} = \text{Cl}_2$

Ans: $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{HCl}$
 $2\text{HCl} + \text{Mg} \rightarrow \text{MgCl}_2 + \text{H}_2\uparrow$

77. Polyphosphates are used as water softening agents because they
 (A) form soluble complexes with anionic species
 (B) precipitate anionic species
 (C) form soluble complexes with cationic species
 (D) precipitate cationic species

Ans: $2\text{Ca}^{2+} + \text{Na}_2[\text{Na}_4(\text{PO}_3)_6] \longrightarrow 4\text{Na}^+ + \underset{\text{Water soluble}}{\text{Na}_2[\text{Ca}_2(\text{PO}_3)_6]}$

78. Identify the correct order of acidic strengths of CO_2 , CuO , CaO , H_2O
 (A) $\text{CaO} < \text{CuO} < \text{H}_2\text{O} < \text{CO}_2$ (D) $\text{H}_2\text{O} < \text{CuO} < \text{CaO} < \text{CO}_2$
 (C) $\text{CaO} < \text{H}_2\text{O} < \text{CuO} < \text{CO}_2$ (D) $\text{H}_2\text{O} < \text{CO}_2 < \text{CaO} < \text{CuO}$

Ans: Non-metallic oxides are acidic and metallic oxides are basic. Thus the order is $\text{CaO} < \text{CuO} < \text{H}_2\text{O} < \text{CO}_2$.

79. Identify the least stable ion amongst the following:
 (A) Li^- (B) Be^-
 (C) B^- (D) C^-

Ans: Be^- is attaining $2s^2 2p^1$ configuration i.e., losing its fulfilled stability of $2s^2$ configuration.

80. Which of the following molecular species has unpaired electron(s)?
 (A) N_2 (B) F_2
 (C) O_2^- (D) O_2^{2-}

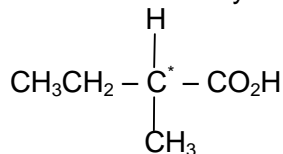
Ans: It contains unpaired electrons in antibonding molecular orbital.

81. The nodal plane in the π -bond of ethene is located in
 (A) the molecular plane
 (B) a plane parallel to the molecular plane
 (C) a plane perpendicular to the molecular plane which bisects the carbon – carbon σ -bond at right angle.
 (D) a plane perpendicular to the molecular plane which contains the carbon – carbon σ -bond.

Ans: The molecular plane does not have any π electron density.

82. Which of the following compounds exhibits stereoisomerism?
 (A) 2-methylbutene-1 (B) 3-methylbutyne-1
 (C) 3-methylbutanoic acid (D) 2-methylbutanoic acid

Ans: It contains one asymmetric centre



83. Which of the following acids has the smallest dissociation constant?
 (A) $\text{CH}_3\text{CHF}\text{COOH}$ (B) $\text{FCH}_2\text{CH}_2\text{COOH}$
 (C) $\text{BrCH}_2\text{CH}_2\text{COOH}$ (D) $\text{CH}_3\text{CHBr}\text{COOH}$

Ans: $\text{BrCH}_2\text{CH}_2\text{CO}_2\text{H}$ is the weakest acid as Br has less – I effect compared to F and is also far from $-\text{CO}_2\text{H}$ group.

84. Consider the following reaction:
 $\text{H}_3\text{C} - \underset{\text{D}}{\text{CH}} - \underset{\text{CH}_3}{\text{CH}} - \text{CH}_3 + \text{Br} \longrightarrow \text{'X'} + \text{HBr}$

Identify the structure of the major product 'X'

- (A) $\text{H}_3\text{C} - \underset{\text{D}}{\text{CH}} - \underset{\text{CH}_3}{\text{CH}} - \text{CH}_2$ (B) $\text{H}_3\text{C} - \underset{\text{D}}{\text{CH}} - \underset{\text{CH}_3}{\text{C}} - \text{CH}_3$
 (C) $\text{H}_3\text{C} - \underset{\text{D}}{\text{C}} - \underset{\text{CH}_3}{\text{CH}} - \text{CH}_3$ (D) $\text{H}_3\text{C} - \text{CH} - \underset{\text{CH}_3}{\text{CH}} - \text{CH}_3$

Ans: Br^\bullet is less reactive, and more selective and so the most stable free radical (3°) will be the major product.

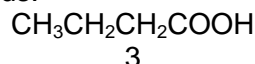
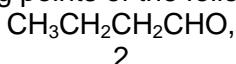
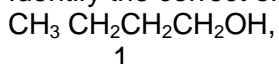
85. Identify the reagent from the following list which can easily distinguish between 1-butyne and 2-butyne

(A) bromine, CCl_4
(C) dilute H_2SO_4 , HgSO_4

(B) H_2 , Lindlar catalyst
(D) ammoniacal Cu_2Cl_2 solution

Ans: 2-butyne will not react with ammoniacal Cu_2Cl_2 .

86. Identify the correct order of boiling points of the following compounds:



(A) $1 > 2 > 3$

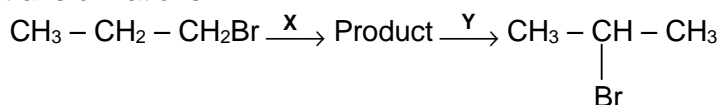
(B) $3 > 1 > 2$

(C) $1 > 3 > 2$

(D) $3 > 2 > 1$

Ans: In carboxylic acid the molecules are more strongly associated.

87. Identify the set of reagent / reaction conditions 'X' and 'Y' in the following set of transformations:



(A) X = dilute aqueous NaOH, 20°C ; Y = HBr/acetic acid, 20°C

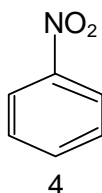
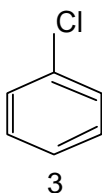
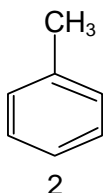
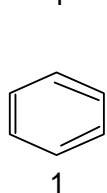
(B) X = concentrated alcoholic NaOH, 80°C ; Y = HBr/acetic acid, 20°C

(C) X = dilute aqueous NaOH, 20°C ; Y = $\text{Br}_2/\text{CHCl}_3$, 0°C

(D) X = concentrated alcoholic NaOH, 80°C ; Y = $\text{Br}_2/\text{CHCl}_3$, 0°C

Ans: Dehydrobromination by strong base alc. NaOH followed by Markownikoff addition of HBr.

88. Identify the correct order of reactivity in electrophilic substitution reactions of the following compounds:



(A) $1 > 2 > 3 > 4$

(B) $4 > 3 > 2 > 1$

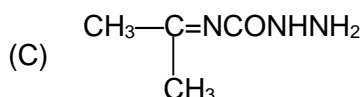
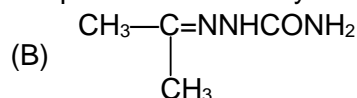
(C) $2 > 1 > 3 > 4$

(D) $2 > 3 > 1 > 4$

Ans: The benzene ring in toluene is activated by the +I as well as hyperconjugation effect of CH_3 group. Cl deactivates the ring as $-I$ effect predominates over +M while $-\text{NO}_2$ group deactivates the ring by $-I$ as well as $-M$ effect.

89. Compound 'A' (molecular formula $\text{C}_3\text{H}_8\text{O}$) is treated with acidified potassium dichromate to form a product 'B' (molecular formula $\text{C}_3\text{H}_6\text{O}$). 'B' forms a shining silver mirror on warming with ammoniacal silver nitrate. 'B' when treated with an aqueous solution of $\text{H}_2\text{NCONHNH}_2 \cdot \text{HCl}$ and sodium acetate gives a product 'C'. Identify the structure of 'C'.

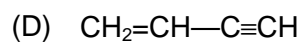
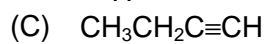
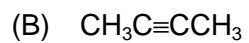
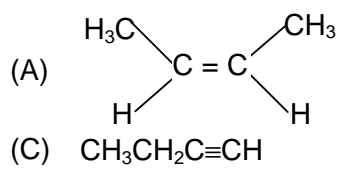
(A) $\text{CH}_3\text{CH}_2\text{CH}=\text{NNHCONH}_2$



(D) $\text{CH}_3\text{CH}_2\text{CH}=\text{NCONHNH}_2$

Ans: Since 'B' gives silver mirror test, it is an aldehyde. Hence 'A' is a primary alcohol.

90. Which of the following hydrocarbons has the lowest dipole moment?



Ans: Compound being linear, and having symmetrical structure, has lowest dipole moment.

