COMEDK 2025 Afternoon Shift

Mathematics

Question1

The terms of an infinitely decreasing geometric progression in which all the terms are positive, the first term is 4, and the difference between third and fifth term is $\frac{32}{81}$, then which of the following is not true

Options:

A. $S_\infty = 3 + 2\sqrt{2}$

B. $r = \frac{1}{3}$

C. $S_\infty = 6$

D. $r = \frac{2\sqrt{2}}{3}$

Answer: A

Solution:

Let $a = 4$ and $r > 0$. We have

Third term minus fifth term:

$4r^2 - 4r^4 = \frac{32}{81} \implies r^2(1 - r^2) = \frac{8}{81}$.

Set $x = r^2$. Then

$x(1 - x) = \frac{8}{81} \implies x^2 - x + \frac{8}{81} = 0 \implies x = \frac{1 \pm \frac{7}{9}}{2} = \frac{8}{9}$ or $\frac{1}{9}$.

Hence

$r = \frac{2\sqrt{2}}{3}$ or $r = \frac{1}{3}$.

Sum to infinity:

$$S_\infty = \frac{a}{1-r} = \begin{cases} \dfrac{4}{1 - \frac{1}{3}} = 6, \\ \dfrac{4}{1 - \frac{2\sqrt{2}}{3}} = \dfrac{12}{3 - 2\sqrt{2}} = 12\left(3 + 2\sqrt{2}\right) = 36 + 24\sqrt{2}. \end{cases}$$

Checking the options:

B: $r = \frac{1}{3}$ ✓

D: $r = \frac{2\sqrt{2}}{3}$ ✓

C: $S_\infty = 6$ (holds when $r = \frac{1}{3}$) ✓

A: $S_\infty = 3 + 2\sqrt{2}$ ✗ (neither of the two sums)

Answer: Option A is not true.

Question2

For real numbers x and y, $xRy \Leftrightarrow x - y + \sqrt{2}$ is an irrational number. Then the relation R is:

Options:

A. Reflexive

B. Symmetric

C. Transitive

D. Equivalence

Answer: A

Solution:

Let's check each property for

$xRy \iff x - y + \sqrt{2}$ is irrational.

Reflexive

For any real x,

$x - x + \sqrt{2} = \sqrt{2}$,

which is irrational.

⇒ R is reflexive.

Symmetric

Suppose xRy, so

$x - y + \sqrt{2} = A \quad (A \notin \mathbb{Q})$.

Then

$y - x + \sqrt{2} = 2\sqrt{2} - A$.

It's possible to pick A irrational so that $2\sqrt{2} - A$ is rational.

E.g. take $x - y = \sqrt{2} - 1$, then

$x - y + \sqrt{2} = 2\sqrt{2} - 1$ (irrational),

but

$y - x + \sqrt{2} = 1$ (rational).

⇒ R is not symmetric.

Transitive

If

$x - y + \sqrt{2} = A \notin \mathbb{Q}, \quad y - z + \sqrt{2} = B \notin \mathbb{Q}$,

then

$x - z + \sqrt{2} = A + B - \sqrt{2}$.

One can choose A, B irrational so that $A + B - \sqrt{2}$ becomes rational.

E.g. $A = \sqrt{3},\ B = \sqrt{2} - \sqrt{3}$ give $x - z + \sqrt{2} = 0 \in \mathbb{Q}$.

⇒ R is not transitive.

Conclusion: R is reflexive only.

Answer: Option A.

Question3

Let $A = \{x : x = 4n + 1, n \in Z, 0 \leq n < 4\}$

$B = \{x : x = 15n + 4, n \in N, n \leq 3\}$
$C = \{x : x \text{ is a prime number} \quad , x \in A \cup B\}$

Then the cardinal number of set C is

Options:

A. $\emptyset$

B. 3

C. 4

D. 5

Answer: B

Solution:

List the elements of A. Since $n = 0, 1, 2, 3$,

$A = \{4n + 1\} = \{1,\ 5,\ 9,\ 13\}$.

List the elements of B. Taking $n = 1, 2, 3$ (usual convention $\mathbb{N} = \{1, 2, \ldots\}$ and $n \leq 3$),

$B = \{15n + 4\} = \{19,\ 34,\ 49\}$.

Form the union and pick out primes:

$A \cup B = \{1, 5, 9, 13, 19, 34, 49\}$,

primes here are $\{5,\ 13,\ 19\}$.

So

$C = \{5, 13, 19\}, \quad |C| = 3$.

Answer: 3.

Question4

If $2y = \left[\cot^{-1}\left(\frac{\sqrt{3}\cos x + \sin x}{\cos x - \sqrt{3}\sin x}\right)\right]^2 \forall x \in \left(0, \frac{\pi}{2}\right)$ then $\frac{dy}{dx}$ is equal to :

Options:

A.

$x - \frac{\pi}{6}$

B.

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

C.

$\frac{\pi}{6} - x$

D.

$\frac{\pi}{3} - x$

Answer: A

Solution:

We are given

$$2y = \left[\cot^{-1}\left(\frac{\sqrt{3}\cos x + \sin x}{\cos x - \sqrt{3}\sin x}\right)\right]^2, \qquad x \in (0, \pi/2)$$

Let

$$\theta = \cot^{-1}\left(\frac{\sqrt{3}\cos x + \sin x}{\cos x - \sqrt{3}\sin x}\right)$$

Step 1: Simplify the argument

Observe:

$$\frac{\sqrt{3}\cos x + \sin x}{\cos x - \sqrt{3}\sin x} = \tan\left(\frac{\pi}{3} + x\right)$$

Thus:

$$\theta = \cot^{-1}\left(\tan\left(\frac{\pi}{3} + x\right)\right)$$

We must choose the correct branch of $\cot^{-1}$ for $x \in (0, \pi/2)$, which yields:

$$\theta = x - \frac{\pi}{6}$$

(This is the branch that keeps θ continuous and inside its principal interval.)

Step 2: Plug into the original function

$$2y = \left(x - \frac{\pi}{6}\right)^2$$

$$y = \frac{1}{2}\left(x - \frac{\pi}{6}\right)^2$$

Step 3: Differentiate

$$\frac{dy}{dx} = \frac{1}{2} \cdot 2\left(x - \frac{\pi}{6}\right) = x - \frac{\pi}{6}$$

✅ **Final Answer**

$$\boxed{x - \frac{\pi}{6}}$$

Question5

Five persons entered the lift cabin on the ground floor of an eight-floor apartment. Suppose that each of them independently and with equal probability, can leave the cabin at any floor beginning with the first floor, then the probability of all five persons leaving at different floors is :

Options:

A. $\frac{7}{{}^{7}P_{5}}$

B. $\frac{{}^{7}P_{5}}{7^{5}}$

C. $\frac{5!}{7^{5}}$

D. $\frac{{}^{7}P_{5}}{5^{7}}$

Answer: B

Solution:

Let each of the five people choose independently one of the 7 floors (1–7).

Total number of ways (sample space):

7^5

Number of ways in which all five choose different floors:

– First person has 7 choices, second 6, …, fifth 3.

– That's the permutation

${}^7P_5 \;=\; 7\cdot 6\cdot 5\cdot 4\cdot 3\,.$

Probability they all leave on distinct floors:

$P \;=\; \frac{\text{favourable}}{\text{total}} \;=\; \frac{{}^7P_5}{7^5}\,.$

So the correct answer is Option B:

$\frac{{}^7P_5}{7^5}\,.$

Question6

If $\cos A = \frac{3}{4}$, then $\left(32 \sin \frac{A}{2} \sin \frac{5A}{2}\right) =$

Options:

A. 7

B. 16

C. 11

D. 8

Answer: C

Solution:

First, use the product-to-sum identity:

$\sin\alpha\,\sin\beta = \frac{\cos(\alpha-\beta)-\cos(\alpha+\beta)}{2}$

with $\alpha = \frac{A}{2}$ and $\beta = \frac{5A}{2}$. Then

$\sin\frac{A}{2}\,\sin\frac{5A}{2} = \frac{\cos(2A)-\cos(3A)}{2},$

so

$32\sin\frac{A}{2}\sin\frac{5A}{2} = 16\big(\cos 2A - \cos 3A\big).$

Next, from $\cos A = \frac{3}{4}$ compute

$\cos 2A = 2\cos^2 A - 1 = 2\cdot\frac{9}{16} - 1 = \frac{1}{8}, \quad \cos 3A = 4\cos^3 A - 3\cos A = 4\cdot\frac{27}{64} - 3\cdot\frac{3}{4} = -\frac{9}{16}.$

Hence

$\cos 2A - \cos 3A = \frac{1}{8} - \left(-\frac{9}{16}\right) = \frac{2+9}{16} = \frac{11}{16},$

and

$32\sin\frac{A}{2}\sin\frac{5A}{2} = 16\cdot\frac{11}{16} = 11.$

Answer: 11. (Option C)

Question7

If $A = \frac{1}{\pi}\begin{bmatrix} \sin^{-1}\frac{1}{2} & \tan^{-1}\frac{x}{\pi} \\ \sin^{-1}\frac{x}{\pi} & \cot^{-1}\sqrt{3} \end{bmatrix}$ $B = \frac{1}{\pi}\begin{bmatrix} -\cos^{-1}\frac{1}{2} & \tan^{-1}\frac{x}{\pi} \\ \sin^{-1}\frac{x}{\pi} & -\tan^{-1}\sqrt{3} \end{bmatrix}$ and I is an identity matrix of order 2×2, then $A - B =$

Options:

A. 2I

B. $\frac{1}{2}I$

C. I

D. 0

Answer: B

Solution:

Let's subtract B from A entrywise. Since both have factor $\frac{1}{\pi}$, we work inside the brackets then divide by π.

Top-left entry:

$\sin^{-1}\frac{1}{2} - \left(-\cos^{-1}\frac{1}{2}\right) = \sin^{-1}\frac{1}{2} + \cos^{-1}\frac{1}{2} = \frac{\pi}{6} + \frac{\pi}{3} = \frac{\pi}{2}$

dividing by π gives $\frac{1}{2}$.

Top-right entry:

$\tan^{-1}\frac{x}{\pi} - \tan^{-1}\frac{x}{\pi} = 0$.

Bottom-left entry:

$\sin^{-1}\frac{x}{\pi} - \sin^{-1}\frac{x}{\pi} = 0$.

Bottom-right entry:

$\cot^{-1}\sqrt{3} - \left(-\tan^{-1}\sqrt{3}\right) = \cot^{-1}\sqrt{3} + \tan^{-1}\sqrt{3} = \frac{\pi}{6} + \frac{\pi}{3} = \frac{\pi}{2}$

dividing by π gives $\frac{1}{2}$.

Putting it all together,

$$A - B = \frac{1}{2}\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = \frac{1}{2}I$$

Answer: Option B.

Question8

The length of the latus rectum of a conic $49y^2 - 16x^2 = 784$ is

Options:

A. $\frac{49}{2}$

B. $\frac{49}{\sqrt{2}}$

C. $\frac{7}{\sqrt{2}}$

D. $\frac{7}{2}$

Answer: A

Solution:

Let's rewrite the given equation in standard form and pick off a and b:

Divide both sides by 784:

$\frac{49y^2}{784} - \frac{16x^2}{784} = 1$

which simplifies to

$\frac{y^2}{16} - \frac{x^2}{49} = 1.$

Here $a^2 = 16$ and $b^2 = 49$, so $a = 4$, $b = 7$.

For a hyperbola of the form

$\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1,$

the length of each latus rectum is

$2\,\frac{b^2}{a}.$

Substitute $a = 4$, $b^2 = 49$:

$2\,\frac{49}{4} = \frac{98}{4} = \frac{49}{2}.$

Answer: $\frac{49}{2}$.

Question9

The curve $4y = 3x^4 - 2x^2$ attains ---------- at the points $x = -\frac{1}{\sqrt{3}}$ and $x = \frac{1}{\sqrt{3}}$

Options:

A. both minimum values

B. a maximum value and a minimum value respectively

C. a minimum value and a maximum value respectively

D. both maximum values

Answer: A

Solution:

Let

$y = \frac{3x^4 - 2x^2}{4}$

then

First derivative:

$y' = \frac{12x^3 - 4x}{4} = 3x^3 - x = x(3x^2 - 1).$

Critical points: $x = 0, \quad x = \pm\frac{1}{\sqrt{3}}.$

Second derivative:

$y'' = 9x^2 - 1.$

– At $x = \pm\frac{1}{\sqrt{3}}$:

$y'' = 9 \cdot \frac{1}{3} - 1 = 3 - 1 = 2 > 0\,,$

so these are local minima.

– (For reference, at $x = 0$, $y'' = -1 < 0$, a local maximum.)

Therefore at $x = -\frac{1}{\sqrt{3}}$ and $x = \frac{1}{\sqrt{3}}$ the curve attains both minimum values.

Answer: Option A.

Question10

The area of the region enclosed by the lines $2x + y = 10, y = 1, y = 5$ and the y-axis is

Options:

A.

28 sq units

B.

9.5 sq units

C.

14 sq units

D.

37.5 sq units

Answer: C

Solution:

We are asked to find the area of the region enclosed by the lines:

- $2x + y = 10$
- $y = 1$
- $y = 5$
- the **y-axis** ($x = 0$)

Step 1: Find intersection points

Line 1 with y = 1

$$2x + 1 = 10 \quad \Rightarrow \quad 2x = 9 \Rightarrow x = 4.5$$

Point: $(4.5, 1)$

Line 1 with y = 5

$$2x + 5 = 10 \quad \Rightarrow \quad 2x = 5 \Rightarrow x = 2.5$$

Point: $(2.5, 5)$

y-axis intersections

At $x = 0$, the horizontal boundaries give:

- $(0, 1)$
- $(0, 5)$

Step 2: Identify the region

The region is a **trapezoid** with vertices:

$$(0, 1), \quad (0, 5), \quad (2.5, 5), \quad (4.5, 1)$$

Left side: vertical (from $y = 1$ to $y = 5$)

Right side: slanted line from intersection points.

Step 3: Use the trapezoid area formula

A trapezoid with horizontal top and bottom edges can be computed as:

$$\text{Area} = \int_{y=1}^{5} x(y)\, dy$$

Solve line for x:

$$2x + y = 10 \Rightarrow 2x = 10 - y \Rightarrow x = 5 - \frac{y}{2}$$

Now integrate:

$$\int_{1}^{5} \left(5 - \frac{y}{2}\right) dy$$

Compute:

$$\int 5\, dy = 5y$$

$$\int -\frac{y}{2}\, dy = -\frac{y^2}{4}$$

Evaluate from 1 to 5:

$$\left[5y - \frac{y^2}{4}\right]_1^5$$

At $y = 5$:

$$25 - \frac{25}{4} = 25 - 6.25 = 18.75$$

At $y = 1$:

$$5 - \frac{1}{4} = 5 - 0.25 = 4.75$$

Subtract:

$$18.75 - 4.75 = 14$$

✅ **Final Answer: 14 square units**

Question11

$x = a(\theta + \sin\theta)$ and $y = a(1 - \cos\theta)$ represents the equation of a curve. If θ changes at a constant rate k then the rate of change of the slope of the tangent to the curve at $\theta = \frac{\pi}{3}$ is

Options:

A. $2k$

B. $\frac{k}{3}$

C. $\frac{2k}{\sqrt{3}}$

D. $\frac{2k}{3}$

Answer: D

Solution:

First, write the slope of the tangent as a function of θ:

Compute

$\frac{dy}{d\theta} = a\sin\theta, \quad \frac{dx}{d\theta} = a(1 + \cos\theta).$

So

$m(\theta) = \frac{dy/d\theta}{dx/d\theta} = \frac{\sin\theta}{1+\cos\theta} = \tan\frac{\theta}{2}.$

Differentiate with respect to time. Since θ = k,

$\frac{dm}{dt} = \frac{dm}{d\theta}\frac{d\theta}{dt} = m'(\theta)\,k = \frac{d}{d\theta}\left(\tan\frac{\theta}{2}\right)k = \frac{1}{2}\sec^2\left(\frac{\theta}{2}\right)k.$

At θ=π/3, we have θ/2=π/6 so

$\sec\frac{\pi}{6} = \frac{1}{\cos(\pi/6)} = \frac{2}{\sqrt{3}}, \quad \sec^2\frac{\pi}{6} = \frac{4}{3}.$

Hence

$\left.\frac{dm}{dt}\right|_{\theta=\frac{\pi}{3}} = \frac{1}{2}\cdot\frac{4}{3}\,k = \frac{2k}{3}.$

Answer: $\frac{2k}{3}$ (Option D).

Question12

The function $f(x) = \begin{cases} \frac{|x|}{x}, & \text{if } x \neq 0 \\ 0, & \text{if } x = 0 \end{cases}$ is discontinuous at

Options:

A. $x = 0$

B. $x > 1$

C. $x > 0$

D. $x < 0$

Answer: A

Solution:

The function can be rewritten as

$$f(x) = \begin{cases} 1, & x > 0, \\ -1, & x < 0, \\ 0, & x = 0. \end{cases}$$

• For any $x > 0$, $f(x) = 1$ is constant ⇒ continuous there.

• For any $x < 0$, $f(x) = -1$ is constant ⇒ continuous there.

• At $x = 0$,

– $\lim_{x \to 0^-} f(x) = -1$

– $\lim_{x \to 0^+} f(x) = 1$

– These one-sided limits differ (and neither equals $f(0) = 0$), so f is discontinuous at 0.

Answer: Option A.

Question13

Integrating factor of the differential equation $\frac{dy}{dx} + y = \frac{x^3+y}{x}$ is

Options:

A. $\frac{x}{e^x}$

B. e^x

C. $\frac{e^x}{x}$

D. xe^x

Answer: C

Solution:

First rewrite the equation in standard linear form:

Start with

$\frac{dy}{dx} + y = \frac{x^3+y}{x}$.

Bring the y/x term to the left:

$\frac{dy}{dx} + y - \frac{y}{x} = x^2 \quad \Longrightarrow \quad \frac{dy}{dx} + \left(1 - \frac{1}{x}\right)y = x^2.$

Here $P(x) = 1 - \frac{1}{x}$. The integrating factor is

$\mu(x) = \exp\left(\int P(x)\,dx\right) = \exp\left(\int \left(1 - \frac{1}{x}\right) dx\right) = \exp\left(x - \ln|x|\right) = \frac{e^x}{x}$.

So the correct choice is **Option C**:

$\boxed{\frac{e^x}{x}}$.

Question14

If $y = \left(\sin^{-1} x\right)^2 + \left(\cos^{-1} x\right)^2$,

then $\left(1 - x^2\right) \frac{d^2y}{dx^2} - x\frac{dy}{dx} =$

Options:

A. 2

B. 3

C. 0

D. 4

Answer: D

Solution:

First, observe that

$\arcsin x + \arccos x = \frac{\pi}{2} \quad \Longrightarrow \quad \arccos x = \frac{\pi}{2} - \arcsin x\,.$

Hence

$y = (\arcsin x)^2 + (\arccos x)^2 = (\arcsin x)^2 + \left(\frac{\pi}{2} - \arcsin x\right)^2 = 2A^2 - \pi A + \frac{\pi^2}{4}, \quad A = \arcsin x.$

Compute y':

$y' = \frac{d}{dx}\left(2A^2 - \pi A\right) = (4A - \pi)\,\frac{dA}{dx} = \frac{4A - \pi}{\sqrt{1 - x^2}}.$

Compute y'':

$y'' = \frac{d}{dx}\left[(4A - \pi)(1 - x^2)^{-1/2}\right] = 4\,(1 - x^2)^{-1} + (4A - \pi)\,\frac{x}{(1 - x^2)^{3/2}}.$

Form the combination:

$(1 - x^2)\,y'' - x\,y' = \left[4 + (4A - \pi)\,\frac{x}{\sqrt{1 - x^2}}\right] - (4A - \pi)\,\frac{x}{\sqrt{1 - x^2}} = 4.$

Answer: **4** (Option D)

Question15

If ${}^{n+2}C_8 : {}^{n-2}P_4 = 57 : 16$, then ' n ' is

Options:

A. 20

B. 19

C. 17

D. 21

Answer: B

Solution:

First write the given ratio in terms of factorials:

$$\frac{{}^{n+2}C_8}{{}^{n-2}P_4} = \frac{\dfrac{(n+2)!}{8!\,(n-6)!}}{\dfrac{(n-2)!}{(n-6)!}} = \frac{(n+2)!}{8!\,(n-2)!} = \frac{(n+2)(n+1)n(n-1)}{8!} = \frac{57}{16}.$$

Multiply both sides by $8! = 40320$:

$$(n-1)\,n\,(n+1)\,(n+2) = \frac{40320 \cdot 57}{16} = 143640.$$

Now test the options:

• $n = 17$: $16 \cdot 17 \cdot 18 \cdot 19 = 93024$

• $n = 19$: $18 \cdot 19 \cdot 20 \cdot 21 = 143640$

• $n = 20$: $19 \cdot 20 \cdot 21 \cdot 22 = 175560$

• $n = 21$: $20 \cdot 21 \cdot 22 \cdot 23 = 212520$

Only $n = 19$ gives 143640.

Answer: 19.

Question16

Differentiate $\log_a x$ with respect to a^x

Options:

A. $\frac{1}{xa^x}$

B. $\frac{1}{xa^x(\log a)^2}$

C. $\frac{a^x}{x(\log a)^2}$

D. $\frac{a^x}{x}$

Answer: B

Solution:

We set

y = $\log_a$ x = ln x / ln a

u = a^x = e^{x ln a}

Then by the chain-rule for “derivative w.r.t.”:

$$\frac{dy}{du} = \frac{\frac{dy}{dx}}{\frac{du}{dx}}.$$

Compute dy/dx:

$$\frac{dy}{dx} = \frac{1}{x\,\ln a}.$$

Compute du/dx:

$$\frac{du}{dx} = a^x\,\ln a.$$

Divide:

$$\frac{dy}{du} = \frac{\frac{1}{x\,\ln a}}{a^x\,\ln a} = \frac{1}{x\,a^x\,(\ln a)^2}.$$

Since $\ln a = \log a$, this matches option B:

$\boxed{\frac{1}{x\,a^x\,(\log a)^2}}$.

Question17

On each working day of a school there are six periods. The number of ways in which five subjects are arranged if each subject is allotted at least one period and no period remains vacant is

Options:

A. 360

B. 1800

C. 120

D. 210

Answer: B

Solution:

We need to fill 6 ordered periods with 5 subjects, each used at least once. Since 6>5, exactly one subject must appear twice and the other four once.

Choose which subject is doubled: 5 ways.

Choose 2 of the 6 periods for that subject: $\binom{6}{2} = 15$ ways.

Arrange the remaining 4 subjects in the 4 leftover slots: $4! = 24$ ways.

Total number of arrangements

$5 \times \binom{6}{2} \times 4! \;=\; 5 \times 15 \times 24 \;=\; 1800.$

Answer: 1800.

Question18

A bag contains $(n+1)$ coins. It is known that one of these coins has a head on both sides, whereas the other coins are fair. One of these coins is selected at random and tossed. If the probability that the toss results in heads is $\frac{7}{12}$, then the value of n is :

Options:

A. 5

B. 3

C. 2

D. 4

Answer: A

Solution:

Let’s write out the probability step by step:

Total coins = $n+1$.

– One is double-headed.

– n are fair.

Probabilities of picking a coin:

– Double-headed: $\frac{1}{n+1}$

– Fair: $\frac{n}{n+1}$

Given a coin, the chance of heads is

– Double-headed: 1

– Fair: $\frac{1}{2}$

So overall

$P(\text{heads}) = \frac{1}{n+1} \cdot 1 \ + \ \frac{n}{n+1} \cdot \frac{1}{2} = \frac{1+\frac{n}{2}}{n+1} = \frac{n+2}{2(n+1)}.$

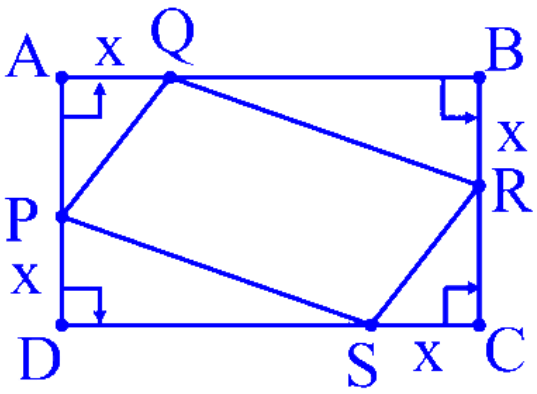
Set this equal to $\frac{7}{12}$ and solve:

$\frac{n+2}{2(n+1)} = \frac{7}{12} \quad \Longrightarrow \quad 12(n+2) = 7 \cdot 2(n+1) \implies 12n + 24 = 14n + 14 \implies 2n = 10 \implies n = 5.$

Answer: $n = 5$. (Option A)

Question19

Quadrilateral PQRS is inscribed inside a rectangle of dimensions $10\ \text{cm} \times 8\ \text{cm}$. The value of ' x ', if the area of the quadrilateral is minimum is



Options:

A.

4 cm

B.

6.5 cm

C.

9 cm

D.

4.5 cm

Answer: D

Solution:

Given

A quadrilateral **PQRS** is inscribed in a **10 cm × 8 cm** rectangle **ABCD**.

Each vertex lies on one side of the rectangle such that the distances from the rectangle's corners are all **x**:

- $AQ = x$ on top side
- $BP = x$ on left side
- $CR = x$ on right side
- $DS = x$ on bottom side

Coordinates (taking $D = (0, 0)$):

- $D(0, 0)$
- $C(10, 0)$
- $B(10, 8)$
- $A(0, 8)$

Thus the points are:

- $P(0, x)$
- $Q(x, 8)$
- $R(10, 8 - x)$
- $S(10 - x, 0)$

We want the **value of x that minimizes the area of quadrilateral PQRS**.

Step 1 — Shoelace Formula

Let the quadrilateral in order be
$P(0, x),\ Q(x, 8),\ R(10, 8 - x),\ S(10 - x, 0)$

Using shoelace:

$$\text{Area} = \frac{1}{2}\left| \begin{matrix} 0 \cdot 8 + x(8 - x) + 10 \cdot 0 + (10 - x)x \\ -\left[x \cdot x + 8 \cdot 10 + (8 - x)(10 - x) + 0 \cdot 0\right] \end{matrix} \right|$$

Simplify step-by-step:

Compute first sum

$$0 + 8x - x^2 + 0 + 10x - x^2 = 18x - 2x^2$$

Compute second sum

$$x^2 + 80 + (80 - 18x + x^2)$$

$$= x^2 + 80 + 80 - 18x + x^2$$

$$= 2x^2 - 18x + 160$$

Area expression

$$A(x) = \frac{1}{2}\left|(18x - 2x^2) - (2x^2 - 18x + 160)\right|$$

Combine terms:

$$18x - 2x^2 - 2x^2 + 18x - 160$$

$$= 36x - 4x^2 - 160$$

$$A(x) = \frac{1}{2}|-4(x^2 - 9x + 40)|$$

Since area is positive:

$$A(x) = 2(x^2 - 9x + 40)$$

Step 2 — Find minimum

The quadratic:

$$A(x) = 2(x^2 - 9x + 40)$$

Minimum occurs at vertex:

$$x = \frac{-b}{2a} = \frac{9}{2} = 4.5 \text{ cm}$$

FINAL ANSWER

$$\boxed{4.5 \text{ cm}}$$

Question20

If $A = \begin{bmatrix} 0 & -1 & 2 \\ 1 & 0 & 3 \\ -2 & -3 & 0 \end{bmatrix}$**, then** $A + 2A^T =$

Options:

A. $-A^T$

B. A^T

C. $2A^2$

D. A

Answer: B

Solution:

Let's compute step by step:

Transpose of A:

$A^T = \begin{pmatrix} 0 & 1 & -2 \\ -1 & 0 & -3 \\ 2 & 3 & 0 \end{pmatrix}.$

Twice the transpose:

$2A^T = \begin{pmatrix} 0 & 2 & -4 \\ -2 & 0 & -6 \\ 4 & 6 & 0 \end{pmatrix}.$

Sum with A:

$A + 2A^T = \begin{pmatrix} 0 & -1 & 2 \\ 1 & 0 & 3 \\ -2 & -3 & 0 \end{pmatrix} + \begin{pmatrix} 0 & 2 & -4 \\ 2 & 0 & -6 \\ 4 & 6 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 & -2 \\ 1 & 0 & -3 \\ 2 & 3 & 0 \end{pmatrix} = A^T.$

Answer: Option B.

Question21

Simplified expression of

$1 - \frac{\sin^2 y}{1+\cos y} + \frac{1+\cos y}{\sin y} - \frac{\sin y}{1-\cos y}$ is :

Options:

A. $\sin y$

B. $\cos y$

C. 1

D. 0

Answer: B

Solution:

Let

$E = 1 - \frac{\sin^2 y}{1+\cos y} + \frac{1+\cos y}{\sin y} - \frac{\sin y}{1-\cos y}.$

We simplify in two stages:

Simplify the first two terms:

$\frac{\sin^2 y}{1+\cos y} = \frac{1-\cos^2 y}{1+\cos y} = 1-\cos y \quad \Longrightarrow \quad 1-\frac{\sin^2 y}{1+\cos y} = \cos y.$

Show the next pair cancels:

$\frac{1+\cos y}{\sin y} = \frac{2\cos^2\frac{y}{2}}{2\sin\frac{y}{2}\cos\frac{y}{2}} = \cot\frac{y}{2}, \quad \frac{\sin y}{1-\cos y} = \frac{2\sin\frac{y}{2}\cos\frac{y}{2}}{2\sin^2\frac{y}{2}} = \cot\frac{y}{2},$

so

$\frac{1+\cos y}{\sin y} - \frac{\sin y}{1-\cos y} = 0.$

Putting it all together,

$E = \cos y + 0 = \cos y.$

Answer: Option B.

Question22

The length of the perpendicular from the point $P(1,-1,2)$ to the given line $\frac{x+1}{2} = \frac{y-2}{-3} = \frac{z+2}{4}$ is

Options:

A. $\sqrt{29}$ units

B. $\sqrt{21}$ units

C. $\sqrt{6}$ units

D. 0 units

Answer: D

Solution:

The point $P(1,-1,2)$ actually lies on the line. To see this, write the line in parametric form with parameter t:

$x = -1+2t, \quad y = 2-3t, \quad z = -2+4t.$

If you set $t = 1$, you get

$x = -1+2 = 1, \quad y = 2-3 = -1, \quad z = -2+4 = 2,$

which is exactly P. Hence the perpendicular distance is

0 units,

Option D.

Question23

The point on the line $x+y=4$ that lie at a unit distance from the line $4x+3y=10$ is

Options:

A.

$(2,2)$

B.

$(3,-1)$

C.

$(5,-1)$

D.

$(-7, 11)$

Answer: D

Solution:

Given

- Point (x, y) lies on the line

$$x + y = 4$$

- Its distance from the line

$$4x + 3y = 10$$

is **1 unit**.

Step 1: Parameterize the line $x + y = 4$

Let $x = t$.
Then $y = 4 - t$.

So the point is $(t, 4 - t)$.

Step 2: Use distance formula from a point to a line

Distance from (x_0, y_0) to line $Ax + By + C = 0$ is

$$d = \frac{|Ax_0 + By_0 + C|}{\sqrt{A^2 + B^2}}$$

Rewrite line:

$$4x + 3y - 10 = 0$$

Plug $(t, 4 - t)$:

$$d = \frac{|4t + 3(4 - t) - 10|}{\sqrt{4^2 + 3^2}}$$

Compute numerator:

$$4t + 12 - 3t - 10 = t + 2$$

So

$$d = \frac{|t + 2|}{5}$$

We need distance = 1:

$$\frac{|t + 2|}{5} = 1$$

Step 3: Solve

$$|t + 2| = 5$$

Two solutions:

1. $t + 2 = 5 \Rightarrow t = 3$
2. $t + 2 = -5 \Rightarrow t = -7$

Step 3: Solve

$$|t+2| = 5$$

Two solutions:

1. $t+2 = 5 \Rightarrow t = 3$
2. $t+2 = -5 \Rightarrow t = -7$

Step 4: Get corresponding points

When $t = 3$:

$$x = 3, \quad y = 4 - 3 = 1$$

But option B is $(3, -1)$, so $(3, 1)$ is **not present** → discard.

When $t = -7$:

$$x = -7, \quad y = 4 - (-7) = 11$$

This matches **Option D:** $(-7, 11)$.

✔ **Correct Answer:** $(-7, 11)$

Question24

The area of the region bounded by the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ is

Options:

A. πab sq units

B. $\pi^2 ab$ sq units

C. $\pi a^2 b$ sq units

D. πab^2 sq units

Answer: A

Solution:

The correct answer is Option A:

The area of the ellipse

$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

is

$\pi\, a\, b$.

Brief reasoning:

Start from the unit circle $x^2 + y^2 = 1$, whose area is π.

Stretch x by a factor a and y by b.

Area scales by $a \cdot b$, giving $\pi \cdot a \cdot b$.

Question25

If $A(\text{adj } A) = \begin{bmatrix} 5 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 5 \end{bmatrix}$**, then the value of** $|A| + |\text{adj } A|$ **is equal to :**

Options:

A. 5

B. 25

C. 125

D. 30

Answer: D

Solution:

We use two key facts for a 3×3 invertible matrix A:

A·adj A = (det A) I_3.

Given

$$A\ \mathrm{adj}\,A\ =\ \begin{pmatrix}5 & 0 & 0\\ 0 & 5 & 0\\ 0 & 0 & 5\end{pmatrix}\ =\ 5\,I_3,$$

so

$\det A = 5$.

$\det(\mathrm{adj}\ A) = (\det A)^{n-1}$ for an n×n matrix.

Here n=3, so

$|\mathrm{adj}\ A| = (\det A)^{3-1} = 5^2 = 25$.

Therefore

$|A| + |\mathrm{adj}\ A| = 5 + 25 = 30$.

Answer: Option D (30).

Question26

In a kabaddi league, two matches are being played between Jaipur and Delhi. It is assumed that the outcomes of the two games are independent. The probability of Jaipur winning, drawing and losing the game against Delhi are $\frac{1}{2}$, $\frac{3}{10}$ and $\frac{1}{5}$ respectively. Each team gets 5 points for win, 3 points for draw and 0 points for loss in a game. After two games, find the probability that Jaipur has more points than Delhi.

Options:

A. $\frac{1}{4}$

B. $\frac{3}{20}$

C. $\frac{11}{20}$

D. $\frac{2}{5}$

Answer: C

Solution:

Let’s label each match outcome for Jaipur as

• W (win), p=½, Jaipur 5 pts, Delhi 0 pts

• D (draw), p=3/10, Jaipur 3 pts, Delhi 3 pts

• L (loss), p=1/5, Jaipur 0 pts, Delhi 5 pts

After two independent games, we look at all 3×3 pairs (first, second). Here are the only cases where Jaipur's total points exceed Delhi's:

(W,W):

• p = ½·½ = ¼

• Jaipur 10 pts vs. Delhi 0 → Jaipur ahead

(W,D) or (D,W):

• p = ½·(3/10) = 3/20 and also (3/10)·½ = 3/20

• Jaipur 5+3 = 8 pts vs. Delhi 0+3 = 3 pts → Jaipur ahead

Summing these probabilities gives

$\frac{1}{4} + \frac{3}{20} + \frac{3}{20} = \frac{5}{20} + \frac{3}{20} + \frac{3}{20} = \frac{11}{20}$.

So the probability Jaipur ends up with more points is **11/20** (Option C).

Question27

$\int \frac{\sin x+\cos x}{\sqrt{1+2\sin x\cos x}}dx = \varphi(x) + C$ **Then** $\varphi(x) =$

Options:

A. $\log x$

B. x

C. $\log(\sin x + \cos x)$

D. $\log \sin(\cos x)$

Answer: B

Solution:

We start by noting the perfect-square identity:

$1 + 2\sin x\cos x = \sin^2 x + \cos^2 x + 2\sin x\cos x = (\sin x + \cos x)^2$.

Assuming $\sin x + \cos x > 0$ so that

$\sqrt{1 + 2\sin x\cos x} = |\sin x + \cos x| = \sin x + \cos x$,

the integrand becomes

$\frac{\sin x+\cos x}{\sin x+\cos x} = 1$.

Hence

$\int \frac{\sin x+\cos x}{\sqrt{1+2\sin x\cos x}}\,dx = \int 1\,dx = x + C$.

So

$\varphi(x) = x$,

which is Option B.

Question28

If the mean of $4, 7, 2, 8, 6$ and k is 7 . Then the mean deviation from the mean of these observations is

Options:

A. 5

B. 3

C. 1

D. 8

Answer: B

Solution:

First, find k from the condition

$\frac{4+7+2+8+6+k}{6} = 7$

which gives

$27 + k = 42 \quad \Longrightarrow \quad k = 15.$

Now the six observations are $4, 7, 2, 8, 6, 15$, and their mean is 7.

Compute the absolute deviations from the mean and average them:

• $|4 - 7| = 3$

• $|7 - 7| = 0$

• $|2 - 7| = 5$

• $|8 - 7| = 1$

• $|6 - 7| = 1$

• $|15 - 7| = 8$

Sum of deviations: $3 + 0 + 5 + 1 + 1 + 8 = 18$.

Mean deviation

MD $= \frac{18}{6} = 3.$

Answer: Option B (3).

Question29

$\int_0^{\frac{\pi}{2}} \log\left(\frac{5+4\sin x}{5+4\cos x}\right) dx =$

Options:

A. 0

B. 2

C. -2

D. $\frac{3}{4}$

Answer: A

Solution:

You can see it vanishes by symmetry. Set

$I = \int_0^{\pi/2} \log \frac{5+4\sin x}{5+4\cos x}\, dx.$

Under the substitution $x \mapsto \frac{\pi}{2} - x$ we have

$\sin x \leftrightarrow \cos x, \quad dx \mapsto dx,$

so

$I = \int_0^{\pi/2} \log \frac{5+4\cos x}{5+4\sin x}\, dx = -I.$

Hence $2I = 0$ and $I = 0$.

Answer: 0.

Question30

The degree of the differential equation $\left[1+\left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{4}}=\left(\frac{d^2y}{dx^2}\right)^{\frac{1}{3}}$

Options:

A. 4

B. 9

C. 6

D. 2

Answer: A

Solution:

First, recall that the degree of a differential equation is the power of the highest-order derivative after the equation has been made free of radicals and fractions in derivatives.

Start with

$\left[1+(y')^2\right]^{\frac{3}{4}} = (y'')^{\frac{1}{3}}$

To eliminate the fractional powers, raise both sides to the least common multiple of 4 and 3, which is 12:

$\left(\left[1+(y')^2\right]^{\frac{3}{4}}\right)^{12} = \left((y'')^{\frac{1}{3}}\right)^{12}$

This gives

$\left[1+(y')^2\right]^9 = (y'')^4$.

Now the equation is a polynomial in y'' (and lower derivatives). The highest power of the highest-order derivative y'' is 4.

Therefore, the degree of the given differential equation is **4**.

Question31

Evaluate the value of $(1.02)^8$ using binomial theorem up to two decimal places.

Options:

A.

1.17

B.

1.18

C.

1.81

D.

1.71

Answer: A

Solution:

To evaluate $(1.02)^8$ using the **binomial theorem**, expand:

$$(1+0.02)^8 = \sum_{k=0}^{8} \binom{8}{k} (1)^{8-k} (0.02)^k$$

Compute term by term (keeping up to 2 decimal places):

Step-by-step expansion

$$(1.02)^8 = 1 + 8(0.02) + \binom{8}{2}(0.02)^2 + \binom{8}{3}(0.02)^3 + \dots$$

Term 1:

$$1$$

Term 2:

$$8(0.02) = 0.16$$

Term 3:

$$\binom{8}{2}(0.02)^2 = 28(0.0004) = 0.0112$$

Term 4:

$$\binom{8}{3}(0.02)^3 = 56(0.000008) = 0.000448$$

Higher-order terms are extremely small (< 0.00001) so they do not affect rounding to **two decimals**.

Add them up

$$1 + 0.16 + 0.0112 + 0.000448 = 1.171648$$

Rounded to **two decimal places**:

$$\boxed{1.17}$$

Correct option: A (1.17)

Question32

$$\int \frac{e^{\tan^{-1}x}}{(1+x^2)}\left(1+x+x^2\right)dx =$$

Options:

A. $e^{\tan^{-1}x} + c$

B. $xe^{\tan^{-1}x} + c$

C. $\frac{e^{\tan^{-1}x}}{(1+x^2)} + c$

D. $\frac{xe^{\tan^{-1}x}}{(1+x^2)} + c$

Answer: B

Solution:

First, set

$u = \tan^{-1}x \quad \Longrightarrow \quad du = \frac{dx}{1+x^2}, \quad x = \tan u\,.$

Then

$$\int \frac{e^{\tan^{-1}x}}{1+x^2}\,(1+x+x^2)\,dx = \int e^u\,(1+\tan u+\tan^2 u)\,du = \int e^u\big(\tan u+\sec^2 u\big)\,du.$$

Notice

$$\frac{d}{du}\big(e^u\tan u\big) = e^u\tan u + e^u\sec^2 u = e^u\big(\tan u+\sec^2 u\big),$$

so the integral is

$$e^u\tan u + C = \; x\,e^{\tan^{-1}x} + C.$$

Answer: Option B.

Question33

Which of the following transformations reduce the differential equation $\frac{dz}{dx} + \frac{z}{x}\log z = \frac{z}{x^2}(\log z)^2$ into the form $\frac{du}{dx} + P(x)u = Q(x)$

Options:

A. $u = (\log z)^{-1}$

B. $u = \log x$

C. $u = (\log z)^2$

D. $u = e^x$

Answer: A

Solution:

The shortcut is to set

$u = \frac{1}{\ln z}$.

Indeed, one finds

$\frac{dz}{dx} = -\frac{z}{u^2}\frac{du}{dx}, \quad \ln z = \frac{1}{u}$

and the original equation

$\frac{dz}{dx} + \frac{z}{x}\ln z = \frac{z}{x^2}(\ln z)^2$

becomes, after dividing by z and clearing denominators,

$\frac{du}{dx} - \frac{1}{x}\,u = -\frac{1}{x^2},$

i.e. a linear ODE of the form

$\frac{du}{dx} + P(x)\,u = Q(x).$

Hence the correct choice is **A**.

Question34

The least area of a circle circumscribing any right-angle triangle of area $\frac{9}{\pi}$ sq units is

Options:

A. 9 sq units

B. π sq units

C. 9π sq units

D. 4.5 sq units

Answer: A

Solution:

We want the smallest possible area of the circum-circle of a right triangle whose area is $\frac{9}{\pi}$.

Let the legs be a and b. Then

$\frac{ab}{2} = \frac{9}{\pi} \quad \Longrightarrow \quad ab = \frac{18}{\pi}.$

The hypotenuse is $c = \sqrt{a^2 + b^2}$, and for a right triangle the circumradius is

$R = \frac{c}{2} = \frac{\sqrt{a^2+b^2}}{2}$.

To minimize c given ab fixed, use

$a^2 + b^2 \geq 2ab = \frac{36}{\pi}$,

so

$c \geq \sqrt{\frac{36}{\pi}} = \frac{6}{\sqrt{\pi}}, \quad R \geq \frac{3}{\sqrt{\pi}}$.

Hence the minimal circum-circle area is

$\pi R^2 \geq \pi\left(\frac{3}{\sqrt{\pi}}\right)^2 = \pi \cdot \frac{9}{\pi} = 9.$

Equality occurs when $a = b$.

Answer: 9 sq units (Option A).

Question35

$\lim_{\theta \to \frac{\pi}{2}} \frac{1-\sin\theta}{\left(\frac{\pi}{2}-\theta\right)\cos\theta}$ is equal to :

Options:

A. $-\frac{1}{2}$

B. -1

C. 1

D. $\frac{1}{2}$

Answer: D

Solution:

Let's set

$h = \frac{\pi}{2} - \theta\,, \qquad h \to 0.$

Then

• $\sin\theta = \sin\left(\frac{\pi}{2} - h\right) = \cos h = 1 - \frac{h^2}{2} + O(h^4)$

• $\cos\theta = \cos\left(\frac{\pi}{2} - h\right) = \sin h = h - \frac{h^3}{6} + O(h^5)$

So the numerator and denominator become

$1 - \sin\theta = \frac{h^2}{2} + O(h^4), \qquad \left(\frac{\pi}{2} - \theta\right)\cos\theta = h\,(h + O(h^3)) = h^2 + O(h^4).$

Hence the limit is

$\lim_{h\to 0} \frac{\frac{h^2}{2}+O(h^4)}{h^2+O(h^4)} = \frac{1}{2}$.

Answer: Option D, $\dfrac{1}{2}$.

Question36

If for two events A and B, $P(A - B) = \frac{1}{5}$ and $P(A) = \frac{3}{5}$ then $P(B/A) =$

Options:

A. $\frac{2}{3}$

B. $\frac{1}{2}$

C. $\frac{3}{5}$

D. $\frac{2}{5}$

Answer: A

Solution:

First, note that

$P(A-B) = P(A \cap B^c) = \frac{1}{5}$

and

$P(A) = \frac{3}{5}$.

Compute $P(A \cap B)$:

$P(A \cap B) = P(A) - P(A \cap B^c) = \frac{3}{5} - \frac{1}{5} = \frac{2}{5}$.

Then

$P(B \mid A) = \frac{P(A \cap B)}{P(A)} = \frac{\frac{2}{5}}{\frac{3}{5}} = \frac{2}{3}$.

So the answer is Option A: $\frac{2}{3}$.

Question37

$\int \frac{x}{(x-1)(x-2)^2} dx = a \log \left| \frac{x-1}{x-2} \right| + \frac{b}{(x-2)} + c$ **then**

Options:

A. $a = -1, b = 2$

B. $a = -1, b = -2$

C. $a = 1, b = -2$

D. $a = 1, b = 2$

Answer: C

Solution:

Let's set up a partial-fraction decomposition

$\frac{x}{(x-1)(x-2)^2} = \frac{A}{x-1} + \frac{B}{x-2} + \frac{C}{(x-2)^2}$.

Then

$x \;=\; A(x-2)^2 + B(x-1)(x-2) + C(x-1)$.

Expanding and matching coefficients gives the system

• $A + B = 0$

• $-4A - 3B + C = 1$

• $4A + 2B - C = 0$

Solving yields $A = 1,\ B = -1,\ C = 2$. Hence

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

and integrating term by term:

$\int \frac{x}{(x-1)(x-2)^2}\,dx = \ln|x-1| - \ln|x-2| - \frac{2}{x-2} + C = \ln\left|\frac{x-1}{x-2}\right| - \frac{2}{x-2} + C.$

Comparing with

$a\ln\left|\frac{x-1}{x-2}\right|+\frac{b}{x-2}+c$

we read off

$a=1,\quad b=-2.$

Answer: Option C.

Question38

The complex number $\frac{1+7i}{(2-i)^2}$ lies in

Options:

A. Quadrant 4

B. Quadrant 3

C. Quadrant 1

D. Quadrant 2

Answer: D

Solution:

Compute the square in the denominator:

$(2-i)^2=4-4i+i^2=4-4i-1=3-4i.$

So our fraction becomes

$\frac{1+7i}{(2-i)^2}=\frac{1+7i}{3-4i}.$

Multiply top and bottom by the conjugate of the denominator, $3+4i$:

$\frac{1+7i}{3-4i}\cdot\frac{3+4i}{3+4i}=\frac{(1+7i)(3+4i)}{3^2+4^2}=\frac{3+4i+21i+28i^2}{9+16}=\frac{3+25i-28}{25}=\frac{-25+25i}{25}=-1+i.$

The result is $-1+i$.

Real part: -1 (negative)

Imaginary part: $+1$ (positive)

A point with negative real part and positive imaginary part lies in Quadrant 2.

Answer: Option D (Quadrant 2).

Question39

If a function $f:[2,\infty)\to R$ defined by $f(x)=x^2-4x+5$, then the range of f is

Options:

A. $[2,\infty)$

B. $[5,\infty)$

C. R

D. $[1,\infty)$

Answer: D

Solution:

Let’s rewrite f by completing the square:

$f(x) = x^2 - 4x + 5 = (x-2)^2 + 1.$

• On the domain $x \geq 2$, we have $(x-2)^2 \geq 0$.

• Hence $f(x) \geq 1$, with equality at $x = 2$.

• As $x \to \infty$, $(x-2)^2 \to \infty$, so $f(x) \to \infty$.

Therefore the range is $[1, \infty)$, i.e. Option D.

Question40

The corner points of the feasible region determined by the system of linear constraints are $(0,3), (1,1)$ and $(3,0)$, If objective function is $Z = px + qy, p, q > 0$ then the condition on p and q so that the minimum of Z occurs at $(3,0)$ and $(1,1)$ is

Options:

A. $p = 3q$

B. $3p = q$

C. $p = \frac{q}{2}$

D. $p = 2q$

Answer: C

Solution:

First equate the objective at the two points:

At (3, 0):

$Z = 3p$.

At (1, 1):

$Z = p + q$.

For these to tie as the minimum,

$3p = p + q \implies 2p = q \implies p = \frac{q}{2}$.

Equivalently, the slope of the iso-cost line is

$-\frac{p}{q} = -\frac{1}{2}$,

which matches the slope of the edge joining (3, 0) and (1, 1).

Hence the required condition is

Option C: $p = \frac{q}{2}$.

Question41

Three bags contain a number of red and white balls are as follows.

Bag I: 3 red balls

Bag II: 2 red balls and 1 white ball

Bag III: 3 White balls

The probability that bag i will be chosen and a ball is selected from it is $\frac{i}{6}, i = 1, 2, 3$. If a white ball is selected, what is the probablity that it came from Bag III

Options:

A. $\frac{9}{11}$

B. $\frac{2}{11}$

C. 0

D. $\frac{1}{11}$

Answer: A

Solution:

To find $P(\text{Bag III} \mid \text{white})$, use Bayes' theorem:

Assign priors:

• $P(B_1) = \frac{1}{6},\ P(B_2) = \frac{2}{6} = \frac{1}{3},\ P(B_3) = \frac{3}{6} = \frac{1}{2}$.

Find likelihoods of drawing white:

• $P(\text{white} \mid B_1) = 0$

• $P(\text{white} \mid B_2) = \frac{1}{3}$

• $P(\text{white} \mid B_3) = 1$

Compute total $P(\text{white})$:

$P(\text{white}) = P(B_1) \cdot 0 + P(B_2) \cdot \frac{1}{3} + P(B_3) \cdot 1 = \frac{1}{3} \cdot \frac{1}{3} + \frac{1}{2} = \frac{1}{9} + \frac{1}{2} = \frac{11}{18}$.

Apply Bayes' rule:

$P(B_3 \mid \text{white}) = \frac{P(B_3)\, P(\text{white} \mid B_3)}{P(\text{white})} = \frac{\frac{1}{2} \cdot 1}{\frac{11}{18}} = \frac{1/2}{11/18} = \frac{9}{11}$.

Answer: $\frac{9}{11}$ (Option A).

Question42

The line AB passes through the point $P(-4, 3)$ and the portion of the line intercepted between the axes is divided internally in the ratio $5 : 3$ by the point P. Given that the point A lies on x-axis and B lies on y-axis, then the x intercept of the line is

Options:

A. $-\frac{32}{3}$

B. $\frac{32}{3}$

C. $-\frac{24}{5}$

D. $\frac{24}{5}$

Answer: A

Solution:

Let A = (a,0) and B = (0,b). Since P divides AB internally in the ratio

AP : PB = 5 : 3,

the section-formula gives for P = (–4,3):

$P_x = \frac{3\cdot a+5\cdot 0}{3+5} = \frac{3a}{8}, \quad P_y = \frac{3\cdot 0+5\cdot b}{8} = \frac{5b}{8}.$

Setting these equal to (–4,3) gives

$\frac{3a}{8} = -4 \implies a = -\frac{4\cdot 8}{3} = -\frac{32}{3}, \qquad \frac{5b}{8} = 3 \implies b = \frac{3\cdot 8}{5} = \frac{24}{5}.$

Hence the x-intercept is

$a = -\frac{32}{3}.$

Answer: Option A.

Question43

If $Q(1,0,1)$ is the image of the point $P(a,b,c)$ in the line $\frac{x+1}{2} = \frac{y-3}{-2} = \frac{z}{-1}$ then $a+b+c$ is equal to :

Options:

A. 4

B. 2

C. 0

D. -2

Answer: C

Solution:

Let $Q = (1,0,1)$ be the reflection of $P = (a,b,c)$ across the line

$\frac{x+1}{2} \;=\; \frac{y-3}{-2} \;=\; \frac{z}{-1}\,.$

Reflection across a line means:

The midpoint M of P and Q lies on the line.

The vector $\overrightarrow{PQ}$ is perpendicular to the line's direction.

Step 1. Parametrize the line. Let

$t = \frac{x+1}{2} = \frac{y-3}{-2} = \frac{z}{-1},$

so

$(x,y,z) = (-1,3,0) + t\,(2,-2,-1).$

Step 2. Midpoint on the line.

$M = \left(\frac{a+1}{2},\ \frac{b+0}{2},\ \frac{c+1}{2}\right) \overset{!}{=} (-1+2t,\ 3-2t,\ -t).$

Equating coordinates gives

$\frac{a+1}{2} = -1+2t, \quad \frac{b}{2} = 3-2t, \quad \frac{c+1}{2} = -t.$

From these

$t = \frac{a+3}{4}, \quad b = 3-a, \quad c = -\frac{a+5}{2}.$

Step 3. Perpendicularity. Direction vector of the line is

$\boldsymbol{v} = (2,-2,-1)$. We require

$\overrightarrow{PQ} = (1-a,\ -b,\ 1-c) \quad \perp\ \boldsymbol{v},$

so

$(1-a)\,2 \;+\; (-b)(-2) \;+\; (1-c)(-1) \;=\; 0.$

Substitute $b = 3-a$ and $c = -(a+5)/2$:

$2(1-a)+2b-(1-c)=0 \implies a=1, \quad b=2, \quad c=-3.$

Hence

$a+b+c=1+2-3=0.$

Answer: 0 (Option C).

Question44

The cost of 4 kg onion, 3 kg wheat and 2 kg rice is ₹ 500 .

The cost of 1 kg onion, 2 kg wheat and 3 kg rice is ₹ 300 .

The cost of 6 kg onion, 2 kg wheat and 3 kg rice is ₹ 575 .

The above situation can be represented in matrix form as $\mathrm{AX}=\mathrm{B}$. Then $\left|5A^{-1}\right|=$

Options:

A. 5

B. 125

C. 1

D. 25

Answer: A

Solution:

First, recall two facts about determinants for an $n \times n$ matrix A:

$\det(cA)=c^n \det(A)$.

$\det(A^{-1})=\frac{1}{\det(A)}$.

Here A is 3×3, so

$\left|5A^{-1}\right|=5^3 \mid A^{-1}|=125 \frac{1}{\det(A)}=\frac{125}{\det(A)}$.

Next, compute $\det(A)$. The coefficient matrix is

$$A=\begin{pmatrix}4 & 3 & 2\\ 1 & 2 & 3\\ 6 & 2 & 3\end{pmatrix}.$$

Expanding along the first row:

$$\det(A)=4\det\begin{pmatrix}2 & 3\\ 2 & 3\end{pmatrix}-3\det\begin{pmatrix}1 & 3\\ 6 & 3\end{pmatrix}+2\det\begin{pmatrix}1 & 2\\ 6 & 2\end{pmatrix}.$$

Evaluate each 2×2 determinant:

$$\det\begin{pmatrix}2 & 3\\ 2 & 3\end{pmatrix}=2\cdot 3-2\cdot 3=0.$$

$$\det\begin{pmatrix}1 & 3\\ 6 & 3\end{pmatrix}=1\cdot 3-6\cdot 3=-15.$$

$$\det\begin{pmatrix}1 & 2\\ 6 & 2\end{pmatrix}=1\cdot 2-6\cdot 2=-10.$$

So

$\det(A)=4\cdot 0 \ - \ 3(-15) \ + \ 2(-10)=0+45-20=25.$

Finally,

$\left|5A^{-1}\right|=\frac{125}{\det(A)}=\frac{125}{25}=5.$

Answer: 5.

Question45

Let A and G denote the arithmetic mean and geometric mean of positive real numbers 5^x and 5^{1-x}. Then the minimum value of the expression $5^x + 5^{1-x}$ where $x \in R$ is

Options:

A. $2\sqrt{5}$

B. 0

C. 1

D. $\sqrt{5}$

Answer: A

Solution:

We want to minimize

$S(x) = 5^x + 5^{1-x}, \quad x \in \mathbb{R}.$

By AM–GM on the two positive terms:

$\frac{5^x + 5^{1-x}}{2} \;\geq\; \sqrt{5^x \cdot 5^{1-x}} = \sqrt{5^{\,x+1-x}} = \sqrt{5}.$

Hence

$5^x + 5^{1-x} \;\geq\; 2\sqrt{5}.$

Equality holds when $5^x = 5^{1-x}$, i.e.\

$x = 1 - x \quad \Longrightarrow \quad x = \frac{1}{2}.$

So the minimum value is

$\boxed{2\sqrt{5}},$

which is Option A.

Question46

In a triangle ABC the coordinate of the vertex A is $(1, 2)$. Equations of the median through B and C are respectively $x + y = 5$ and $x = 4$. Then the equation of side $\mathbf{AB}$ is

Options:

A. $2x - 3y + 4 = 0$

B. $2x + 3y = 8$

C. $3x - 2y + 1 = 0$

D. $3x + 2y = 5$

Answer: B

Solution:

Let A=(1,2), B=(x_1,y_1), C=(x_2,y_2).

Median from C is x=4.

So C has x_2=4.

The midpoint of AB is ((1+x_1)/2, (2+y_1)/2), and it lies on x=4 ⇒ (1+x_1)/2=4 ⇒ x_1=7.

Median from B is the line x+y=5.

B=(7,y_1) lies on x+y=5 ⇒ 7+y_1=5 ⇒ y_1=−2, so B=(7,−2).

The midpoint of AC is ((1+4)/2, (2+y_2)/2)=(5/2,(2+y_2)/2), also on x+y=5 ⇒

$\frac{5}{2} + \frac{2+y_2}{2} = 5 \implies 7 + y_2 = 10 \implies y_2 = 3,$

so C=(4,3).

Equation of AB through A(1,2) and B(7,−2):

Slope m = (−2−2)/(7−1)=−4/6=−2/3.

Point-slope: y−2=−(2/3)(x−1) ⇒ 2x+3y=8.

Answer: 2x+3y=8 (Option B).

Question47

The radius of the circle passes through the foci of a conic $\frac{x^2}{16} + \frac{y^2}{9} = 1$ and has its centre at $(0, 3)$, then the diameter of the circle is ---

Options:

A. 7 units

B. $2\sqrt{12}$ units

C. 8 units

D. 4 units

Answer: C

Solution:

We have the ellipse

$$\frac{x^2}{16} + \frac{y^2}{9} = 1$$

For this ellipse:

- $a^2 = 16 \Rightarrow a = 4$ (semi-major axis along the x-axis)
- $b^2 = 9 \Rightarrow b = 3$

The distance of each focus from the center is

$$c^2 = a^2 - b^2 = 16 - 9 = 7 \Rightarrow c = \sqrt{7}$$

So the foci are at $(\pm\sqrt{7}, 0)$.

The circle's center is at $(0, 3)$, and its radius passes through the foci — meaning each focus lies on the circle.
So the radius r is the distance from $(0, 3)$ to either focus, say $(\sqrt{7}, 0)$:

$$r^2 = (\sqrt{7} - 0)^2 + (0 - 3)^2 = 7 + 9 = 16 \Rightarrow r = 4$$

Hence the **diameter** of the circle is

$$2r = 2 \times 4 = 8 \text{ units.}$$

Answer: 8 units.

Question48

If $A = \{1, 2, 4\}$ $B = \{2, 4, 5\}$ $C = \{2, 5\}$ then $(A - B) \cap (B - C) =$

Options:

A. $\{2, 4, 5\}$

B. $\{1, 2, 4, 5\}$

C. $\emptyset$

D. $\{4, 5\}$

Answer: C

Solution:

Let's work it out step by step:

A – B = { x∈A | x∉B }

A={1,2,4}, B={2,4,5} ⇒ A–B={1}

B – C = { x∈B | x∉C }

B={2,4,5}, C={2,5} ⇒ B–C={4}

(A–B) ∩ (B–C) = {1} ∩ {4} = ∅

So the answer is the empty set, Option C.

Question49

$\int \frac{dx}{x\sqrt{4x^2-9}} =$

Options:

A. $\frac{2}{3}\log\left|\frac{x-3}{x+3}\right| + c$

B. $\frac{4}{3}\tan^{-1}\left(\frac{\sqrt{4x^2-9}}{3}\right) + c$

C. $\frac{2}{3}\log\left|\frac{x+3}{x-3}\right| + c$

D. $\frac{1}{3}\tan^{-1}\left(\frac{\sqrt{4x^2-9}}{3}\right) + c$

Answer: D

Solution:

The easiest way is a secant-substitution. Set

$x = \frac{3}{2}\sec\theta, \quad dx = \frac{3}{2}\sec\theta\tan\theta\,d\theta, \quad \sqrt{4x^2-9} = 3\tan\theta.$

Then

$\int \frac{dx}{x\sqrt{4x^2-9}} = \int \frac{\frac{3}{2}\sec\theta\tan\theta\,d\theta}{\left(\frac{3}{2}\sec\theta\right)(3\tan\theta)} = \frac{1}{3}\int d\theta = \frac{\theta}{3} + C.$

Since $\tan\theta = \dfrac{\sqrt{4x^2-9}}{3}$, we get

$\int \frac{dx}{x\sqrt{4x^2-9}} = \frac{1}{3}\tan^{-1}\left(\frac{\sqrt{4x^2-9}}{3}\right) + C.$

That's Option D.

Question50

In the interval $(0,1)$ the function $f(x) = x^2 - x + 1$ is

Options:

A. Strictly decreasing

B. Increasing

C. Neither increasing nor decreasing

D. Decreasing

Answer: C

Solution:

First, compute the derivative:

$f'(x) = 2x - 1.$

On the interval $0 < x < 1$:

For $0 < x < \frac{1}{2}$, $2x - 1 < 0$, so f is decreasing there.

For $\tfrac12, so$ is increasing there.

Because it decreases on $(0, \frac{1}{2})$ and increases on $(\frac{1}{2}, 1)$, it's not monotonic over the whole $(0,1)$.

Answer: Option C (Neither increasing nor decreasing).

Question51

If $|\vec{a}| = 2\sqrt{2}$ and $|\vec{b}| = 3$ and angle between $\vec{a}$ and $\vec{b}$ is $\frac{\pi}{4}$. If a parallelogram is constructed with adjacent sides $\vec{p} = 2\vec{a} - 3\vec{b}$ and $\vec{q} = \vec{a} + \vec{b}$ then the product of length of both the diagonals is :

Options:

A. $12\sqrt{26}$

B. 6

C. $60\sqrt{2}$

D. $18\sqrt{260}$

Answer: A

Solution:

First, note the two diagonals of the parallelogram are

• $d_1 = p + q = (2a - 3b) + (a + b) = 3a - 2b$

• $d_2 = p - q = (2a - 3b) - (a + b) = a - 4b$

We want $|d_1| \cdot |d_2|$. Compute step by step:

Compute the dot-products and magnitudes you'll need:

• $|a|^2 = (2\sqrt{2})^2 = 8$

• $|b|^2 = 3^2 = 9$

• $a \cdot b = |a|\,|b| \cos(\pi/4) = (2\sqrt{2})(3)(\sqrt{2}/2) = 6$

$|d_1|^2 = |3a - 2b|^2$

$= 9|a|^2 + 4|b|^2 - 2 \cdot 3 \cdot 2\,(a \cdot b)$

$= 9 \cdot 8 + 4 \cdot 9 - 12 \cdot 6$

$= 72 + 36 - 72$

$= 36$

$\Rightarrow |d_1| = 6$

$|d_2|^2 = |a - 4b|^2$

$= |a|^2 + 16|b|^2 - 2 \cdot 1 \cdot 4\,(a \cdot b)$

$= 8 + 144 - 8 \cdot 6$

$= 8 + 144 - 48$

$= 104$

$\Rightarrow |d_2| = \sqrt{104} = 2\sqrt{26}$

Product of the lengths

$|d_1| \cdot |d_2| = 6 \cdot (2\sqrt{26}) = 12\sqrt{26}$

Answer: $12\sqrt{26}$ (Option A)

Question52

The value of $\tan^{-1}\left(\tan\frac{7\pi}{6}\right)$ is

Options:

A. $\frac{\pi}{6}$

B. $\frac{\pi}{3}$

C. $\frac{5\pi}{6}$

D. $\frac{7\pi}{6}$

Answer: A

Solution:

To find $y = \tan^{-1}\left(\tan\frac{7\pi}{6}\right)$, follow these steps:

Note the principal range of $\tan^{-1} x$ is

$-\frac{\pi}{2} < y < \frac{\pi}{2}$.

Compute

$\tan\left(\frac{7\pi}{6}\right) = \tan\left(\pi + \frac{\pi}{6}\right) = \tan\left(\frac{\pi}{6}\right) = \frac{1}{\sqrt{3}}$.

Since $\frac{1}{\sqrt{3}}$ lies in the range of $\tan^{-1}$, we get

$y = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) = \frac{\pi}{6}$.

Answer: $\frac{\pi}{6}$ (Option A).

Question53

The cofactor of the element a_{21} in the expansion of $\Delta = \begin{vmatrix} 1 & 4 & 4 \\ -3 & 5 & 9 \\ 2 & 1 & 2 \end{vmatrix}$ is

Options:

A. 5

B. -24

C. -4

D. -5

Answer: C

Solution:

Let's find the cofactor C_{21} of a_{21} (the entry in row 2, column 1).

Identify $a_{21} = -3$.

Form the minor M_{21} by deleting row 2 and column 1, leaving the 2×2 matrix

$\begin{pmatrix} 4 & 4 \\ 1 & 2 \end{pmatrix}$.

Compute its determinant:

$M_{21} = \det\begin{pmatrix} 4 & 4 \\ 1 & 2 \end{pmatrix} = 4 \cdot 2 \;-\; 4 \cdot 1 = 8 - 4 = 4.$

Apply the sign factor:

$C_{21} = (-1)^{2+1} M_{21} = (-1)^3 \cdot 4 = -4.$

Answer: -4 (Option C).

Question54

If for real values of x, $\cos\theta = x + \frac{1}{x}$, then X

Options:

A. θ is an obtuse angle.

B. No value of θ is possible

C. θ is right angle

D. θ is an acute angle

Answer: B

Solution:

Let's look at the range of

$f(x) = x + \frac{1}{x}\,,\ x \neq 0.$

For $x > 0$, by AM–GM:

$x + \frac{1}{x} \geq 2\,,$ with equality at $x = 1$.

For $x < 0$, set $y = -x > 0$ gives

$x + \frac{1}{x} = -\left(y + \frac{1}{y}\right) \leq -2\,,$ with equality at $y = 1$ $(x = -1)$.

So

$f(x) \in (-\infty, -2] \cup [2, \infty)\,.$

But for a real angle θ,

$\cos\theta \in [-1, 1]\,.$

There is no overlap between $[-1, 1]$ and $(-\infty, -2] \cup [2, \infty)$, so

no real θ can satisfy

$\cos\theta = x + \frac{1}{x}\,.$

Answer: Option B (no value of θ is possible).

Question55

Solution of the differential equation $y\frac{dy}{dx} + x = 0$ represents a family of

Options:

A. Ellipse

B. Parabola

C. Circles

D. Hyperbola

Answer: C

Solution:

First, rewrite and separate variables:

$y\,\frac{dy}{dx} + x = 0 \implies y\,\frac{dy}{dx} = -x$

$y\,dy = -\,x\,dx$

Now integrate both sides:

$$\int y\,dy = -\int x\,dx$$

$\frac{y^2}{2} = -\frac{x^2}{2} + C$

Multiply through by 2 and rearrange:

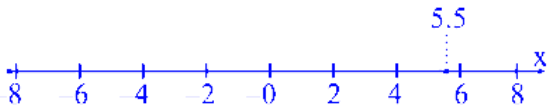
$$x^2 + y^2 = 2C \ = \ K \quad (K > 0)$$

This is the equation of a circle (centered at the origin, radius $\sqrt{K}$).

Answer: Option C (Circles).

Question56

The inequality representing the following graph is



Options:

A. $x \in \left(\frac{11}{2}, \infty\right)$

B. $x \in \left[\frac{11}{2}, \infty\right)$

C. $x \in \left(-\infty, \frac{11}{2}\right)$

D. $x \in \left(-\infty, \frac{11}{2}\right]$

Answer: C

Solution:

From the graph, the open circle is at **5.5**, which is the same as

$$5.5 = \frac{11}{2}.$$

Because the point is **open**, the value $x = 5.5$ is **not included**, and the shading extends to the **left**, meaning all numbers **less than** 5.5.

So the inequality is:

$$x < \frac{11}{2}$$

In interval notation, that is:

$$(-\infty, \tfrac{11}{2})$$

✔ Correct answer: C

Question57

Position vector of P and Q are $\hat{\imath} + 3\hat{\jmath} - 7\hat{k}$ and $5\hat{\imath} - 2\hat{\jmath} + 4\hat{k}$ respectively. Then the cosine of the angle between $\overrightarrow{PQ}$ and y -axis is

Options:

A. $\frac{4}{\sqrt{162}}$

B. $\frac{5}{\sqrt{162}}$

C. $-\frac{5}{\sqrt{162}}$

D. $-\frac{4}{\sqrt{162}}$

Answer: C

Solution:

Let P = (1, 3, −7) and Q = (5, −2, 4). The angle between $\overrightarrow{PQ}$ and the y-axis satisfies

Compute $\overrightarrow{PQ}$:

$\overrightarrow{PQ} = Q - P = (5-1)\,\hat{\imath} + (-2-3)\,\hat{\jmath} + (4-(-7))\,\hat{k} = 4\,\hat{\imath} - 5\,\hat{\jmath} + 11\,\hat{k}$

Its magnitude:

$|\overrightarrow{PQ}| = \sqrt{4^2 + (-5)^2 + 11^2} = \sqrt{16 + 25 + 121} = \sqrt{162}$

The y-axis direction is $\hat{\jmath}$. So

$\cos\theta = \frac{\overrightarrow{PQ}\cdot\hat{\jmath}}{|\overrightarrow{PQ}|\ |\hat{\jmath}|} = \frac{-5}{\sqrt{162}}$.

Answer: $-\dfrac{5}{\sqrt{162}}$ (Option C).

Question58

Domain of the function $f(x) = \sqrt{\sin^{-1}(2x) + \frac{\pi}{6}}$ for real valued of x is

Options:

A. $\left[-\frac{1}{4},\quad \frac{1}{2}\right]$

B. $\left[-\frac{1}{2}, \frac{1}{2}\right]$

C. $\left[-\frac{1}{4}, \frac{1}{4}\right]$

D. $\left(-\frac{1}{2},\quad \frac{1}{9}\right)$

Answer: A

Solution:

Let’s find all real x for which

1) $\sin^{-1}(2x)$ is defined, and

2) the expression under the square-root is nonnegative.

Step 1. Domain of $\sin^{-1}(2x)$

We need $-1 \le 2x \le 1$, i.e. $x \in \left[-\frac{1}{2},\ \frac{1}{2}\right]$.

Step 2. Nonnegativity under the square-root

Require

$\sin^{-1}(2x) + \frac{\pi}{6} \ge 0 \quad\Longrightarrow\quad \sin^{-1}(2x) \ge -\frac{\pi}{6}$.

Since $\sin^{-1} u$ is increasing on $[-1, 1]$, this is equivalent to

$2x \ge \sin\left(-\frac{\pi}{6}\right) = -\frac{1}{2} \quad\Longrightarrow\quad x \ge -\frac{1}{4}$.

Combining both conditions gives

$x \in \left[-\frac{1}{4},\ \frac{1}{2}\right]$.

Answer: Option A.

Question59

Shortest distance between the lines $\vec{r} = (8 + 3\lambda)\hat{i} - (9 + 16\lambda)\hat{j} + (10 + 7\lambda)\hat{k}$ and $\vec{r} = 15\hat{i} + 29\hat{j} + 5\hat{k} + \mu(3\hat{i} + 8\hat{j} - 5\hat{k})$ is

Options:

A. 3 units

B. 7 units

C. 14 units

D. 2 units

Answer: C

Solution:

Identify a point and direction on each line

• Line 1:

– Point $P_1 = (8,\ -9,\ 10)$

– Direction $\mathbf{d}_1 = (3,\ -16,\ 7)$

• Line 2:

– Point $P_2 = (15,\ 29,\ 5)$

– Direction $\mathbf{d}_2 = (3,\ 8,\ -5)$

Compute the cross product

$$\mathbf{d}_1 \times \mathbf{d}_2 = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 3 & -16 & 7 \\ 3 & 8 & -5 \end{vmatrix} = (24,\ 36,\ 72)$$

Its magnitude is

$$\left|\mathbf{d}_1 \times \mathbf{d}_2\right| = \sqrt{24^2 + 36^2 + 72^2} = 84.$$

Form the connector vector

$$\overrightarrow{P_1P_2} = P_2 - P_1 = (15 - 8,\ 29 - (-9),\ 5 - 10) = (7,\ 38,\ -5).$$

Compute the scalar triple product (absolute)

$$\left|\overrightarrow{P_1P_2} \cdot (\mathbf{d}_1 \times \mathbf{d}_2)\right| = |(7, 38, -5) \cdot (24, 36, 72)| = |7 \cdot 24 + 38 \cdot 36 - 5 \cdot 72| = |1176| = 1176.$$

Plug into the distance formula

Distance $= \frac{1176}{84} = 14.$

Answer: 14 units (Option C).

Question60

$\lim_{x\to 1} \frac{(\sqrt{x}-1)(2x-3)}{2x^2+x-3}$ **is**

Options:

A. $\frac{1}{10}$

B. 0

C. 1

D. $-\frac{1}{10}$

Answer: D

Solution:

$L = \lim_{x\to 1} \frac{(\sqrt{x}-1)(2x-3)}{2x^2+x-3}$.

Factor the quadratic in the denominator:

$2x^2 + x - 3 = (x-1)(2x+3)$.

Rewrite $\sqrt{x} - 1$ using a conjugate trick:

$\sqrt{x} - 1 = \frac{x-1}{\sqrt{x}+1}$.

Substitute both into the original expression:

$$\frac{(\sqrt{x}-1)(2x-3)}{2x^2+x-3} = \frac{\dfrac{x-1}{\sqrt{x}+1}\,(2x-3)}{(x-1)(2x+3)} = \frac{2x-3}{(\sqrt{x}+1)(2x+3)}, \quad x \neq 1.$$

Now take $x \to 1$:

$L = \frac{2\cdot 1-3}{(\sqrt{1}+1)(2\cdot 1+3)} = \frac{-1}{(1+1)\,5} = -\frac{1}{10}$.

So the limit equals $-\frac{1}{10}$, which is Option D.

Chemistry

Question1

An organic compound $\mathrm{A}\ (\mathrm{C_5H_9\ N})$ upon reaction with $\mathrm{Na/Hg/C_2H_5OH}$ gives compound B . B reacts with $\mathrm{NaNO_2/HCl}$ at 274 K to form C with quantitative liberation of $\mathrm{N_2}$ gas. B also reacts with Hinsberg's reagent to form a compound which is soluble in alkali. Identify compound B.

Options:

A. $[(CH_3)_3 - N - CH_2CH_3]^+$

B. $CH_3 - (CH_2)_3 - NH - CH_3$

C. $CH_3 - (CH_2)_4 - NH_2$

D. $CH_3 - (CH_2)_2 - N - (CH_3)_2$

Answer: C

Solution:

Let's look at the behaviour of B:

Na/Hg/EtOH reduction of A (C_5H_9N) introduces two H's to give B;

B + $NaNO_2$/HCl at 274 K → N_2 (quantitative) ⇒ B must be a primary aliphatic amine (only R–NH_2 gives unstable alkyldiazonium that explodes to N_2);

B + Hinsberg's reagent → sulfonamide soluble in alkali ⇒ again only R–NH_2 (the N–H of a primary sulfonamide can be deprotonated).

Among the options the only primary amine is

CH_3–$(CH_2)_4$–NH_2

(Option C).

Question2

The $E^o_{M^{3+}/M^{2+}}$ values for Cr, Mn, Fe and Co are $-0.41, +1.57, +0.77$ and +1.97 V respectively.

For which of these metals, the change in oxidation state from +2 to +3 is the easiest?

Options:

A. Fe

B. Mn

C. Cr

D. Co

Answer: C

Solution:

To decide which $M^{2+} \rightarrow M^{3+}$ is easiest, note that the given potentials

$M^{3+} + e^- \rightarrow M^{2+}$ (E°_{red})

must be reversed for oxidation:

$M^{2+} \rightarrow M^{3+} + e^-$ $(E^\circ_{\text{ox}} = -E^\circ_{\text{red}})$.

The more positive E°_{ox}, the easier the oxidation. Since Cr^{3+}/Cr^{2+} has the most negative reduction potential (–0.41 V), it gives the most positive oxidation potential (+0.41 V).

Answer: Option C, Cr.

Question3

Given are 4 pairs of covalent molecules. Identify the pair in which both molecules have the same shape.

Options:

A. XeF_2 & $HgCl_2$

B. BF_3 & NH_3

C. XeF4 & SF_4

D. BrF_5 & PCl_5

Answer: A

Solution:

The only pair that share the same molecular shape is Option A.

XeF_2

– Electron-pair geometry: trigonal–bipyramidal

– Lone pairs: 3 (all equatorial)

– Molecular shape: linear

$HgCl_2$

– Electron-pair geometry: linear (no lone pairs on central Hg)

– Molecular shape: linear

All the others differ (BF_3 is trigonal-planar vs NH_3 pyramidal; XeF_4 square-planar vs SF_4 seesaw; BrF_5 square-pyramidal vs PCl_5 trigonal-bipyramidal). Therefore, Option A is correct.

Question4

Lead storage battery contains $4.25M H_2SO_4$ which has a density of $1.24\ g/ml$. Calculate the molality of aqueous solution of H_2SO_4.

Options:

A. 6.264

B. 3.427

C. 5.161

D. 4.108

Answer: C

Solution:

To find the molality b (moles of solute per kg of solvent) from molarity and density:

Determine mass of 1 L solution

Density = 1.24 g/mL ⇒ $\text{mass}_{\text{soln}}$ = 1 000 mL × 1.24 g/mL = 1240 g

Find mass of H_2SO_4 in that liter

Molarity = 4.25 mol/L

Molar mass $M_{H_2SO_4} \approx 98.08$ g/mol

$m_{\text{solute}} = 4.25 \text{ mol} \times 98.08 \text{ g/mol} = 417.3 \text{ g}$

Compute mass of solvent (water)

$m_{\text{solvent}} = 1240 \text{ g} - 417.3 \text{ g} = 822.7 \text{ g} = 0.8227 \text{ kg}$

Calculate molality

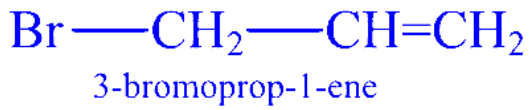
$b = \frac{\text{moles solute}}{\text{kg solvent}} = \frac{4.25 \text{ mol}}{0.8227 \text{ kg}} \approx 5.17 \text{ mol/kg}$

Answer: about 5.16 m, so option C.

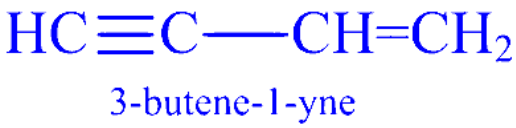
Question5

Which of the following is the correct name according to IUPAC rules?

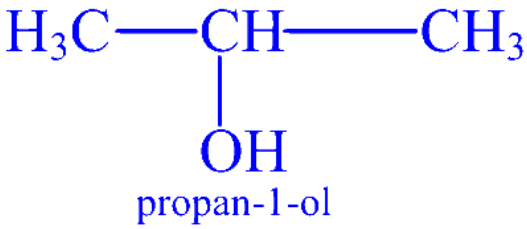
Options:

A. 

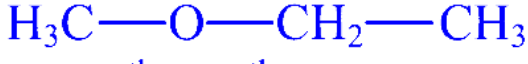
3-bromoprop-1-ene

B. 

3-butene-1-yne

C. 

propan-1-ol

D. 

ethoxymethane

Answer: A

Solution:

The correct option is **(A)**.

1. **A) 3-bromoprop-1-ene**
   - **Structure:** $\mathrm{Br-CH_2-CH=CH_2}$
   - **Parent Chain:** The longest carbon chain containing the principal functional group (the double bond) has 3 carbons, so the root is **prop-**.
   - **Functional Group:** The double bond makes it an alkene (**-ene**).
   - **Numbering:** We number the chain starting from the end closest to the double bond.

$$\mathrm{Br-C_3H_2-C_2H=C_1H_2}$$

   - **Locants:** The double bond starts at carbon 1 (prop-**1-ene**). The bromo (Br) substituent is on carbon 3 (**3-bromo**).
   - **Final Name:** 3-bromoprop-1-ene.
   - **Verdict: This name is correct.**

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2. **B) 3-butene-1-yne**
   - **Structure:** $\mathrm{HC\equiv C-CH=CH_2}$
   - **Rule:** When a chain contains both a double bond (ene) and a triple bond (yne), we number from the end that gives the lowest locant to the *first* multiple bond. If there is a tie, the double bond (ene) gets the lower number.
   - **Numbering (Right to Left):** $\mathrm{HC\equiv C_3-C_2H=C_1H_2}$. Locants are 1 (ene) and 3 (yne).
   - **Numbering (Left to Right):** $\mathrm{HC_1\equiv C_2-C_3H=C_4H_2}$. Locants are 1 (yne) and 3 (ene).
   - **Applying the Tie-breaker:** Since both directions give the locant set {1, 3}, the double bond gets the lower number. Thus, numbering from the right is correct.
   - **Correct Name:** But-1-ene-3-yne.
   - **Verdict:** The given name (3-butene-1-yne) is **incorrect**.

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3. **C) propan-1-ol**
   - **Structure:** $\mathrm{H_3C-CH(OH)-CH_3}$
   - **Parent Chain:** The longest chain has 3 carbons (prop-).
   - **Functional Group:** The alcohol (-OH) makes it an alkanol (**-ol**).
   - **Numbering:** We number the chain to give the -OH group the lowest possible number.

$$\mathrm{C_1H_3-C_2H(OH)-C_3H_3}$$

   - **Locant:** The -OH group is on carbon 2.
   - **Correct Name:** propan-2-ol. (The name propan-1-ol refers to $\mathrm{CH_3CH_2CH_2OH}$).
   - **Verdict:** The given name (propan-1-ol) is **incorrect**.

4. **D) ethoxymethane**
    - **Structure:** $H_3C - O - CH_2 - CH_3$
    - **Rule (Ethers):** Ethers are named as alkoxyalkanes. The *longer* carbon chain is the parent alkane, and the *shorter* chain (with the oxygen) is the alkoxy substituent.
    - **Chains:** We have a methyl group (1 carbon) and an ethyl group (2 carbons).
    - **Parent Chain:** The longer chain is ethyl, so the parent name is **ethane**.
    - **Substituent:** The shorter chain is methyl + oxygen, which is **methoxy**.
    - **Correct Name:** Methoxyethane.
    - **Verdict:** The given name (ethoxymethane) is **incorrect**.

Question6

The Enthalpy of combustion of 1.0 mole of a reactive metal X at $27^{\circ}C$ and 1.0 bar pressure to form a solid oxide (XO) is $-601.83\ kJ/mol$. The Internal energy change for this reaction is _____ kJ. $\left(R = 8.314j\ K^{-1}\ mol^{-1}\right)$

Options:

A. 701.33

B. 754.58

C. −614.30

D. −600.58

Answer: D

Solution:

First write the reaction and count $\Delta n_{(gas)}$:

$X(s) + ½\ O_2(g) \rightarrow XO(s)$

$\Delta n_{(gas)} = 0 - ½ = -½$

We have the relation

$\Delta H = \Delta U + \Delta n_{gas}\, RT$

so

$\Delta U = \Delta H - \Delta n_{gas}\, RT = -601.83\ \text{kJ} - (-\frac{1}{2})(8.314\ \text{J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1})(300\ \text{K})$

Convert R T term to kJ:

$\frac{1}{2} \cdot 8.314 \cdot 300 = 1247.1\ J = 1.2471\ kJ.$

Thus

$\Delta U = -601.83\ \text{kJ} + 1.2471\ \text{kJ} = -600.58\ \text{kJ}$

Answer: –600.58 kJ (Option D).

Question7

The ionisation constant of the weak acid HF whose concentration is 0.1 M is 3.5×10^{-4} The Equilibrium constant value for the reaction $F^- + H_2O \leftrightharpoons HF + OH^-$ is _____ and the pH of aqueous solution of the weak acid is _____ .

Options:

A. $\mathrm{K_{eq}} = 4.4 \times 10^{-11} \& \mathrm{pH} = 4.25$

B. $\mathrm{K_{eq}} = 3.58 \times 10^{-11} \& \mathrm{pH} = 4.19$

C. $\mathrm{K_{eq}} = 2.86 \times 10^{-11} \& \mathrm{pH} = 3.23$

D. $\mathrm{K_{eq}} = 3.92 \times 10^{-10} \& \mathrm{pH} = 4.07$

Answer: C

Solution:

Let HF ionize as

$HF \rightleftharpoons H^+ + F^-$

with Ka = 3.5×10⁻⁴ and C₀ = 0.10 M.

Equilibrium constant for

$F^- + H_2O \rightleftharpoons HF + OH^-$

is the base-dissociation constant of F⁻:

$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{3.5 \times 10^{-4}} = 2.86 \times 10^{-11}$

pH of 0.10 M HF:

Approximate $[H^+] \approx \sqrt{K_a\, C_0}$, so

$[H^+] \approx \sqrt{(3.5 \times 10^{-4})(0.10)} \approx 5.9 \times 10^{-3}\, M$

$\text{pH} = -\log[H^+] \approx 2.23$

Among the given options the only one matching the correct K_b is C.

Question8

An Alkene " X " on reaction with hot acidified $\mathrm{KMnO_4}$ gave a mixture of Ethanoic acid and Propanone. Identify " X ".

Options:

A. Pent-2-ene

B. 2-Methylbut-2-ene.

C. But-2-ene

D. 2,3 -Dimethylbut-2-ene

Answer: B

Solution:

Let’s look at how hot, acidified $KMnO_4$ oxidatively cleaves a C=C bond:

Any sp^2-C bearing at least one H becomes a carboxylic acid:

R–CH= → R–COOH

Any sp^2-C bearing no H (i.e. fully substituted) becomes a ketone:

$R_2C=$ → $R_2C=O$

We need one fragment to be ethanoic acid (CH_3COOH) and the other to be propanone (CH_3COCH_3). That implies:

One alkene carbon is CH–R (it has one H and an R = CH_3) → gives CH_3COOH.

The other is C–$(CH_3)_2$ (no H, two methyls) → gives $(CH_3)_2CO$.

The corresponding alkene is thus CH_3–CH= $C(CH_3)_2$, i.e. 2-methylbut-2-ene.

Reaction in LaTeX:

$$\mathrm{CH_3CH=C(CH_3)_2} \xrightarrow{\mathrm{KMnO_4/H^+}} \mathrm{CH_3COOH + (CH_3)_2CO}$$

Answer: Option B) 2-Methylbut-2-ene.

Question9

Imagine an R - moiety of a pentapeptide molecule having one $-\mathrm{SH}, -\mathrm{CONH_2}, -\mathrm{NH_2}$ groups each and two $-$COOH groups in the amino acids forming the pentapeptide. If the pH is maintained at 13.2, what would be the total number of negative charges on the pentapeptide?

Options:

A. 4

B. 2

C. 3

D. 5

Answer: C

Solution:

Given

A pentapeptide with R-groups containing:

- 1 –SH group
- 1 $–CONH_2$ group
- 1 $–NH_2$ group
- 2 –COOH groups

At **pH = 13.2** (very strongly basic).

We must determine the **total number of negative charges** on the pentapeptide.

Step 1 — Identify which groups can become negatively charged

At high pH, **acidic groups lose H^+ → become negatively charged.**

The relevant acidic groups:

1. –COOH groups (carboxylic acids)

pKa ≈ 2–4
At pH 13.2 >> pKa → **fully deprotonated → become $–COO^-$**

There are **2 –COOH → 2 negative charges**

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2. –SH group (thiol)

pKa ≈ 8–10
At pH 13.2 >> pKa → **fully deprotonated → becomes $–S^-$**

So **–SH → $–S^-$ → 1 negative charge**

Step 2 — Identify groups that do NOT contribute negative charge

$-CONH_2$

Amide group → **cannot ionize**, stays neutral.

$-NH_2$

Amino group pKa ≈ 9–10

At pH 13.2 >> pKa → **deprotonated and neutral** (NOT negative).

(Remember: $NH_3^+ \leftrightarrow NH_2$; NH_2 is neutral, never negative.)

Step 3 — Count the negative charges

Group	# of groups	Charge per group	Total
$-COO^-$	2	−1	−2
$-S^-$	1	−1	−1
$-CONH_2$	1	0	0
$-NH_2$	1	0	0

Total negative charges = −2 + −1 = −3

✔ Final Answer: 3

Question10

An aqueous solution which contains 42% by weight (w/W) of a volatile liquid "A" of molar mass of $140\ g/mol$, has a vapour pressure of 2141.4 mm of Hg at $37^\circ C$. What is the vapour pressure of the pure liquid " A "? Vapour pressure of water at $37^\circ C$ is 2019.1 mm .

Options:

A. 3457.6 mm

B. 293 mm

C. 2356.4 mm

D. 2519.2 mm

Answer: A

Solution:

Assume 100 g of solution

– mass of A = 42 g

– mass of water = 58 g

Compute moles

– $n_A = \dfrac{42}{140} = 0.300 \text{ mol}$

– $n_w = \dfrac{58}{18} \approx 3.222 \text{ mol}$

Mole fractions

– $n_{\text{tot}} = 0.300 + 3.222 = 3.522 \text{ mol}$

– $x_A = \dfrac{0.300}{3.522} \approx 0.0852$

– $x_w = \dfrac{3.222}{3.522} \approx 0.9148$

Raoult's law for a mixed vapor (both components volatile):

$P_{\text{tot}} = x_w \overset{\circ}{P}_w + x_A \overset{\circ}{P}_A$

We know

$P_{\text{tot}} = 2141.4\,, \quad \overset{\circ}{P}_w = 2019.1\,,$

so

$2141.4 = 0.9148 \times 2019.1 + 0.0852 \times \overset{\circ}{P}_A.$

Solve for $\overset{\circ}{P}_A$:

$2141.4 - (0.9148 \times 2019.1) = 0.0852\,\overset{\circ}{P}_A \implies \overset{\circ}{P}_A \approx \frac{2141.4 - 1846.7}{0.0852} \approx 3458 \text{ mm Hg}.$

That matches Option A: **3457.6 mm Hg**.

Question11

What would be the cell potential for the Galvanic cell which is represented by the electrochemical reaction: $2\text{Cr}_{(\text{S})} + 3\text{Fe}^{2+}(0.02\text{M}) \rightarrow 2\text{Cr}^{3+}(0.2\text{M}) + 3\text{Fe}$ $\text{E}^0\text{Fe}^{2+}/\text{Fe} = -0.42\text{ V} \quad \text{E}^0\text{Cr}^{3+}/\text{Cr} = -0.72\text{ V}$

Options:

A. 0.3197 V

B. 0.3364 V

C. 0.2636 V

D. 0.2803 V

Answer: C

Solution:

Let's work it out step by step:

Identify half-reactions (as reductions) and their standard potentials:

• Cathode:

$\text{Fe}^{2+} + 2e^- \longrightarrow \text{Fe} \quad E^0_{\text{red}} = -0.42\,\text{V}$

• Anode (written as reduction, but it will be reversed):

$\text{Cr}^{3+} + 3e^- \longrightarrow \text{Cr} \quad E^0_{\text{red}} = -0.72\,\text{V}$

Standard cell potential:

$E^0_{\text{cell}} = E^0_{\text{cathode}} - E^0_{\text{anode}} = (-0.42) - (-0.72) = +0.30\,\text{V}$

Overall reaction (balanced for electrons):

$2\,\mathrm{Cr}(s) + 3\,\mathrm{Fe}^{2+} \rightarrow 2\,\mathrm{Cr}^{3+} + 3\,\mathrm{Fe}(s)$

transfers $n = 6$ electrons.

Reaction quotient:

$Q = \frac{[\mathrm{Cr}^{3+}]^2}{[\mathrm{Fe}^{2+}]^3} = \frac{(0.20)^2}{(0.02)^3} = 5000$

Apply the Nernst equation at 25 °C:

$E_{\text{cell}} = E^0_{\text{cell}} - \frac{0.0592}{n}\log_{10} Q = 0.30 - \frac{0.0592}{6}\log_{10}(5000) \approx 0.2636\,\mathrm{V}$

That corresponds to **Option C: 0.2636 V**.

Question12

The hydrogenation of Ethyne is carried out at 600 K . The same reaction when carried out in presence of a catalyst maintaining the same rate constant, the temperature required is only 400 K . If the catalyst lowers the Activation energy of the reaction by $20\ \mathrm{kJ/mol}$, what is the value of $\mathrm{E_a}$?

Options:

A. $60\ \mathrm{kJ/mol}$

B. $100\ \mathrm{kJ/mol}$

C. $50\ \mathrm{kJ/mol}$

D. $80\ \mathrm{kJ/mol}$

Answer: A

Solution:

We use the Arrhenius equation

$k = A\,e^{-E_a/(RT)}$

Since the uncatalyzed reaction at $T_1 = 600\,\mathrm{K}$ and the catalyzed one at $T_2 = 400\,\mathrm{K}$ have the same k, and the catalyst lowers the barrier by $\Delta E = 20\,\mathrm{kJ/mol}$, we set

$A\,e^{-E_a/(R\,T_1)} \;=\; A\,e^{-(E_a-\Delta E)/(R\,T_2)}$

Taking logs and rearranging:

$-E_a/(R\,T_1) = -(E_a - \Delta E)/(R\,T_2)$

$\frac{E_a}{T_1} = \frac{E_a - \Delta E}{T_2}$

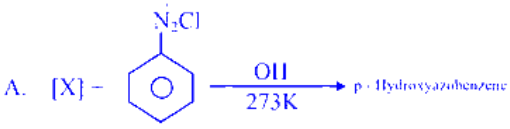
$E_a\,(T_2 - T_1) = -\,\Delta E\,T_1$

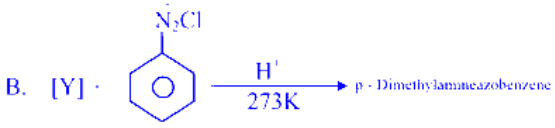
$E_a = \frac{\Delta E\,T_1}{T_1 - T_2} = \frac{20\,\mathrm{kJ/mol} \times 600}{600 - 400} = 60\,\mathrm{kJ/mol}.$

Answer: 60 kJ/mol (Option A).

Question13

Complete the following 2 reactions A \& B by choosing appropriate reactants $[\mathrm{X}]\&[\mathrm{Y}]$.





Options:

A.

$[\mathrm{X}] = \mathrm{C_6H_5CHO} \qquad [\mathrm{Y}] = \mathrm{CH_3 - CO - CH_3}$

B.

$[\mathrm{X}] = \mathrm{C_6H_5Br} \qquad [\mathrm{Y}] = \mathrm{CH_3CH_2 - N - (CH_3)_2}$

C.

$[\mathrm{X}] = \mathrm{C_6H_5OH} \qquad [\mathrm{Y}] = \mathrm{C_6H_5 - N - (CH_3)_2}$

D.

$[\mathrm{X}] = \mathrm{C_6H_5NH_2} \qquad [\mathrm{Y}] = \mathrm{C_6H_5OH}$

Answer: C

Solution:

Solution:

This is a **diazonium coupling** problem. The benzene diazonium chloride shown will undergo electrophilic substitution with **activated aromatic rings**.

Reaction A

Product: **p-Hydroxyazobenzene**

To obtain this, the coupling component must be **phenol (C_6H_5OH)**, because phenol couples at the para-position to give p-hydroxyazobenzene.

So,

- **[X] = C_6H_5OH**

Reaction B

Product: **p-Dimethylaminoazobenzene**

This is formed when benzene diazonium chloride couples with **N,N-dimethylaniline**, which is **$C_6H_5–N(CH_3)_2$**.

So,

- **[Y] = $C_6H_5–N(CH_3)_2$**

✓ Correct Answer: Option C

Question14

The time needed for completion of 80% is y times the half-life period of a first order reaction. What is the value of y ?

Options:

A. 0.648

B. 3.46

C. 2.32

D. 0.322

Answer: C

Solution:

First-order decay follows

$[A]_t = [A]_0 e^{-kt}$.

For 80 % completion, 20 % remains, so

$e^{-kt_{80}} = 0.20 \implies kt_{80} = \ln \frac{1}{0.20} = \ln 5.$

The half-life is $t_{1/2} = \frac{\ln 2}{k}$.

Their ratio is

$y = \frac{t_{80}}{t_{1/2}} = \frac{\ln 5/k}{\ln 2/k} = \frac{\ln 5}{\ln 2} \approx \frac{1.609}{0.693} \approx 2.32.$

Answer: 2.32 (Option C).

Question15

A current of 1.5 A is passed for 2 hours through an aqueous solution of $\mathrm{PdXn_n}$ where X is a monovalent anion. During the electrolysis process 2.977 g of Palladium metal gets deposited at the cathode. Calculate the charge on Pd ions. (Atomic mass of $\mathrm{Pd} = 106.4\ \mathrm{g/mol}$).

Options:

A. $\mathrm{n} = 4$

B. $\mathrm{n} = 6$

C. $\mathrm{n} = 3$

D. $\mathrm{n} = 2$

Answer: A

Solution:

Total charge passed

$Q = I \times t = 1.5\ \mathrm{A} \times (2\,\mathrm{h} \times 3600\,\mathrm{s/}h) = 1.5 \times 7200 = 10800\ \mathrm{C}$

Moles of electrons delivered

$n_e = \frac{Q}{F} = \frac{10800}{96485} \approx 0.112\ \mathrm{mol\ e^-}$

Moles of Pd deposited

$n_{\mathrm{Pd}} = \frac{\text{mass}}{\text{Molar mass}} = \frac{2.977\ \mathrm{g}}{106.4\ \mathrm{g/mol}} \approx 0.0280\ \mathrm{mol}$

Electrons per Pd atom (i.e. cation charge)

valency $n = \frac{n_e}{n_{\mathrm{Pd}}} \approx \frac{0.112}{0.0280} \approx 4$

Answer: n = 4 (Option A).

Question16

Choose the statements which are incorrect in the case of Lanthanoids.

A. Ce^{4+} is diamagnetic while Sm^{3+} is paramagnetic.

B. The atomic size of the transition metals having atomic number greater than 71 are very close to that of the elements above them.

C. Lanthanoids react with hot water forming water soluble $Ln(OH)_3$ with the liberation of O_2.

D. The general electronic configuration of Lanthanoids is $(n-2)f^{1-14}5\,d^{0}6\,s^{2}$, where $n = 6$.

Options:

A. C & D

B. B & D

C. A & B

D. A & D

Answer: A

Solution:

The incorrect statements are C and D (Option A).

Statement C is wrong because lanthanoids react with water to give hydrogen gas, not oxygen, and their hydroxides are sparingly soluble.

$2\,Ln + 6\,H_2O \longrightarrow 2\,Ln(OH)_3 + 3\,H_2$

Statement D is too restrictive. While many lanthanoids follow

$[Xe]\,4f^{n}5d^{0}6s^{2}$,

several (La, Ce, Gd, etc.) actually have a 5d electron:

– La: $[Xe]\,5d^{1}6s^{2}$ (f^{0})

– Ce: $[Xe]\,4f^{1}5d^{1}6s^{2}$

– Gd: $[Xe]\,4f^{7}5d^{1}6s^{2}$

Statements A and B are correct.

Question17

Larger number of oxidation states are exhibited by the actinoids than those of lanthanoids. The reason is:

Options:

A. Lesser energy difference between 5 f and 6 d than between 4 f and 5 d orbitals

B. More energy difference between 5 f and 6 d than between 4 f and 5 d orbitals

C. 4 f orbitals are more diffused than 5 f orbitals

D. Highly reactive nature of the actinoids

Answer: A

Solution:

The correct answer is Option A.

Reasoning:

In actinoids, the energy gap between the 5f and 6d orbitals is relatively small.

Because these orbitals lie close in energy, electrons from both 5f and 6d (and even 7s) can participate in bonding.

This flexibility allows actinoids to exhibit a wide range of oxidation states (from +3 up to +7 in early actinoids).

By contrast, in the lanthanoids the 4f–5d energy gap is much larger. The deeply buried 4f electrons are less available for bonding, so lanthanoids are mostly restricted to the +3 state (with a few +2 or +4 exceptions).

Question18

Given below are 2 statements: one Assertion and the other Reason. Which one of the following options is correct?

Assertion : Sulphur dioxide and Hydrogen peroxide can act as both oxidising and reducing agents but Nitric acid can act as only oxidising agent.

Reason : Sulphur and Oxygen can exhibit more than one stable oxidation states while Nitrogen does not.

Options:

A. Assertion is correct but Reason is wrong.

B. Both Assertion and Reason are wrong.

C. Both Assertion and Reason are correct.

D. Assertion is wrong but Reason is correct.

Answer: A

Solution:

Option A

• Assertion is correct

– In SO_2 (S oxidation state +4) you can oxidise it to SO_4^{2-} (S +6) or reduce it to S^0, so it acts as both a reducing and an oxidising agent.

– In H_2O_2 (O oxidation state –1) you can oxidise it to O_2 (O^0) or reduce it to H_2O (O –2), so it too is amphiprotic in redox terms.

– In HNO_3 (N oxidation state +5, the maximum for nitrogen) it can only be reduced (i.e. it behaves solely as an oxidising agent).

• Reason is wrong

– Nitrogen actually exhibits multiple stable oxidation states (from –3 up to +5), so the statement “Nitrogen does not” is false.

Question19

From among the 4 given compounds identify the compounds which possess a net dipole moment.

A. cis-1,2-Dichloroethene

B. Tetrachloromethane

C. o-Dichlorobenzene

D. trans 2,3-Dibromobut-2-ene

Options:

A. A and D

B. D and B

C. A and C

D. B and C

Answer: C

Solution:

The only polar molecules are cis-1,2-dichloroethene (A) and o-dichlorobenzene (C). Hence the correct choice is Option C (A and C).

• cis-1,2-Dichloroethene (A)

– Two C–Cl bond dipoles point roughly in the same direction, so they don't cancel.

– Net dipole $\vec{\mu}_{\text{net}} = \vec{\mu}_{C\text{–}Cl_1} + \vec{\mu}_{C\text{–}Cl_2} \neq 0$.

• Tetrachloromethane (B)

– Tetrahedral symmetry makes all C–Cl dipoles cancel (non-polar).

• o-Dichlorobenzene (C)

– The two adjacent C–Cl dipoles are separated by 60°, so their vector sum is nonzero.

• trans-2,3-Dibromobut-2-ene (D)

– Two C–Br dipoles are exactly opposite (180°), so they cancel (non-polar).

Question20

Which is the correct order of increasing number of unpaired electrons in the following ions?

$$\mathrm{A} = \mathrm{Cr}^{2+}(\mathrm{Z}=24) \mathrm{B} = \mathrm{Cu}^{2+}(\mathrm{Z}=29) \quad \mathrm{C} = \mathrm{Ni}^{2+}(\mathrm{Z}=28) \mathrm{D} = \mathrm{Fe}^{3+}(\mathrm{Z}=26)$$

Options:

A. $\mathrm{B} < \mathrm{C} < \mathrm{A} < \mathrm{D}$

B. $\mathrm{D} < \mathrm{C} < \mathrm{A} < \mathrm{B}$

C. $\mathrm{B} < \mathrm{C} < \mathrm{D} < \mathrm{A}$

D. $\mathrm{C} < \mathrm{B} < \mathrm{D} < \mathrm{A}$

Answer: A

Solution:

Let's work out the d-electron counts and unpaired electrons in each ion:

Cr^{2+} (Z = 24)

– Neutral Cr: $[\mathrm{Ar}]\,3d^5\,4s^1$

– Cr^{2+} loses the 4s electron and one 3d electron → $[\mathrm{Ar}]\,3d^4$

– Four d-electrons occupy four orbitals singly ⇒ 4 unpaired electrons

Fe^{3+} (Z = 26)

– Neutral Fe: $[\mathrm{Ar}]\,3d^6\,4s^2$

– Fe^{3+} loses two 4s and one 3d → $[\mathrm{Ar}]\,3d^5$

– Five d-electrons each in a separate orbital ⇒ 5 unpaired electrons

Ni^{2+} (Z = 28)

– Neutral Ni: $[\mathrm{Ar}]\,3d^8\,4s^2$

– Ni^{2+} loses the two 4s electrons → $[\mathrm{Ar}]\,3d^8$

– Hund's rule: 5 orbitals get 5 electrons singly, the remaining 3 pair up ⇒ 2 unpaired electrons

Cu^{2+} (Z = 29)

– Neutral Cu: $[\mathrm{Ar}]\,3d^{10}\,4s^1$

– Cu^{2+} loses 4s and one 3d → $[\mathrm{Ar}]\,3d^9$

– Nine electrons fill 4 orbitals completely and leave 1 singly occupied ⇒ 1 unpaired electron

Summarizing unpaired electrons:

• Cu^{2+} (B): 1

• Ni^{2+} (C): 2

• Cr^{2+} (A): 4

• Fe^{3+} (D): 5

So in order of increasing unpaired electrons:

B < C < A < D

That corresponds to Option A.

Question21

Which one of the following is incorrect?

Options:

A. Rate constant equals the rate of reaction when concentration of reactants equals unity.

B. Larger the value of rate constant (k) value faster is the chemical reaction.

C. The unit for rate constant for n^{th} order reaction is $\left(\mathrm{molL}^{-1}\right)^{n-1}\,\mathrm{s}^{-1}$

D. The value of rate constant (k) is independent of concentration of reactants.

Answer: C

Solution:

The incorrect statement is Option C.

Explanation:

• For an n^{th}-order reaction,

Rate = $k\,[A]^n$ and Rate has units mol L^{-1} s^{-1}.

So

$[k] = \frac{\text{mol L}^{-1}\,\text{s}^{-1}}{(\text{mol L}^{-1})^n} = \text{mol}^{1-n}\,\text{L}^{n-1}\,\text{s}^{-1}$.

• Option C claims the units are

$(\text{mol L}^{-1})^{n-1}\,\text{s}^{-1} = \text{mol}^{n-1}\,\text{L}^{-(n-1)}\,\text{s}^{-1}$,

which is the reciprocal of the correct form.

All other options are true:

A) If [reactants] = 1, Rate = k.

B) Larger k → faster reaction.

D) k does not depend on reactant concentrations.

Question22

A dilute solution of $\mathrm{K_2HgI_4}$ reagent is 95% ionised. What would be the approximate value of its van't Hoff factor?

Options:

A. 1.85

B. 1.50

C. 2.05

D. 2.90

Answer: D

Solution:

Here's the quick way to see it:

• $K_2HgI_4 \rightleftharpoons 2\ K^+ + HgI_4^{2-}$, so if fully dissociated you'd get n = 3 ions.

• Degree of dissociation α = 0.95.

• The van't Hoff factor is

$i = 1 + \alpha\,(n-1) = 1 + 0.95 \times (3-1) = 1 + 1.90 = 2.90.$

So the closest choice is **2.90 (Option D)**.

Question23

For a hypothetical chemical reaction $\mathrm{A_2} + 3\ \mathrm{B_2} +$ Heat $\cdots \rightarrow 2\mathrm{AB_3}$, which one of the following combinations of state variables would support the spontaneity of the reaction at a particular temperature?

Options:

A. $\Delta \mathrm{H} < 0, \Delta\ \mathrm{S} > 0, \Delta \mathrm{G} > 0$

B. $\Delta \mathrm{H} > 0, \Delta\ \mathrm{S} > 0, \Delta \mathrm{G} < 0$

C. $\Delta \mathrm{H} > 0, \Delta\ \mathrm{S} < 0, \Delta \mathrm{G} < 0$

D. $\Delta \mathrm{H} > 0, \Delta\ \mathrm{S} < 0, \Delta \mathrm{G} > 0$

Answer: B

Solution:

First, recall the criterion for spontaneity at constant T and P:

$\Delta G = \Delta H - T\Delta S < 0$.

• The reaction as written "+ Heat →" means it absorbs heat, so it is endothermic:

$\Delta H > 0$.

• To make $\Delta G < 0$ with a positive ΔH, you need

$T\,\Delta S > \Delta H \quad \Longrightarrow \quad \Delta S > 0.$

Among the options, only B has

• $\Delta H > 0$

• $\Delta S > 0$

• $\Delta G < 0$

Answer: Option B.

Question24

Choose the incorrect statement from the following.

Options:

A. CH_2Cl_2 is widely used as a propellant in aerosols.

B. DDT was widely used because of its effectiveness against mosquitos that spread malaria

C. Freon 1, 2 is manufactured from trichloromethane by Swartz reaction

D. Antiseptic property of Iodoform is due to the liberation of I_2 when it comes in contact with skin

Answer: C

Solution:

The incorrect statement is Option C.

Explanation:

Freon-12 (dichlorodifluoromethane, CCl_2F_2) is made by fluorinating carbon tetrachloride (CCl_4), not trichloromethane ($CHCl_3$).

• Swarts reaction (halogen exchange) example:

$$CCl_4 + 2\,HF \xrightarrow{SbCl_5} CCl_2F_2 + 2\,HCl$$

By contrast:

• Option A: Methylene chloride (CH_2Cl_2) has indeed been used as an aerosol propellant/solvent.

• Option B: DDT was widely employed because it effectively killed malaria-carrying mosquitoes.

• Option D: Iodoform's antiseptic action comes from slow release of I_2 on contact with skin.

Question25

Which one of the following compounds will give a yellow precipitate when reacted with $I_2/NaOH$?

Options:

A. C_6H_5OH

B. $C_6H_5CH_2OH$

C. $(CH_3)_3C-OH$

D. $C_6H_5CHOH-CH_3$

Answer: D

Solution:

The Iodoform test (I_2/NaOH) gives a yellow precipitate of CHI_3 only when the substrate has a $–COCH_3$ group or a $–CHOH–CH_3$ fragment.

– Option A (phenol) and B (benzyl alcohol) lack any $CH_3–CHOH$ or $CH_3–CO$ unit.

– Option C (tert-butanol) is a tertiary alcohol and cannot be oxidized to a methyl ketone.

– Option D, $C_6H_5–CHOH–CH_3$ (1-phenylethanol), contains a $–CHOH–CH_3$ group and on oxidation gives acetophenone ($PhCOCH_3$), which then undergoes the haloform reaction to yield CHI_3.

Answer: Option D.

Question26

Identify X and Y formed in the following two reactions.

(i) Decan-1-ol $\xrightarrow{\text{Jones reagent}}$ X

(ii). Sodium salt of X $\xrightarrow{\text{NaOH/CaO},\Delta}$ Y

Options:

A. A. X = Decanoic acid Y = Nonane

B. X = Octanoic acid Y = Heptane.

C. X = 1− Methoxy nonane Y = Octane.

D. X = Decan-2-one Y = Octane.

Answer: A

Solution:

When you oxidize decan-1-ol with Jones reagent (CrO_3/H_2SO_4), the primary alcohol goes all the way to the carboxylic acid.

So

• X = decanoic acid.

Heating its sodium salt (sodium decanoate) with soda-lime (NaOH/CaO, Δ) decarboxylates it, giving the C_9 alkane: nonane.

So

• Y = nonane.

That corresponds to Option A.

Question27

Choose the incorrect statement.

Options:

A. The increasing order of boiling points of 5 compounds having comparable molar masses is as follows: Methoxyethane < Propanone < Propanal < Propan-1-ol

B. During nucleophilic addition of HCN to RCHO , the hybridisation changes from sp^2 to sp^3 and a tetrahedral intermediate is formed.

C. Acetone undergoes Wolff Kishner reaction to yield Propane.

D. The order of reactivity towards Nucleophilic attack is Methanal > Di-tert.butyl ketone > Benzaldehyde > Acetophenone

Answer: A

Solution:

The two statements that are actually incorrect are A and D:

Option A: “Methoxyethane < Propanone < Propanal < Propan-1-ol”

– Propanone (acetone) boils at 56 °C, whereas propanal boils at 49 °C.

– The correct increasing b.p. order is

• Methoxyethane (–24 °C)

• Propanal (49 °C)

• Propanone (56 °C)

• Propan-1-ol (97 °C)

Option D: “Reactivity toward nucleophiles: Methanal > Di-tert-butyl ketone > Benzaldehyde > Acetophenone”

– Steric hindrance and electron-donation by the two tert-butyl groups make di-tert-butyl ketone the least reactive.

– Benzaldehyde is more reactive than acetophenone (only one electron-donating CH_3 vs. conjugated phenyl) and far more reactive than a heavily hindered aliphatic ketone.

– The correct electrophilic order is roughly

Formaldehyde > Benzaldehyde > Acetophenone > Di-tert-butyl ketone.

Statements B and C are both correct.

Question28

Match A, B, C and D with the appropriate functions given.

	Column I		Functions
A.	Oxidoreductase	P.	Malfunctioning leads to Addison's disease.
B.	Phosphodiester bonds	Q.	Regulates responses to external stimuli.
C.	Adrenal cortex	R.	Catalyses glycolysis.
D.	Epinephrine	S.	Links nucleotides together.

Options:

A. $\mathrm{A = R \quad B = S \quad C = Q \quad D = P}$

B. $\mathrm{A = R \quad B = S \quad C = P \quad D = Q}$

C. $\mathrm{A = R \quad B = P \quad C = S \quad D = Q}$

D. $\mathrm{A = Q \quad B = R \quad C = S \quad D = P}$

Answer: B

Solution:

Here's the correct pairing:

• A (Oxidoreductase) → R (catalyses glycolysis)

• B (Phosphodiester bonds) → S (links nucleotides together)

• C (Adrenal cortex) → P (malfunctioning leads to Addison's disease)

• D (Epinephrine) → Q (regulates responses to external stimuli)

In shorthand:

$A = R, \quad B = S, \quad C = P, \quad D = Q$

So the answer is Option B.

Question29

Two statements, One Assertion and the other Reason, are given.

Which one of the following is the correct option?

Assertion: The acid strength of 4 compounds in the descending order is p-Nitrophenol > p-Methoxyphenol > Phenol > p-chlorophenol.

Reason: Electron withdrawing groups increase the acid strength while Electron donating groups decrease the acid strength of Phenol and its derivatives.

Options:

A. Assertion is correct but Reason is wrong.

B. Both Assertion and Reason are wrong.

C. Assertion is wrong but Reason is correct.

D. Both Assertion and Reason are correct.

Answer: C

Solution:

The correct choice is Option C.

• The Reason is true: electron-withdrawing groups (–I/–R) stabilize the phenoxide anion and so increase acidity, while electron-donating groups (+ R/ + I) destabilize it and so decrease acidity.

• The Assertion's order is wrong. The actual acid strengths (descending) are

p-Nitrophenol (strongest, $–NO_2$ is a strong EWG)

p-Chlorophenol (–Cl is a moderate EWG)

Phenol

p-Methoxyphenol ($–OCH_3$ is an EDG)

Hence: Assertion wrong but Reason correct.

Question30

Identify the incorrect statement.

Options:

A. When (—)-2-bromooctane is reacted with aqueous KOH , the substitution follows S_N2 mechanism and product formed is (—) -Octan-2-ol.

B. Benzylic halides show higher reactivity towards S_N1 reaction.

C. The reaction of $C_6H_5CH_2 - CHCl - C_6H_5$ with alc. KOH on heating yields two products.

D. Optically active (-)-2-Methylbutan-1-ol on reaction with HCl yields a product $(+)$-1-Chloro-2-methylbutane.

Answer: A

Solution:

The statement in Option A is incorrect.

– In an SN2 reaction the configuration at the stereogenic centre is inverted.

– Starting from (–)-2-bromooctane, attack by OH^- inverts the configuration, giving (+)-2-octanol, not (–)-2-octanol.

Question31

Arrange the following ions in the decreasing order of covalent double bonds formed by the transition metal with oxygen.

A. $=$ chromate $B =$ permanganate $C =$ dichromate

Options:

A.

$A > B > C$

B.

$B > C > A$

C.

$B > A > C$

D.

$C > B > A$

Answer: D

Solution:

A = Chromate (CrO_4^{2-})

Structure:

- Tetrahedral
- **4 Cr=O double bonds**

B = Permanganate (MnO_4^-)

Structure:

- Tetrahedral
- **4 Mn=O double bonds**
  However, Mn is in **+7 oxidation state**, giving **stronger M=O bonding** than in chromate (Cr^{6+}).
  Thus, **each double bond is stronger** than in chromate.

C = Dichromate ($Cr_2O_7^{2-}$)

Structure:

- Two Cr centers
- Total of **6 Cr=O double bonds**
  (each Cr has 3 terminal Cr=O double bonds, plus a bridging oxygen that is not a double bond)

So dichromate has **the largest number** of M=O double bonds.

Final Order (Decreasing M=O double bonds):

C > B > A

✔ **Dichromate > Permanganate > Chromate**

Question32

Which one of the following structures in Column I does not have the correct IUPAC name as given in Column II.

S.No.	Structure		IUPAC name
A.	$[CoBr_2(en)_2]Cl$	P.	Dibromidodi-(ethan-1, 2 - diamine)cobalt (III) chloride
B.	$Na\,[PtBrCl\,(NO_2)\,(NH_3)]$	Q.	Sodium amminebromidochloridonitrito- N - palatinate(II)
C.	$[Cr(H_2O)_2(NH_3)_4Cl]SO_4$	R.	Tetraamminediaquachloridochromium (III) sulphate.
D.	$[Pt(NH_3)_4]\,[PtCl_4]$	S.	Tetraammineplatinum (II) tetrachloridoplatinate (II)

Options:

A. B

B. A

C. D

D. C

Answer: B

Solution:

Let’s check each pairing:

A ↔ P

– [$CoBr_2(en)_2$]Cl is correctly named “dibromido(diethane-1,2-diamine)cobalt(III) chloride.”

– P matches.

C ↔ R

– $[Cr(H_2O)_2(NH_3)_4Cl]_2^{+}\cdot SO_4^{2-}$ is “tetraamminediaquachloridochromium(III) sulfate.”

– R matches.

D ↔ S

– $[Pt(NH_3)_4]^{2+}$ is “tetraammineplatinum(II)” and $[PtCl_4]^{2-}$ is “tetrachloridoplatinate(II).”

– S matches.

B ↔ Q

– The given name Q (“sodium amminebromidochloridonitrito-N-palatinate(II)”) is flawed:

• It misspells “platinate” as “palatinate.”

• Nitrite bound via N should be “nitro-κN” (or simply “nitro”), not “nitrito-N.”

– Q is incorrect.

Therefore the only wrong match is B.

Answer: B.

Question33

When $0.4\ \mathrm{g CH_3COOH}$ is added to 40 g of Benzene to form a solution, the freezing point is depressed by $0.45^{\circ}\mathrm{C}$. If Acetic acid undergoes dimerisation in Benzene ($\mathrm{K_f = 5.12\ K\ kg/mol}$) what is the percentage association of the acid in Benzene?

Options:

A. 50.12

B. 47.2

C. 94.54

D. 20.10

Answer: C

Solution:

To find the percentage of acetic-acid molecules that associate into dimers in benzene, let α be the fraction (by mole) that dimerizes:

Calculate the moles of CH_3COOH added:

$n_0 = \frac{0.4\ \text{g}}{60\ \text{g/mol}} = 0.006667\ \text{mol}$

When monomers associate into dimers ($2A \rightleftharpoons A_2$), the van ’t Hoff factor is

$i = \frac{\text{total particles}}{n_0} = 1 - \frac{\alpha}{2}$

The observed freezing-point depression is

$\Delta T_f = K_f \cdot m_{\text{eff}} = K_f \, \frac{i\, n_0}{\text{kg solvent}} = K_f \, \frac{(1-\alpha/2)\, n_0}{0.04}$

Solve for α:

$1 - \frac{\alpha}{2} = \frac{\Delta T_f\,(0.04)}{K_f\, n_0} = \frac{0.45 \times 0.04}{5.12 \times 0.006667} \approx 0.5273 \quad \Longrightarrow \quad \alpha = 2\,(1 - 0.5273) \approx 0.9454$

Percentage association = $\alpha \times 100\% \approx$ **94.54%**

Answer: Option C (94.54).

Question34

Two subatomic particles 1 and 2, with the same kinetic energies have their de-Broglie wavelengths as $\lambda_1 \& \lambda_2$ and masses as 3 m and 6 m respectively. Determine the ratio $\lambda_1 : \lambda_2$.

Options:

A. $2 : 1$

B. $1 : 2$

C. $\sqrt{2} : 1$

D. $1 : \sqrt{2}$

Answer: C

Solution:

Since both particles have the same kinetic energy K, their de Broglie wavelengths satisfy

$\lambda = \frac{h}{p}$ and $K = \frac{p^2}{2m} \implies p = \sqrt{2mK} \implies \lambda = \frac{h}{\sqrt{2mK}}$

So at fixed K,

$\lambda \propto \frac{1}{\sqrt{m}}$.

For particle 1 ($m_1 = 3m$) and particle 2 ($m_2 = 6m$),

$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2}{m_1}} = \sqrt{\frac{6m}{3m}} = \sqrt{2}$.

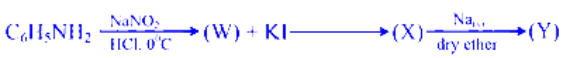
Hence

$\lambda_1 : \lambda_2 = \sqrt{2} : 1$

Option C.

Question35

Identify the product (Y) formed in the given reaction and the name of the reaction where $(\mathrm{X}) \rightarrow (\mathrm{Y})$.



Options:

A. $Y =$ Ethoxybenzene Wurtz-Fittig reaction

B. $\mathrm{Y} =$ Diphenyl Fittig reaction

C. $\mathrm{Y} = 1,4$ - Diiodobenzene Wurtz reaction

D. $Y =$ Iodobenzene Sandmeyer's reaction

Answer: B

Solution:

Step 1: Identify (W) from Aniline ($C_6H_5NH_2$)

Aniline is treated with **$NaNO_2$ + HCl at 0°C**, which forms a **diazonium salt**:

$$C_6H_5NH_2 \xrightarrow{NaNO_2/HCl,\,0^\circ C} C_6H_5N_2^+Cl^- \quad (W)$$

So,

(W) = Benzene diazonium chloride

Step 2: Reaction of Diazonium Salt with KI → (X)

Diazonium salts react with **KI** to give **iodobenzene**:

$$C_6H_5N_2^+Cl^- + KI \rightarrow C_6H_5I \quad (X)$$

So,

(X) = Iodobenzene

Step 3: Reaction of Aryl Halide (X) with Na metal in dry ether → (Y)

An aryl halide treated with **sodium metal in dry ether** undergoes **Fittig reaction**:

$$2\,C_6H_5I + 2Na \rightarrow C_6H_5{-}C_6H_5 + 2NaI$$

This forms **diphenyl (biphenyl)**.

Thus,

(Y) = Diphenyl (Biphenyl)

Final Answer

✅ **Y = Diphenyl**

✅ **Reaction: Fittig Reaction**

Correct option: (B)

Question36

Choose the correct statement:

Options:

A. Aliphatic amines are weaker bases than NH_3 while aromatic amines are stronger bases than NH_3.

B. Gabriel phthalimide synthesis is used for preparing both Ethyl amine and Aniline.

C. Anilinium ion is less resonance stabilised than Aniline.

D. Sec-butylamine is optically inactive because Nitrogen atom of the $-NH_2$ group is achiral.

Answer: C

Solution:

The correct answer is Option C.

Reasoning:

In aniline ($C_6H_5NH_2$), the lone pair on N can delocalize into the aromatic ring, giving significant resonance stabilization.

In the anilinium ion ($C_6H_5NH_3^+$), that lone pair is tied up in bonding to H^+, so it can't delocalize → much less resonance stabilization.

All other options are false:

A is backwards: aliphatic amines are stronger bases than NH_3; aromatic (aniline) is weaker.

B is wrong because Gabriel synthesis works only for alkyl halides, not aryl halides (so you can't make aniline that way).

D is false since sec-butylamine ($CH_3CH(NH_2)CH_2CH_3$) has a stereogenic carbon at C-2 and can be optically active; the achirality of N doesn't erase a chiral C.

Question37

A transition metal M forms 4 homoleptic octahedral coordination compounds, A, B, C and D of the type $[MX_6]^{z-}$ with monodentate ligands a, b, c and d respectively. These compounds absorb red. blue. yellow and blue-green light respectively. Which one of the options shows the correct order of decreasing ligand strength?

Options:

A. $B > D > C > A$

B. $D > C > B > A$

C. $A > C > D > B$

D. $A > B > C > D$

Answer: A

Solution:

Ligand strength in an octahedral complex is proportional to the crystal-field splitting Δ, which in turn is the energy of the absorbed photon:

$\Delta = \frac{hc}{\lambda}$

– shorter λ ⇒ larger Δ ⇒ stronger ligand.

Compounds absorb:

• A → red (≈700 nm) ⇒ smallest Δ

• C → yellow (≈580 nm)

• D → blue–green (≈490 nm)

• B → blue (≈450 nm) ⇒ largest Δ

So in order of decreasing ligand strength (largest Δ first):

B > D > C > A

That corresponds to Option A.

Question38

Which one of the following is the correct statement?

Options:

A. Fructose exists as a five membered ring named furanose.

B. Glucose gives Saccharic acid on reaction with Br_2 water.

C. Amylose is a water insoluble branched chain polymer of $\alpha - D - (-)$-glucose.

D. Cellulose is a branched chain polysaccharide having only $\propto$-D-glucose units.

Answer: A

Solution:

The only correct statement is Option A.

• Fructose readily cyclizes via its C-2 keto group and C-5 OH to form a five-membered hemiacetal ring, known as a furanose.

• The other options are false:

– Glucose + $Br_2/H_2O \rightarrow$ gluconic acid (not saccharic acid).

– Amylose is a linear (unbranched), water-soluble α-D-glucose polymer.

– Cellulose is an unbranched β-D-glucose polymer.

Question39

(i) and (ii) are 2 chemical reactions carried out at TK.

(i). $X \rightarrow Y + W$ with k_1 as rate constant.

(ii). $X \rightarrow Z + W$ with k_2 as rate constant.

The Activation energy for reaction (ii) is 3 times that of reaction (i). What is the expression for k_1 ?

Options:

A. $k_1 = -2k_2e^{2Ea_1/RT}$

B. $k_1 = k_2e^{2Ea_1/RT}$

C. $k_1 = 2k_2e^{Ea_1/RT}$

D. $k_1 = k_2/2e^{-Ea_1/RT}$

Answer: B

Solution:

Using the Arrhenius equation

$k = A\,e^{-E_a/(RT)}$

and noting that $E_{a2} = 3E_{a1}$, we get

$\frac{k_1}{k_2} = \frac{A\,e^{-E_{a1}/(RT)}}{A\,e^{-3E_{a1}/(RT)}} = e^{2E_{a1}/(RT)}$.

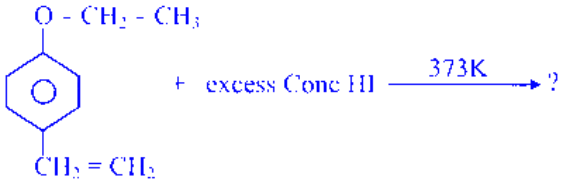
Hence

$\boxed{k_1 = k_2\,e^{2E_{a1}/(RT)}}$

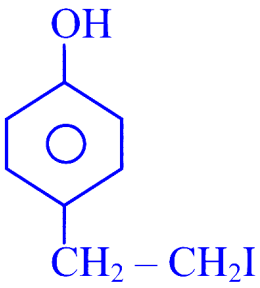
which is Option B.

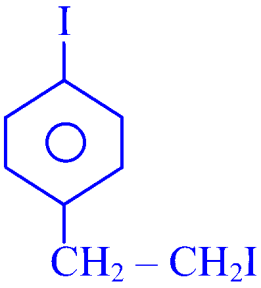
Question40

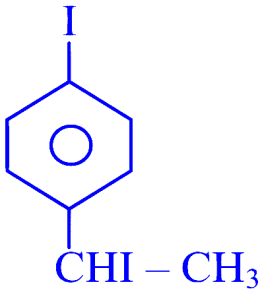
Which one of the following is the major product formed when the given reaction occurs?

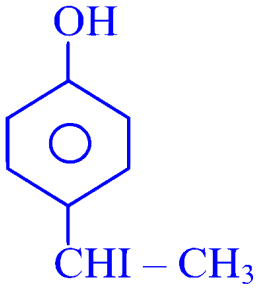


Options:

A. 

B. 

C. 

D. 

Answer: D

Solution:

Given Reaction

A phenyl ether:

$$\mathrm{Ph{-}O{-}CH(CH_3){-}CH_3}$$

with an **isopropyl group on oxygen** (i-propyl phenyl ether), and an **allyl substituent on the ring** ($CH_2{=}CH_2$ shown, likely allyl).

Reagent: **excess conc. HI at 373 K**

Key Concepts

1. Reaction of ethers with HI

Hot concentrated HI cleaves ethers by **SN1 or SN2**, depending on the alkyl group attached to oxygen:

- Cleavage tends to occur at the **alkyl–oxygen** bond, NOT the aryl–oxygen bond
  (C–O–aryl bond cannot undergo SN1/SN2 cleavage).
- The isopropyl group gets protonated and then cleaves to give **isopropyl iodide**:

$$\mathrm{Ph{-}O{-}iPr + HI \rightarrow Phenol + i\text{-}propyl\ iodide}$$

So you ALWAYS get **phenol as the aromatic product.**

---

2. What happens to the side chain?

The aromatic ring already has a substituent ($CH_2{=}CH_2$). That group stays untouched because HI under these conditions cleaves ethers, not alkenes on a ring.

Thus aromatic product = **phenol with the original side-chain still attached.**

The only change is:
O–iPr → OH, and the iPr becomes **i-propyl iodide.**

3. Compare with options

Correct major product: phenol with $CHI{-}CH_3$ (isopropyl iodide) leaving group?

Option **D** shows:

- A phenol ring
- With **the side chain unchanged**
- And isopropyl group converted to **$CHI{-}CH_3$**, meaning the leaving group is i-propyl iodide.

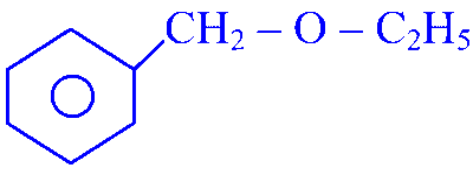
This matches the expected products of ether cleavage.

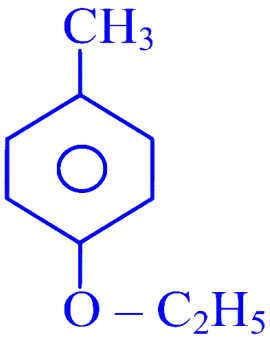
✅ Final Answer: Option D

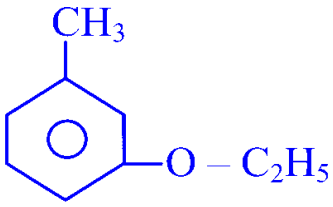
Question41

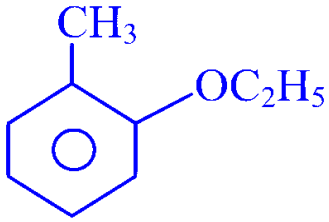
Toluene when reacted with Cl_2 gas at 385 K forms a product X which undergoes further reaction with Sodium ethoxide to yield product Y . The structure of Y is _____ .

Options:

A. 

B. 

C. 

D. 

Answer: A

Solution:

Solution:

1. **First reaction:**
   Toluene ($C_6H_5–CH_3$) reacts with **Cl_2 at 385 K** → this temperature favors **side-chain chlorination**, not ring chlorination.
   Thus, the product **X** is **benzyl chloride**:

$$C_6H_5CH_2Cl$$

2. **Second reaction:**
   Benzyl chloride reacts with **sodium ethoxide (NaOEt)**.
   This undergoes a **SN2 reaction**, forming **benzyl ethyl ether**:

$$C_6H_5CH_2O–C_2H_5$$

This structure corresponds to **Option A** in your image.

✅ **Final Answer: Option A — Benzyl ethyl ether ($C_6H_5–CH_2–O–C_2H_5$)**

Question42

A dilute solution of an ionic compound A_3B has an Osmotic pressure which is 6 times that of $0.02M MgCl_2$. What is the molar concentration of A_3B assuming that it undergoes complete dissociation in water?

Options:

A. 0.03 M

B. 0.26 M

C. 0.12 M

D. 0.09 M

Answer: D

Solution:

Let's denote

• i_1, C_1 for A_3B

• i_2, C_2 for $MgCl_2$

Van 't Hoff factors (complete dissociation):

– $MgCl_2 \rightarrow Mg^{2+} + 2\ Cl^- \Rightarrow i_2 = 3$

– $A_3B \rightarrow 3\ A^+ + B^{3-} \Rightarrow i_1 = 4$

Osmotic pressure $\pi \propto i \cdot C \cdot R \cdot T$, so

$$\frac{\pi_{A_3B}}{\pi_{MgCl_2}} = \frac{i_1 C_1}{i_2 C_2} = 6$$

Plug in $i_2=3$, $C_2=0.02$ M, $i_1=4$:

$$\frac{4 C_1}{3 \times 0.02} = 6$$

$$4 C_1 = 6 \times 0.06 = 0.36$$

$$C_1 = \frac{0.36}{4} = 0.09 \text{ M}$$

Answer: 0.09 M.

Question43

An organic compound " A " reacts with Zn/Hg / Conc. HCl to form p-Xylene. It reduces Tollen's reagent and on oxidation with $KMnO_4/H^+$ it yields 1, 4-benzenedicarboxylic acid. Identify compound A.

Options:

A. p-methylbenzaldehyde.

B. p- Cresol.

C. m-Cresol.

D. 4-Methylacetophenone.

Answer: A

Solution:

The only structure that fits all three tests is p-methylbenzaldehyde (4-methylbenzaldehyde).

• Tollen's test positive ⇒ A must have an –CHO group (rules out phenols and ketones).

• Clemmensen (Zn/Hg, HCl) reduces –CHO to $–CH_3$ ⇒ p-methylbenzaldehyde becomes 1,4-dimethylbenzene (p-xylene).

• $KMnO_4/H^+$ oxidizes both the –CHO and the $–CH_3$ to –COOH ⇒ gives 1,4-benzenedicarboxylic acid (terephthalic acid).

Answer: Option A, p-methylbenzaldehyde.

Question44

The first ionisation enthalpy of Al in $kJmol^{-1}$ is: [Given the first ionisation enthalpy of Na, Mg and Si in $kJmol^{-1}$ are 497,738 and 787 respectively]

Options:

A. 769

B. 578

C. 488

D. 857

Answer: B

Solution:

The correct answer is Option B: 578 $kJ \cdot mol^{-1}$.

Why it dips at Al:

Electronic configurations

– Mg: [Ne] $3s^2$

– Al: [Ne] $3s^2$ $3p^1$

– Si: [Ne] $3s^2$ $3p^2$

Removal of a 3p electron (Al) requires less energy than removing a 3s electron (Mg), because the 3p orbital is higher in energy and more effectively shielded.

Thus

$$IE_1(Mg) = 738 \text{ kJ} \cdot \text{mol}^{-1} \quad \longrightarrow \quad IE_1(Al) = 578 \text{ kJ} \cdot \text{mol}^{-1} \quad \longrightarrow \quad IE_1(Si) = 787 \text{ kJ} \cdot \text{mol}^{-1}$$

Question45

Choose the coordination compound which does not exhibit Optical activity.

Options:

A. cis $-[PtCl_2(en)2]^{2+}$

B. $[Co(en)_3]^{3+}$

C. trans $-[CoCl_2(en)_2]^{+}$

D. cis $-[CoCl_2(en)_2]^{+}$

Answer: C

Solution:

The only complex in which a mirror-plane (or inversion center) survives is the trans isomer. In all the others the arrangement of the bidentate en ligands is helical (Δ/Λ) and you get optical isomers.

Answer: Option C,

trans–$[CoCl_2(en)_2]^{+}$ is achiral and does not show optical activity.

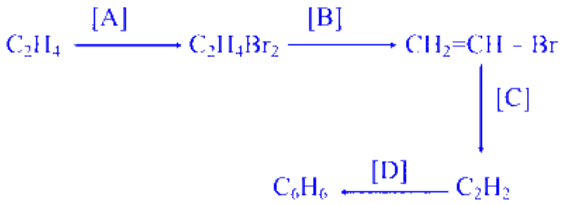
Why trans is achiral:

The two Cl^- ligands sit 180° apart, defining an inversion center (or a σ-plane through Co and bisecting opposite N–Co–N angles).

Each en chelate then sits symmetrically on either side of that element, so the mirror image is superimposable.

Question46

Identify the reagents to be used to complete the given reaction.



Options:

A.

A = Br_2/CCl_4 B = alc. KOH C = $NaNH_2$ D = Red hot Fe tube

B.

A = HBr B = alc. KOH C = CaC_2 D = Red hot Ni tube

C.

A = $CHBr_3$ *B* = aq. KOH *C* = Conc. HI *D* = Red hot Pd tube

D.

A = Br_2/CCl_4 B = aq. KOH C = Conc. H_2SO_4 D = Red hot Cu tube

Answer: A

Solution:

✅ **Correct Option: A**

Reagents:

- **A = Br_2 / CCl_4**
- **B = alc. KOH**
- **C = $NaNH_2$**
- **D = Red–hot Fe tube**

Step-wise Explanation

1. C_2H_4 → $C_2H_4Br_2$ (Reagent A: Br_2/CCl_4)

Ethene reacts with bromine in an inert solvent (CCl_4) to form **vicinal dibromoethane (ethylene dibromide)**.

2. $C_2H_4Br_2$ → CH_2=CHBr (Reagent B: alcoholic KOH)

Alcoholic KOH causes **dehydrohalogenation**, removing HBr to form **vinyl bromide** (bromoethene).

3. CH_2=CHBr → C_2H_2 (Reagent C: $NaNH_2$)

Sodium amide ($NaNH_2$) performs **dehydrohalogenation of vinyl bromide**, forming **acetylene (ethyne)**.

4. C_6H_6 → C_2H_2 (Reagent D: Red-hot Fe tube)

Passing benzene vapors over red-hot iron tube causes **cracking**, forming **acetylene**.

✓ Therefore, the correct set of reagents is:

**A = Br_2/CCl_4

B = alcoholic KOH
C = $NaNH_2$
D = Red-hot Fe tube**

This corresponds to **Option A**.

Question47

What is the standard electrode potential at 298 K for the reaction: $Cu^{2+} + 1e- \rightarrow Cu^{+1}$?

Given: $E_0Cu^{+1}/Cu = 0.5\ V \quad \& \quad E_0Cu^{+2}/Cu = 0.335\ V$

Options:

A. 0.34V

B. 0.17V

C. 0.492V

D. 0.410V

Answer: B

Solution:

To find E° for

$Cu^{2+} + e^- \longrightarrow Cu^+$,

use the known half-cell data and Gibbs energy additivity.

Write the two given half-reactions (with n electrons and their E°):

• $Cu^+ + e^- \rightarrow Cu, \quad n = 1, \quad E_1^\circ = 0.500\ V$

• $Cu^{2+} + 2e^- \rightarrow Cu, \quad n = 2, \quad E_2^\circ = 0.335\ V$

Let E_3° be the potential for

$Cu^{2+} + e^- \rightarrow Cu^+, \quad n = 1.$

Use $\Delta G^\circ = -nFE^\circ$, which is additive for sequential steps:

$\Delta G_2^\circ = \Delta G_3^\circ + \Delta G_1^\circ$.

Hence

$-2F\,E_2^\circ = -F\,E_3^\circ \;-\; F\,E_1^\circ \quad\Longrightarrow\quad E_3^\circ = 2E_2^\circ - E_1^\circ$.

Plug in numbers:

$E_3^\circ = 2(0.335) - 0.500 = 0.670 - 0.500 = 0.170\ \text{V}$.

Answer: 0.17 V (Option B).

Question48

Which one of the following molecules attains greater stability on formation of its diatomic monovalent anion?

Options:

A. C_2

B. O_2

C. N_2

D. F_2

Answer: A

Solution:

Among these, only C_2 gains a bond-strength (and thus a stability) on adding one electron. Here's why, in terms of MO bond orders:

C_2 (8 e^-)

– MO config: $\sigma 2s^2\ \sigma^*2s^2\ \pi 2p_x^2\ \pi 2p_y^2$

– Bond order = (6 bonding – 2 antibonding)/2 = 2

– C_2^- (9 e^-): the 9th e^- goes into σ2p_z (a bonding orbital)

– New bond order = (7 – 2)/2 = 2.5 → bond order ↑, more stable

N_2 (10 e^-) → N_2^- (11 e^-) adds into π*2p (antibonding) → bond order drops 3 → 2.5

O_2 (12 e^-) → O_2^- (13 e^-) adds into π*2p → bond order drops 2 → 1.5

F_2 (14 e^-) → F_2^- (15 e^-) adds into π*2p → bond order drops 1 → 0.5

Only in C_2 does the extra electron enter a bonding orbital.

Answer: Option A, C_2.

Question49

The Standard Reduction potential at 25°C for $(\text{MnO}_4)^{-1}/\text{H}^+$ is +1.49 V . The E^0 values for four Metal ions :

(a). $\text{Co}^{3+}/\text{Co}^{2+}$

(b). Cr^{3+}/Cr

(c). Au^{3+}/Au **and**

(d). Ag^{+}/Ag

are $+1.81\ \mathrm{V}, -0.74\ \mathrm{V}, +1.50\ \mathrm{V}$ and +0.8 V respectively. Identify two of them which cannot be oxidised by $(\mathrm{MnO_4})^{-1}/\mathrm{H}^+$

Options:

A. a & d

B. a & c

C. b & d

D. b & c

Answer: B

Solution:

First, recall that for a redox pair "MnO_4^-/Mn^{2+}" acting as oxidant (cathode) and a metal couple "M^{n+}/M" acting as reductant (anode), the cell voltage is

$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$

with

• $E°_{cathode} = +1.49\ V\ (MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O)$

• $E°_{anode} = E°(M^{n+} + ne^- \rightarrow M)$

For oxidation of $M \rightarrow M^{n+} + ne^-$ to be spontaneous, we need

$$E°_{\rm cell} \;>\;0\;\Longrightarrow\;E°_{\rm anode}$$

Now compare each metal's reduction potential $E°(M^{n+}/M)$ with +1.49 V:

a) $Co^{3+} + e^- \rightarrow Co^{2+}$ $E° = +1.81\ V$

• $E°_{anode} = +1.81\ V > 1.49\ V \Rightarrow E°_{cell} < 0 \Rightarrow Co^{2+}$ cannot be oxidized.

b) $Cr^{3+} + 3e^- \rightarrow Cr$ $E° = -0.74\ V$

• $-0.74\ V < 1.49\ V \Rightarrow E°_{cell} > 0 \Rightarrow$ Cr can be oxidized.

c) $Au^{3+} + 3e^- \rightarrow Au$ $E° = +1.50\ V$

• $+1.50\ V > 1.49\ V \Rightarrow E°_{cell} < 0 \Rightarrow$ Au cannot be oxidized.

d) $Ag^+ + e^- \rightarrow Ag$ $E° = +0.80\ V$

• $+0.80\ V < 1.49\ V \Rightarrow E°_{cell} > 0 \Rightarrow$ Ag can be oxidized.

Therefore the two metal couples that cannot be oxidised by MnO_4^-/H^+ are (a) Co^{3+}/Co^{2+} and (c) Au^{3+}/Au.

Answer: Option B (a & c).

Question50

The best method for the separation of *o*-nitrophenol and *p*-nitrophenol from their mixture is :

Options:

A. Crystallisation

B. Steam distillation

C. Sublimation

D. Simple distillation

Answer: B

Solution:

The best choice is Option B: steam distillation.

• Ortho-nitrophenol (2-nitrophenol) forms a strong intramolecular H-bond, exists largely as a monomer and is readily carried over with steam.

• Para-nitrophenol (4-nitrophenol) dimerizes via intermolecular H-bonds, has a much lower vapour pressure with steam and remains behind.

By passing steam through the mixture you co-distil o-nitrophenol into the receiver, then isolate p-nitrophenol from the residue.

Question51

For the reaction $\mathrm{A_2 + B_2 \cdots\cdots > 2AB}, \Delta \mathrm{H_f} = -400\ \mathrm{kJ/mol}$. The bond dissociation enthalpies of $\mathrm{A_2}$, $\mathrm{B_2}$ and AB are in the ratio $1 : 0.75 : 1$. What is the bond dissociation enthalpy of $\mathrm{B_2}$ in $\mathrm{kJ/mol}$?

Options:

A. 1600

B. 2400

C. 3200

D. 800

Answer: B

Solution:

Let’s denote the bond-dissociation enthalpies as

• D(A₂)=x

• D(B₂)=0.75 x

• D(AB)=x

Since ΔH_f of AB is –400 kJ mol⁻¹, forming 2 mol AB releases 2×(–400)=–800 kJ. By Hess’s law for

A₂ + B₂ → 2 AB

we have

$\Delta H = [D(A_2) + D(B_2)] - 2\,D(AB) = x + 0.75x - 2x = -0.25x$

Setting this equal to –800 kJ gives

$-0.25x = -800 \quad \Longrightarrow \quad x = 3200\ \text{kJ mol}^{-1}$.

Therefore

$D(B_2) = 0.75\,x = 0.75 \times 3200 = 2400\ \text{kJ mol}^{-1}$.

Answer: 2400 kJ mol⁻¹.

Question52

The correct order of spin only magnetic moments among the following is: [Given: Atomic numbers: $\mathrm{Mn} = 25, \mathrm{Fe} = 26, \mathrm{Co} = 27$]

Options:

A. $[\mathrm{Fe(CN)_6}]^{4-} > [\mathrm{MnCl_4}]^{2-} > [\mathrm{CoCl_4}]^{2-}$

B. $[\mathrm{MnCl_4}]^{2-} > [\mathrm{CoCl_4}]^{2-} > [\mathrm{Fe(CN)_6}]^{4-}$

C. $[\mathrm{Fe(CN)_6}]^{4-} > [\mathrm{CoCl_4}]^{2-} > [\mathrm{MnCl_4}]^{2-}$

D. $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$

Answer: B

Solution:

Let's work out the number of unpaired electrons (n) and the spin-only moment

$\mu_{spin} = \sqrt{n(n+2)}$ BM

for each complex:

$[Fe(CN)_6]^{4-}$

• Fe oxidation state: +2 (CN^-×6 gives –6; Fe–6=–4 ⇒ Fe=+2)

• d^6, CN^- is a strong-field ligand ⇒ low-spin t_2g^6 → n=0

• μ = √[0·(0+2)] = 0 BM

$[MnCl_4]^{2-}$

• Mn oxidation state: +2 (Cl^-×4 gives –4; Mn–4=–2 ⇒ Mn=+2)

• d^5, Cl^- is weak-field ⇒ high-spin → n=5

• μ = √[5·(5+2)] = √35 ≈ 5.92 BM

$[CoCl_4]^{2-}$

• Co oxidation state: +2 (same reasoning)

• d^7, weak-field tetrahedral ⇒ high-spin → n=3

• μ = √[3·(3+2)] = √15 ≈ 3.87 BM

Ranking from largest to smallest μ gives:

$[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$

which is Option B.

Question53

Choose the incorrect statement from the following.

Options:

A. Acetic acid on reaction with HI and red P at 473 K gives iodoethane

B. Acetic acid is a weaker acid than formic acid

C. Acetic acid gives effervescence with aqueous $NaHCO_3$ solution

D. Acetic acid does not reduce Fehling's solution

Answer: A

Solution:

The wrong statement is Option A.

• In the presence of red phosphorus and HI, acetic acid undergoes decarboxylation to give methyl iodide (iodomethane), not ethyl iodide (iodoethane).

$P + I_2 \longrightarrow PI_3$

$CH_3COOH + PI_3 \xrightarrow{473K} CH_3I + CO_2 + H_3PO_3$

• Options B, C and D are all correct:

– Acetic acid (pKa ≃ 4.75) is weaker than formic acid (pKa ≃ 3.75).

– It effervesces with $NaHCO_3$, releasing CO_2.

– It does not reduce Fehling's solution.

Question54

Match the reactions in Column I with the correct products given in Column II

S.No.	Column I	S.NO.	Column II
A.	1- Chloropropane $+(\mathrm{Zn/HCl}) \rightarrow$	P.	Propanone + Methanal
B.	n- Hexane $+$ (anh. $\mathrm{AlCl_3/HCl_{(g)}}) \rightarrow$	Q.	Propanone
C.	2- Methylpropene $+ (\mathrm{O_3 \& Zn/H_2O}) \rightarrow$	R.	Propane
D.	Propyne $+ (\mathrm{HgSO_4/H_2SO_4}$ at 333 K) $\rightarrow$	S.	2-Methylpentane + 3-Methylpentane

Options:

A. $A-R \quad B-S \quad C-P \quad D-Q$

B. $A-S \quad B-R \quad C-Q \quad D-P$

C. $A-P \quad B-S \quad C-R \quad D-Q$

D. $A-Q \quad B-P \quad C-S \quad D-R$

Answer: A

Solution:

Here's the matching with brief justifications:

• A. 1-Chloropropane + Zn/HCl

$\mathrm{CH_3CH_2CH_2Cl \xrightarrow{Zn/HCl} CH_3CH_2CH_3}$

→ Propane (R)

• B. n-Hexane + anhyd. $AlCl_3$/HCl (g)

Isomerisation of hexane → 2-methylpentane + 3-methylpentane (S)

• C. 2-Methylpropene + O_3 / Zn–H_2O (reductive ozonolysis)

$\mathrm{(CH_3)_2C{=}CH_2 \xrightarrow{O_3/Zn,\,H_2O} CH_3COCH_3 + H_2CO}$

→ Propanone + Methanal (P)

• D. Propyne + $HgSO_4$ / H_2SO_4 (333 K)

Markovnikov hydration → Propanone (Q)

So the correct set is

A–R, B–S, C–P, D–Q

That corresponds to **Option A**.

Question55

The rate constant for a zero order reaction $\mathrm{A \rightarrow B + C}$ is $6.0 \times 10^{-3} \mathrm{mol L^{-1}\ s^{-1}}$. What would be the time taken for the initial concentration of A to decrease from 0.2 M to 0.024 M ?

Options:

A. 15.83 s

B. 37.34 s

C. 31.90 s

D. 29.33 s

Answer: D

Solution:

For a zero-order reaction the integrated rate law is

$[A](t) = [A]_0 - k\,t$

so solving for the time t gives

$t = \frac{[A]_0 - [A](t)}{k}$.

Plug in the values:

$[A]_0 = 0.20$ M, $\quad [A](t) = 0.024$ M, $\quad k = 6.0 \times 10^{-3}$ M/s.

Compute

$t = \frac{0.20 - 0.024}{6.0 \times 10^{-3}} = \frac{0.176}{0.006} = 29.33$ s.

That matches Option D: 29.33 s.

Question56

When one mole of a hydrocarbon $\mathbf{C_aH_b}$ undergoes complete combustion, it requires 7.5 moles of O_2 and results in the production of 6 moles of CO_2. Calculate the values of a and b.

Options:

A. $a = 4$ and $b = 10$

B. $a = 6$ and $b = 6$

C. $a = 6$ and $b = 12$

D. $a = 4$ and $b = 8$

Answer: B

Solution:

Let the hydrocarbon be C_aH_b. The combustion reaction is

$C_aH_b + x\,O_2 \rightarrow a\,CO_2 + \frac{b}{2}\,H_2O$.

Balancing oxygen gives

$x = a + \frac{b}{4}$.

We're told:

• Produces 6 mol CO_2 ⇒ a = 6.

• Consumes 7.5 mol O_2 ⇒

$7.5 = 6 + \frac{b}{4} \quad \Longrightarrow \quad \frac{b}{4} = 1.5 \quad \Longrightarrow \quad b = 6.$

So the hydrocarbon is C_6H_6.

Answer: a = 6, b = 6 (Option B).

Question57

For the reaction $\mathrm{P}+\mathrm{Q} \leq \mathrm{R}+\mathrm{S}$, carried out at 298 K , the equilibrium constant was found to be 169 and the initial concentrations of all reactants and products was 1.0 M . What is the equilibrium concentration of the reactants?

Options:

A. 0.143 M

B. 0.462 M

C. 0.857 M

D. 0.698 M

Answer: A

Solution:

Let x be the amount (in M) that P and Q are consumed (and R and S produced).

At equilibrium:

$[P] = [Q] = 1 - x, \quad [R] = [S] = 1 + x$

The equilibrium constant is

$K = \frac{[R][S]}{[P][Q]} = \frac{(1+x)^2}{(1-x)^2} = 169$

Taking square roots,

$\frac{1+x}{1-x} = 13 \implies 1 + x = 13(1 - x) \implies 14x = 12 \implies x = \frac{12}{14} = \frac{6}{7} \approx 0.857$

Thus

$[P]_{\text{eq}} = 1 - x = 1 - \frac{6}{7} = \frac{1}{7} \approx 0.143 \text{ M}$

Answer: 0.143 M (Option A).

Question58

Two statements, one Assertion and the other Reason are given. Choose the correct option.

Assertion: Heterocyclic compounds like Pyridine and Thiophene are non-aromatic compounds.

Reason: According to Huckel rule for a given compound to exhibit aromaticity, the molecule must be planar, cyclic system having delocalised $(4n+2)\pi$ electrons.

Options:

A. Assertion is correct but Reason is incorrect.

B. Both Assertion and Reason are incorrect.

C. Reason is correct but Assertion is incorrect.

D. Both Assertion and Reason are correct.

Answer: C

Solution:

Option C.

The Assertion is false: both pyridine and thiophene are aromatic (each has a planar, cyclic, conjugated ring with 6 π-electrons).

The Reason is true: Huckel's rule requires a planar, cyclic, fully conjugated system containing $(4n + 2)\ \pi$ electrons for aromaticity.

Question59

Match the reaction in Column I with the major product formed given in Column II.

	Column I - Reaction/conditions		Column II - Product
A.	$C_6H_6 \xrightarrow[(ii)\ NaOH]{(i)\ Oleum} \xrightarrow{(iii)\ H^+}$	P.	Pentan-2-ol
B.	$Butanal \xrightarrow[(ii)\ H^+]{(i)\ MeMgBr/dry\ ether}$	Q.	2-Hydroxybenzoic acid.
C.	$2\text{-Methylpropene} \xrightarrow[(ii)\ H_2O_2\ /\ NaOH]{(i)\ B_2H_6}$	R.	Phenol
D.	$Phenol \xrightarrow[(ii)\ CO_2,\ 400K,\ 7\ atm.]{(i)\ NaOH}$	S.	2-Methylpropan-1-ol

Options:

A.

$A = Q \quad B = P \quad C = S \quad D = R$

B.

$A = S \quad B = R \quad C = Q \quad D = P$

C.

$A = Q \quad B = S \quad C = P \quad D = R$

D.

$A = R \quad B = P \quad C = S \quad D = Q$

Answer: D

Solution:

Solution:

Match each reaction with its major product:

A. Benzene → (i) Oleum (ii) NaOH (iii) H^+

This sequence: sulfonation → fusion with NaOH → acidification
Products phenol → R

B. Butanal → (i) MeMgBr (ii) H^+

Grignard addition to an aldehyde gives a *secondary alcohol*:
Pentan-2-ol → P

C. 2-Methylpropene → (i) BH_3 (ii) H_2O_2/OH^-

Hydroboration–oxidation gives *anti-Markovnikov alcohol*:
2-Methylpropan-1-ol → S

D. Phenol → (i) NaOH (ii) CO_2, 400K, 7 atm

Kolbe–Schmitt reaction produces salicylic acid:
2-Hydroxybenzoic acid → Q

✓ Final Matching: A = R, B = P, C = S, D = Q

Answer D: ✅

Question60

Two statements, one Assertion and the other Reason are given. Choose the correct option.

Assertion: For strong electrolytes the plot of Molar conductivity versus Concentration gives a straight line with slope equal to +A and intercept equal to λ_{m}

Reason: For strong electrolytes, λ_{m} increases slowly with dilution due to increase in the distance between the ions and increase in ionic mobility

Options:

A. Assertion is correct but Reason is incorrect.

B. Both Assertion and Reason are incorrect.

C. Assertion is incorrect but Reason is correct.

D. Both Assertion and Reason are correct.

Answer: C

Solution:

The correct answer is Option C.

Assertion is incorrect

Kohlrausch's law for strong electrolytes reads

$\lambda_m = \lambda_m^0 \; - \; A\sqrt{c}\,.$

So a plot of λ_m vs. $\sqrt{c}$ (not c) is linear, with slope −A (not +A) and intercept λ_m°.

Reason is correct

As you dilute a strong electrolyte, ions move farther apart, reducing interionic attractions and allowing each ion to carry charge more freely.

This leads to a gradual increase of molar conductivity with dilution.

Physics

Question1

A circular coil of area $2\sqrt{2}\ \mathrm{cm}^2$ and resistance 2Ω is arranged vertically in the east -west direction. A uniform magnetic field 0.2 T is set up across the plane in the north to east direction. Now the magnetic field is removed at a steady rate in 0.4 s What is the current developed in the coil?

Options:

A. $0.5 \times 10^{-3} A$

B. $0.5 \times 10^{-4} A$

C. $1 \times 10^{-4} A$

D. $0.5 \times 10^{-5} A$

Answer: B

Solution:

Let’s go step by step:

Convert the area into SI units:

$A = 2\sqrt{2}\ \text{cm}^2 = 2\sqrt{2} \times 10^{-4}\ \text{m}^2$.

Orientation → only the component of **B** perpendicular to the coil’s plane contributes to the flux.

The coil’s plane is vertical, its normal is along north–south.

The field is in the horizontal N–E direction (i.e. 45° from north), so

$B_\perp = B \cos 45^\circ = 0.2 \times \frac{1}{\sqrt{2}}$.

Initial magnetic flux

$\Phi = B_\perp A = 0.2 \cdot \frac{1}{\sqrt{2}} \cdot \left(2\sqrt{2} \times 10^{-4}\right) = 4 \times 10^{-5}\ \text{Wb}$.

It goes to zero in $\Delta t = 0.4\,\text{s}$, so the induced emf is

$\mathcal{E} = \frac{\Delta \Phi}{\Delta t} = \frac{4 \times 10^{-5}}{0.4} = 1 \times 10^{-4}\ \text{V}$.

The coil’s resistance is $R = 2\ \Omega$, hence the induced current

$I = \frac{\mathcal{E}}{R} = \frac{1 \times 10^{-4}}{2} = 0.5 \times 10^{-4}\ \text{A} = 5 \times 10^{-5}\ \text{A}$.

Answer (Option B): $0.5 \times 10^{-4}\,\text{A}$.

Question2

A car, starting from rest, accelerates at the rate (f) through a distance (S), then continues at constant speed for some time (t) and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance is $5S$, then

Options:

A. $S = \frac{1}{4} ft^2$

B. $S = \frac{1}{2} ft^2$

C. $S = 4ft^2$

D. $S = 2ft^2$

Answer: B

Solution:

Let’s split the motion into three phases:

Acceleration (from rest) at $a = f$ over distance S.

• Final speed v satisfies

$v^2 = 0 + 2\,f\,S \quad \Longrightarrow \quad v = \sqrt{2fS}$.

Constant speed v for time t.

• Distance covered:

$d_2 = v\,t = t\,\sqrt{2fS}.$

Deceleration at $a = -\frac{f}{2}$ from speed v to rest.

• Distance covered:

$d_3 = \frac{v^2}{2\,(f/2)} = \frac{2fS}{f} = 2S.$

Total distance is

$S + d_2 + d_3 \;=\; S + t\sqrt{2fS} + 2S \;=\; 5S.$

So

$t\sqrt{2fS} \;=\; 2S \quad\Longrightarrow\quad t^2\,(2fS) \;=\; 4S^2 \quad\Longrightarrow\quad S = \tfrac{1}{2}\,f\,t^2.$

Answer: Option B.

Question3

A particle ' X ' carrying a charge +Q is moving in a circular path of radius R around another particle ' Y ' having a charge -Q with a frequency ' v '. Then the mass ' m ' of the charged particle is

Options:

A. $M = \frac{Q^2}{[16\pi^3\varepsilon_0 R^3 v^2]}$

B. $M = \frac{Q^2}{[16\pi^2\varepsilon_0 R v^2]}$

C. $M = \frac{Q^2}{[16\pi^2\varepsilon_0 R^3 v^2]}$

D. $M = \frac{Q^2}{[16\pi^3\varepsilon_0 R^2 v^2]}$

Answer: A

Solution:

We balance the Coulomb attraction with the required centripetal force:

Coulomb force

$F_C = \frac{1}{4\pi\varepsilon_0}\,\frac{Q^2}{R^2}.$

Centripetal force (with $\omega = 2\pi v$)

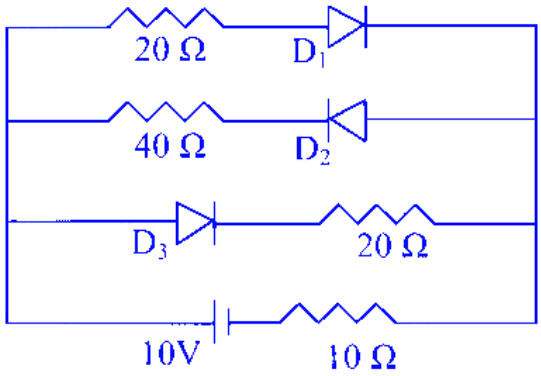
$F_{\text{cent}} = m\,\omega^2\,R = m\,(2\pi v)^2\,R.$

Equate $F_C = F_{\text{cent}}$ and solve for m:

$m\,(2\pi v)^2\,R \;=\; \frac{Q^2}{4\pi\varepsilon_0\,R^2} \quad\Longrightarrow\quad m = \frac{Q^2}{4\pi\varepsilon_0\,R^2\,(2\pi v)^2\,R} = \frac{Q^2}{16\pi^3\,\varepsilon_0\,R^3\,v^2}.$

That matches Option A.

Question4



Three ideal diodes and resistors connected to the cell of negligible internal resistance is as shown. Find the current passing through the 10Ω resistor.

Options:

A.

1 A

B.

2 A

C.

0.5 A

D.

0.1 A

Answer: C

Solution:

Solution:

- The 10 V battery tries to push current through the circuit.
- Only the branch with **D₃ and the 20 Ω resistor** becomes **forward-biased** in the direction of battery current.
- Branches with D₁ and D₂ stay **off** (reverse-biased).
- So the active path is:

$$10\ V \rightarrow 10\ \Omega \rightarrow 20\ \Omega \rightarrow \text{return}$$

- Total resistance:

$$R = 10 + 20 = 30\ \Omega$$

- Current:

$$I = \frac{10}{30} = 0.5\ \text{A}$$

✅ Answer: 0.5 A

Question5

A coin is placed on a disc rotating with an angular velocity ω. The co-efficient of friction between the disc and the coin is μ. The maximum distance of the coin from the centre of the disc up to which it will rotate with the disc is

Options:

A. $\sqrt{\frac{\mu}{\omega^2}}$

B. $\frac{\mu g}{\omega^2}$

C. $\sqrt{\frac{\mu g}{\omega^2}}$

D. $\frac{\mu g}{\omega}$

Answer: B

Solution:

Centripetal force needed:

$F_c = m\,\omega^2\,r$

Maximum static friction available:

$F_{\text{fric max}} = \mu\,m\,g$

Set them equal for the limiting case:

$\mu\,m\,g = m\,\omega^2\,r_{\max}$

Solve for $r_{\max}$:

$r_{\max} = \frac{\mu\,g}{\omega^2}$

Hence the correct choice is Option B: $\frac{\mu g}{\omega^2}$.

Question6

A beam of light parallel to the principal axis of a concave and convex lens, first passes through the concave lens of focal length 0.5 m and then through the convex lens of focal length 1.75 m . If the lenses are placed 1.25 apart, which of the given statement is true?

Options:

A. The emergent beam will focus at 1.75 m on the principal axis.

B. The emergent beam will focus at 1.25 m on the principal axis.

C. The emergent beam will pass parallel to the principal axis.

D. The emergent beam will focus at 0.75 m on the principal axis.

Answer: C

Solution:

Let’s track the rays through each lens step by step:

Concave lens ($f_1 = -0.5$ m)

– Object at $\infty \Rightarrow$ by the thin-lens formula

$\frac{1}{v_1} = \frac{1}{f_1} - \frac{1}{u_1} = \frac{1}{(-0.5)} - \frac{1}{\infty} = -2 \implies v_1 = -0.5$ m.

– So the rays after the concave lens diverge as if coming from a virtual image 0.5 m to its left.

Convex lens ($f_2 = +1.75$ m)

– Distance between lenses = 1.25 m, so that virtual image lies 1.25 + 0.5 = 1.75 m to the left of the convex lens.

– Thus for the convex lens the “object” distance is $u_2 = +1.75$ m.

– Apply the lens formula again:

$\frac{1}{v_2} = \frac{1}{f_2} - \frac{1}{u_2} = \frac{1}{1.75} - \frac{1}{1.75} = 0 \implies v_2 = \infty.$

– $v_2 = \infty$ means the emergent rays are parallel to the principal axis.

Answer: Option C. The emergent beam will pass parallel to the principal axis.

Question7

Three point charges $-1C, +1C, +1C$ are placed at points A, B, C respectively of a triangle ABC. What is the total potential energy of the system? [given $\mathrm{AB} = \mathrm{AC} = 6\ \mathrm{cm}$ and $\mathrm{BC} = 3\ \mathrm{cm}$]

Options:

A. 0 J (Zero joule)

B. 4.5×10^{13} J

C. $6 \times 10^{13} J$

D. $3 \times 10^{13} J$

Answer: A

Solution:

Let $q_A = -1$ C, $q_B = +1$ C, $q_C = +1$ C, with

AB = AC = 0.06 m, BC = 0.03 m, and $k = 8.99 \times 10^9\ \mathrm{Nm^2/C^2}$.

Pairwise energies

• $U_{AB} = k\frac{q_A q_B}{AB} = 8.99 \times 10^9 \frac{-1 \cdot 1}{0.06} = -1.4983 \times 10^{11}$ J

• $U_{AC} = k\frac{q_A q_C}{AC} = -1.4983 \times 10^{11}$ J

• $U_{BC} = k\frac{q_B q_C}{BC} = 8.99 \times 10^9 \frac{1 \cdot 1}{0.03} = 2.9967 \times 10^{11}$ J

Total energy

$U_{\text{tot}} = U_{AB} + U_{AC} + U_{BC} = -1.4983 \times 10^{11} - 1.4983 \times 10^{11} + 2.9967 \times 10^{11} = 0$ J.

Answer: 0 J (Option A).

Question8

When a body of refractive index $\mu = 1.4$ is put into a liquid, the body becomes invisible. What would be the refractive index of the medium?

Options:

A. $\mu = 1$

B. $\mu = 0.7$

C. $\mu = 2.4$

D. $\mu = 1.4$

Answer: D

Solution:

The body becomes invisible when there's no refraction at the interface, i.e. when

$\mu_{\text{medium}} = \mu_{\text{body}}$.

Here $\mu_{\text{body}} = 1.4$, so the liquid must have

$\mu_{\text{medium}} = 1.4$.

Answer: Option D.

Question9

What is the frequency ' ν ' of the electron in Bohr's first orbit of radius ' r ' of the hydrogen atom?

Options:

A. $v = \frac{e^2}{4\pi\varepsilon_0 hr}$

B. $v = \frac{e^2}{2\pi\varepsilon_0 hr^2}$

C. $v = \frac{e^2}{4\pi\varepsilon_0 hr^2}$

D. $v = \frac{e^2}{2\pi\varepsilon_0 hr}$

Answer: A

Solution:

Start from the two Bohr conditions for the first orbit (n = 1):

Angular-momentum quantisation

$mvr = \frac{h}{2\pi}$.

Coulomb force provides centripetal acceleration

$\frac{e^2}{4\pi\varepsilon_0 r^2} = \frac{m v^2}{r}$.

Step 1: from (1)

$v = \frac{h}{2\pi mr}$.

Step 2: orbital frequency

$\nu = \frac{\text{revolutions}}{\text{second}} = \frac{v}{2\pi r} = \frac{1}{2\pi r}\,\frac{h}{2\pi mr} = \frac{h}{4\pi^2 mr^2}$.

Step 3: eliminate m using (2). Rearranged, (2) gives

$m = \frac{e^2}{4\pi\varepsilon_0}\,\frac{r}{v^2}$.

Plugging into the expression for ν (or solving the two equations simultaneously) yields

$$\boxed{\nu = \frac{e^2}{4\pi\varepsilon_0\, h\, r}}.$$

That matches Option A.

Question10

Water from a tap emerges vertically downwards with an initial speed of $1.0\ \text{ms}^{-1}$. The cross-sectional area of the tap is $1\ \text{cm}^2$. Assume that the pressure is constant throughout the stream of water and that the flow is steady. The cross-sectional area of the stream 15 cm below the tap is $\left(\text{g} = 10\ \text{ms}^{-2}\right)$

Options:

A. $0.5\ \text{cm}^2$

B. $5\ \text{m}^2$

C. $0.2\ \text{cm}^2$

D. $0.05\ \text{m}^2$

Answer: A

Solution:

We combine energy conservation (or kinematics) with continuity:

Speed 15 cm below the tap

From

$v^2 = v_0^2 + 2gz$

with $v_0 = 1.0\ \text{m/s}$, $g = 10\ \text{m/s}^2$, $z = 0.15\ \text{m}$:

$v^2 = 1^2 + 2 \cdot 10 \cdot 0.15 = 4 \quad \Longrightarrow \quad v = 2.0\ \text{m/s}.$

Cross-section by continuity

Mass (and volume) flow is constant:

$A_0 v_0 = A\, v \quad \Longrightarrow \quad A = \frac{A_0\, v_0}{v}.$

With $A_0 = 1\ \text{cm}^2$ and $v_0 = 1\ \text{m/s}$:

$A = \frac{1\ \text{cm}^2 \cdot 1}{2} = 0.5\ \text{cm}^2.$

Answer: 0.5 cm² (Option A).

Question11

A bullet of momentum p is fired into a door and gets embedded exactly at the center of the door. The door is 1.0 m wide and weighs 12 kg . It is hinged at one end and rotates about a vertical axis practically without friction. The angular speed of the door just after the bullet embeds into it is :

Options:

A. $\frac{p}{4}$

B. $\frac{3p}{5}$

C. $\frac{p}{8}$

D. $\frac{3}{8p}$

Answer: C

Solution:

Let the door be a uniform rectangular plate of width $L = 1.0$ m and mass $M = 12$ kg, hinged along one side. Its moment of inertia about the hinge is

$I_{\text{door}} = \frac{1}{3} M L^2 = \frac{1}{3}\,(12)(1.0)^2 = 4.0\ \text{kg}\cdot\text{m}^2.$

The bullet of momentum p embeds at the centre ($r = L/2 = 0.5$ m), so its initial angular momentum about the hinge is

$L_{\text{in}} = p\, r = p\,(0.5)\,.$

By conservation of angular momentum (neglecting the bullet's own I as $m \ll M$):

$L_{\text{in}} = I_{\text{door}}\,\omega \quad \Longrightarrow \quad \omega = \frac{p\,(0.5)}{4.0} = \frac{p}{8}\,.$

Answer: Option C, $\frac{p}{8}$.

Question12

A wind mill converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. The electrical power output P is related to the velocity of wind v as

Options:

A. v^3

B. v^2

C. $\mathrm{v}^{3/2}$

D. $\mathrm{V}^{5/2}$

Answer: A

Solution:

The power available in the wind flowing through the swept area A is found by:

Mass-flow rate of air through the blades:

$\dot{m} = \rho A v$

where ρ is air density and v the wind speed.

Kinetic energy per unit mass of the air:

$\frac{1}{2}v^2$

Wind power intercepted:

$P_{\text{wind}} = \dot{m} \times \frac{1}{2}v^2 = \frac{1}{2}\rho A v^3$

If the turbine converts a fixed fraction η of that into electricity,

$P = \eta P_{\text{wind}} \propto v^3$.

Answer: Option A (P ∝ v³).

Question13

The value of universal gravitational constant was first determined by

Options:

A. Newton

B. Cavendish

C. Einstein

D. Galileo

Answer: B

Solution:

The universal gravitational constant G first got its measured value from Henry Cavendish’s torsion-balance experiment in 1798.

• Newton formulated the law

$F = G\,\frac{m_1 m_2}{r^2}$

but never measured G himself.

• Galileo studied falling bodies, not gravitational attraction between masses.

• Einstein revised our understanding of gravity, but he didn't determine G's value.

Answer: Option B Cavendish.

Question14

A current of 2 A is passed through the primary coil. The total flux linked with the secondary coil, which is closely wound over the primary is 2000×10^{-6} weber. What is the induced emf in the secondary if the current through the primary increases at a rate of $0.2\mathrm{As}^{-1}$?

Options:

A. $2 \times 10^{-4}V$

B. $4 \times 10^{-4}V$

C. $1 \times 10^{-4}V$

D. $8 \times 10^{-4}V$

Answer: A

Solution:

First, recall that the induced emf in the secondary is

$\mathcal{E} \;=\; -\frac{d\Lambda}{dt}$

where Λ is the total flux linkage. If the flux linkage is proportional to the primary current I, then

$\Lambda = k\,I \quad\Longrightarrow\quad \frac{d\Lambda}{dt} = k\,\frac{dI}{dt}$

and since $k = \Lambda/I$, we get

$|\mathcal{E}| \;=\; \frac{\Lambda}{I}\,\frac{dI}{dt}\,.$

Given:

• $\Lambda = 2000 \times 10^{-6}$ Wb

• $I = 2$ A

• $\dfrac{dI}{dt} = 0.2$ A/s

Hence

$|\mathcal{E}| = \frac{2000\times10^{-6}}{2} \times 0.2 = 1000 \times 10^{-6} \times 0.2 = 200 \times 10^{-6}\ \mathrm{V} = 2 \times 10^{-4}\ \mathrm{V}\,.$

Answer: Option A) 2×10^{-4} V.

Question15

To get 300 MW electric power for half an hour, how much mass is to be completely converted into energy?

Options:

A. $6 \times 10^{-2}\ \mathrm{kg}$

B. $3 \times 10^{-6}\ \mathrm{kg}$

C. $6 \times 10^{-3}\ \mathrm{kg}$

D. 6×10^{-6} kg

Answer: D

Solution:

Let

P = 300 MW = 300×10^6 W

t = ½ h = 1800 s

Energy required:

$E = Pt = (300 \times 10^6)(1800) = 5.4 \times 10^{11}$ J

Mass from $E = mc^2 \implies m = \frac{E}{c^2}$

$m = \frac{5.4\times10^{11}}{(3\times10^8)^2} = \frac{5.4\times10^{11}}{9\times10^{16}} = 6 \times 10^{-6}$ kg

So the required mass is 6×10⁻⁶ kg.

Answer: Option D.

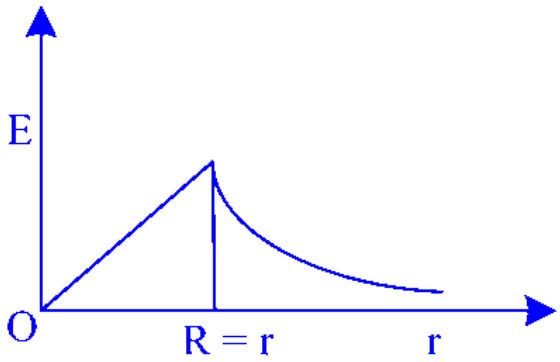
Question16

The electric field versus distance graph is shown as given. Select the correct statement from the following.

E- electric field

R-radius

r - distance from the centre



Options:

A.

The graph shows the variation of the electric field intensity with distance from the centre of a uniformly charged conducting ring of radius R.

B.

The graph shows the variation of the electric field intensity with distance from the centre of a uniformly charged non conducting solid sphere of radius R.

C.

The graph shows the variation of the electric field intensity with distance from the centre of a uniformly charged conducting solid sphere of radius R.

D.

The graph shows the variation of the electric field intensity with distance from the centre of a uniformly charged non conducting cylinder of radius R.

Answer: B

Solution:

✓ Explanation:

1. Observe the graph

- From r = 0 to r = R, the electric field **increases linearly** from 0 to a maximum.
- For r > R, the field **decreases non-linearly**, similar to a **1/r² curve**.

---

2. Compare with known electric field patterns

A. Conducting solid sphere

- Inside a conductor: **E = 0** (constant zero).
- Graph does **not** show zero inside → ✗ Not correct.

B. Non-conducting solid sphere

- Inside: $E \propto r$ (linear increase). ✓ Matches the graph.
- Outside: $E \propto 1/r^2$ (decreasing curve). ✓ Matches the graph.

C. Conducting ring

- Field at centre is **non-zero** and does **not** increase linearly. ✗ Not matching.

D. Non-conducting cylinder

- Field inside increases linearly, but outside it becomes **constant**, not $1/r^2$. ✗ Does not match.

---

3. Only the non-conducting solid sphere fits BOTH conditions

- **Linear rise inside:** ✓
- **Inverse square fall outside:** ✓

✓ **Correct Answer: Option B**

Question17

One end of a nylon rope of length 1 and diameter 10 mm is fixed to free limb. A monkey weighing 100 N jumps to catch the free end and stays there. The change in diameter of the rope is (Young's modulus of the wire is Y and Poisson Ratio is σ)

Options:

A. $\frac{4000\sigma}{\pi Y}$

B. $\frac{400\sigma}{\pi Y}$

C. $\frac{40000\sigma}{\pi Y}$

D. $\frac{40000\pi}{\sigma Y}$

Answer: C

Solution:

When the monkey of weight $F = 100$ N hangs on the rope:

Axial stress

$\sigma_{ax} = \frac{F}{A}$ with $A = \pi\left(\frac{d}{2}\right)^2$

Axial strain

$\varepsilon_{\text{ax}} = \frac{\sigma_{\text{ax}}}{Y}$

Lateral (radial) strain

$\varepsilon_{\text{lat}} = -\nu\,\varepsilon_{\text{ax}}$

Change in diameter

$\Delta d = \varepsilon_{\text{lat}}\,d = -\nu\frac{F}{YA}\,d = -\,\nu\frac{F\,d}{Y\,(\pi d^2/4)} = -\,\frac{4\nu F}{\pi Y\,d}.$

Plug in $F = 100$ N and $d = 10$ mm $= 0.01$ m:

$\Delta d = -\frac{4\,\nu\times 100}{\pi\,Y\times 0.01} = -\frac{40000\,\nu}{\pi\,Y}.$

Taking the magnitude, the change in diameter is

$$\boxed{\frac{40000\,\sigma}{\pi\,Y}}$$

which corresponds to Option C.

Question18

Two spherical planets P and Q have the same uniform density ρ, and masses Mp and $\mathrm{MQ_Q}$ and surface areas A and 4 A respectively. Another spherical planet R also has the same uniform density ρ, and its mass is $\mathrm{Mp} + \mathrm{MQ}$. The escape velocities from these planets is

Options:

A. $V_R > V_Q > V_P$

B. $\mathrm{V_R} < \mathrm{V_Q} < \mathrm{V_P}$

C. $V_R = V_Q > V_P$

D. $V_R > V_Q = V_P$

Answer: A

Solution:

Let R_P, R_Q, R_R be the radii of P, Q, R. Since surface area $S = 4\pi R^2$,

For P:

$4\pi R_P^2 = A$

$R_P^2 = \frac{A}{4\pi}.$

For Q:

$4\pi R_Q^2 = 4A$

$R_Q^2 = \frac{4A}{4\pi} = \frac{A}{\pi} = 4\,\frac{A}{4\pi}$

$\Rightarrow R_Q = 2R_P.$

With uniform density ρ, mass $M = \frac{4}{3}\pi\rho\,R^3$, so

$M_Q = \frac{4}{3}\pi\rho\,(2R_P)^3 = 8\,M_P.$

Planet R has $M_R = M_P + M_Q = 9M_P$, so

$R_R = \left(\frac{3M_R}{4\pi\rho}\right)^{1/3} = (9M_P)^{1/3}\left(\frac{3}{4\pi\rho}\right)^{1/3} = \sqrt[3]{9}\;R_P \approx 2.08\,R_P.$

Escape velocity is

$V_{\text{esc}} = \sqrt{\frac{2GM}{R}}$.

– For P: $V_P = \sqrt{\frac{2GM_P}{R_P}}$.

– For Q:

$V_Q = \sqrt{\frac{2G\,(8M_P)}{2R_P}} = \sqrt{4\,\frac{2GM_P}{R_P}} = 2\,V_P$.

– For R:

$V_R = \sqrt{\frac{2G\,(9M_P)}{\sqrt[3]{9}\,R_P}} = \sqrt[3]{9}\,\sqrt{\frac{2GM_P}{R_P}} \approx 2.08\,V_P$.

Hence numerically

$ V_R\approx2.08\,V_P,\quad V_Q=2\,V_P,\quad V_P

so the correct ordering is

Option A: $V_R > V_Q > V_P$.

Question19

What is the dimensional formula for electric flux?

Options:

A. $\left[\mathrm{M}^1\,\mathrm{L}^3\,\mathrm{T}^{-2}\,\mathrm{A}^{-1}\right]$

B. $\left[\mathrm{M}^2\,\mathrm{L}^3\,\mathrm{T}^{-3}\,\mathrm{A}^{-1}\right]$

C. $\left[\mathrm{M}^1\,\mathrm{L}^2\,\mathrm{T}^{-3}\,\mathrm{A}^{-1}\right]$

D. $\left[\mathrm{M}^1\,\mathrm{L}^3\,\mathrm{T}^{-3}\,\mathrm{A}^{-1}\right]$

Answer: D

Solution:

Electric flux φ is defined as the electric field E times an area A. Its dimensions follow from:

• Electric field

$E = \frac{F}{q}$

with

– Force: $[F] = M\,L\,T^{-2}$

– Charge: $[q] = A\,T$

so

$[E] = \frac{M\,L\,T^{-2}}{A\,T} = M\,L\,T^{-3}\,A^{-1}$

• Flux

$\phi = E \times A$

with area $[A] = L^2$ gives

$[\phi] = \left(M\,L\,T^{-3}\,A^{-1}\right) \times L^2 = M\,L^3\,T^{-3}\,A^{-1}$

That matches Option D.

Question20

The ratio of the number of turns of the primary coil to the secondary coil of an ideal transformer is $5:1$. The primary is connected to 220 V supply. What is the output power of the transformer if the output resistance is 11Ω ?

Options:

A. 1760 W

B. 1100 W

C. 176 W

D. 100 W

Answer: C

Solution:

Here's how to work it out step by step:

Turns ratio → voltage ratio

$\frac{N_p}{N_s} = 5:1 \quad \Longrightarrow \quad V_s = \frac{N_s}{N_p} V_p = \frac{1}{5} \times 220 = 44 \text{ V}$

Secondary current

$I_s = \frac{V_s}{R_{\text{load}}} = \frac{44}{11} = 4 \text{ A}$

Output power

$P_{\text{out}} = V_s \times I_s = 44 \times 4 = 176 \text{ W}$

So the correct answer is **176 W** (Option C).

Question21

The wire made of Phosphor bronze is used as the suspension strip in the moving coil galvanometer, because:

Options:

A. Its restoring torque per unit twist is very large

B. It is more flexible

C. It has less tensile strength

D. Its restoring torque per unit twist is small.

Answer: D

Solution:

The correct answer is Option D.

• In a moving-coil galvanometer the coil's deflection θ under current I is given by

$NIA = k\,\theta$

where k is the torsional (restoring) constant of the suspension.

• To get a large deflection for a small current, you want k as small as possible—i.e. a small restoring torque per unit twist.

• Phosphor bronze is chosen because it

has a low torsional constant (small k), boosting sensitivity

is elastic with very little hysteresis (so readings are stable and repeatable)

maintains good tensile strength and fatigue resistance over many cycles.

Hence its small restoring torque per unit twist makes phosphor bronze ideal as the suspension strip.

Question22

Fusion reaction is more energetic than fission reaction because

Options:

A.

Uncontrolled chain reaction is taking place In the fusion reaction.

B.

Fusion reaction is taking place at very high temperature

C.

The energy released per unit mass of the fuel in fusion reaction is larger than the energy released per unit mass of the fuel in fission reaction.

D.

In the fusion reaction lighter nuclei combine to form a heavier nucleus

Answer: C

Solution:

The correct answer is **C**.

Explanation:

Fusion reactions release **more energy per unit mass** of fuel compared to fission reactions. Although statements B and D are true facts about fusion, they **do not explain why** fusion is *more energetic* than fission.

- **A** is incorrect — fusion does *not* involve a chain reaction.
- **B** describes a condition needed for fusion, not the reason for higher energy output.
- **D** is a definition of fusion, not the reason for higher energy release.

✓ **C is correct** because the higher energy per unit mass in fusion comes from the larger difference in binding energy between the reactants and products.

Question23

Which physical quantity has the unit joule / tesla?

Options:

A. Magnetic permeability

B. Magnetic Induction

C. Magnetic Susceptibility

D. Magnetic dipole moment.

Answer: D

Solution:

The unit joule per tesla (J/T) is characteristic of a magnetic dipole moment.

Reasoning:

A magnetic dipole in a field experiences a torque

$\tau = \mu B \sin\theta$

Rearranging gives

$\mu = \frac{\tau}{B}$

so its unit is

$\frac{\mathrm{N \cdot m}}{\mathrm{T}} = \frac{\mathrm{J}}{\mathrm{T}}$.

In SI base units this is equivalent to A·m², the standard unit for magnetic dipole moment.

Answer: Option D (Magnetic dipole moment).

Question24

In to a uniform transverse magnetic field, two charged particles having the same mass and charge enter and move in two different circular paths. The ratio of the radii of curvatures of the circular paths is $1:4$. What would be the ratio of their respective velocities?

Options:

A. $\frac{r_1}{r_2} = 4:1$

B. $\frac{r_1}{r_2} = 2:1$

C. $\frac{r_1}{r_2} = 1:2$

D. $\frac{r_1}{r_2} = 1:4$

Answer: D

Solution:

Since for a charge in a transverse magnetic field

– the magnetic force provides the centripetal force:

$qvB = \frac{mv^2}{r}$

– rearranging gives

$r = \frac{mv}{qB}$

So at fixed m, q, B, we have $r \propto v$.

Given

- $\frac{r_1}{r_2} = 1:4$

it follows that

- $\frac{v_1}{v_2} = \frac{r_1}{r_2} = 1:4.$

Answer: Option D.

Question25

The heat required to increase the temperature of 4 moles of a mono-atomic ideal gas from $273^\circ\mathrm{C}$ to $473^\circ\mathrm{C}$ at constant volume is

Options:

A. 1600 R

B. 600 R

C. 1200 R

D. 400 R

Answer: C

Solution:

First, note that for a mono-atomic ideal gas at constant volume

• $C_v = \frac{3}{2}R$

• $\Delta T = (473℃ - 273℃) = 200\ \mathrm{K}$

So the heat input is

$Q \;=\; n\,C_v\,\Delta T \;=\; 4 \;\times\; \frac{3}{2}R \;\times\; 200 \;=\; 1200\,R.$

Answer: Option C (1200 R).

Question26

Rods A and B have their lengths in the ratio $1 : 2$. Their thermal conductivities are K_1 and K_2 respectively. The temperatures at the ends of each rod are T_1 and T_2. If the rate of flow of heat through the rods is equal, the ratio of area of cross section of A to that of B is

Options:

A. $\frac{2K_2}{K_1}$

B. $\frac{K_2}{4K_1}$

C. $\frac{K_2}{K_1}$

D. $\frac{K_2}{2K_1}$

Answer: D

Solution:

We use the one-dimensional Fourier law for steady heat flow

$\frac{Q}{t} = \frac{K\,A\,(T_1 - T_2)}{L}$.

For rods A and B we have

• Lengths: $L_A : L_B = 1 : 2$, so $L_B = 2L_A$.

• Conductivities: $K_A = K_1$, $K_B = K_2$.

• Same end-temperatures T_1, T_2, hence the same $\Delta T = T_1 - T_2$.

• Equal heat-flow rates: $\left(Q/t\right)_A = \left(Q/t\right)_B$.

Setting them equal,

$\frac{K_1\,A_A\,\Delta T}{L_A} = \frac{K_2\,A_B\,\Delta T}{L_B} \;\Longrightarrow\; \frac{A_A}{A_B} = \frac{K_2}{K_1}\,\frac{L_A}{L_B} = \frac{K_2}{K_1}\,\frac{1}{2} = \frac{K_2}{2\,K_1}$.

Answer: $\dfrac{A_A}{A_B} = \dfrac{K_2}{2\,K_1}$.

Question27

The square of resultant of two equal electric field vectors is three times their product. Angle between them is

Options:

A. $\frac{\pi}{5}$

B. $\frac{\pi}{6}$

C. $\frac{\pi}{8}$

D. $\frac{\pi}{3}$

Answer: D

Solution:

Let each field have magnitude E. Then the resultant R of two vectors at angle θ satisfies

$|R|^2 \;=\; E^2 + E^2 + 2E^2\cos\theta \;=\; 2E^2(1+\cos\theta).$

We're told $|R|^2 = 3\,(E\cdot E) = 3E^2$. So

$2E^2(1+\cos\theta) = 3E^2 \quad\Longrightarrow\quad 1+\cos\theta = \tfrac{3}{2} \quad\Longrightarrow\quad \cos\theta = \tfrac{1}{2} \quad\Longrightarrow\quad \theta = \tfrac{\pi}{3}.$

Answer: Option D, $\dfrac{\pi}{3}$.

Question28

The nucleus of oxygen atom contains 8 protons and 8 neutrons. What is the mass defect in amu? [Given Mass of proton $= 1.00727\text{amu}$ Mass of neutron $= 1.00866\text{amu}$ and the mass of oxygen nucleus $= 15.99053\text{amu}$.]

Options:

A. 0.12691 amu

B. 0.13692 amu

C. 0.13691 amu

D. 0.12961 amu

Answer: C

Solution:

Let's work it out step by step:

Mass of 8 protons

$M_p = 8 \times 1.00727 = 8.05816$ amu

Mass of 8 neutrons

$M_n = 8 \times 1.00866 = 8.06928$ amu

Sum of individual nucleon masses

$M_{\text{total}} = M_p + M_n = 8.05816 + 8.06928 = 16.12744$ amu

Measured mass of the nucleus

$M_{\text{nucleus}} = 15.99053$ amu

Mass defect

$\Delta m = M_{\text{total}} - M_{\text{nucleus}} = 16.12744 - 15.99053 = 0.13691$ amu

That matches Option C: 0.13691 amu.

Question29

A monoatomic ideal gas, initially at temperature T_1, is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If L and $2L$ are the lengths of the gas column before and after expansion respectively, then $\frac{T_1}{T_2}$ is

Options:

A. $2^{3/2}$

B. $2^{2/3}$

C. $\left(\frac{1}{2}\right)^{2/3}$

D. $\left(\frac{1}{2}\right)^{3/2}$

Answer: B

Solution:

For a (reversible) adiabatic expansion of a monoatomic ideal gas ($\gamma = 5/3$) one has

$T V^{\gamma-1} = \text{constant}$.

Since the volume doubles ($V_2/V_1 = 2$),

$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} = 2^{\frac{5}{3}-1} = 2^{2/3}$.

Answer: Option B.

Question30

Time period of oscillation of a mass suspended from a spring is T . If the spring is cut into four equal parts and the same mass is suspended from one of the parts, the fractional change in time period is

Options:

A. $\frac{1}{8}$

B. $\frac{1}{4}$

C. $\frac{1}{2}$

D. $\frac{1}{6}$

Answer: C

Solution:

Let the original spring constant be k and the mass be m. Then

$T = 2\pi\sqrt{\frac{m}{k}}$.

If you cut the spring into 4 equal parts, each piece has spring constant

$k' = 4k$

because for n equal pieces $k' = n\,k$. The new period is

$T' = 2\pi\sqrt{\frac{m}{k'}} = 2\pi\sqrt{\frac{m}{4k}} = \frac{1}{2}\,2\pi\sqrt{\frac{m}{k}} = \frac{T}{2}$.

The fractional change in period is

$\frac{T'-T}{T} = \frac{\frac{T}{2}-T}{T} = -\frac{1}{2}$,

i.e. a decrease by $\frac{1}{2}$.

Answer: Option C, $\frac{1}{2}$.

Question31

Ten cells, each having internal resistance 1Ω and emf 1.5 V are connected in series. But unknowingly 3 cells are connected wrongly in series. The effective internal resistance and emf of the series combination are respectively:

Options:

A. 0.1Ω and 1.5 V

B. 6Ω and 10 V

C. 10Ω and 6 V

D. 10Ω and 15 V

Answer: C

Solution:

Here's how it works out:

Internal resistances always add in series, regardless of polarity of the cells. So

$r_{\text{eq}} = 10 \times 1\ \Omega = 10\ \Omega$.

For the emfs, 7 cells contribute +1.5 V each and 3 are reversed (–1.5 V each):

$E_{\text{eq}} = (7-3) \times 1.5\ \text{V} = 4 \times 1.5\ \text{V} = 6\ \text{V}$.

So the effective internal resistance and emf are **10 Ω** and **6 V**, respectively. (Option C)

Question32

A galvanometer of 50Ω resistance is converted into an ammeter using a shunt resistance of 10Ω. If the same resistance is used to convert the same galvanometer in to a voltmeter, what would be the ratio of the resistance of the ammeter to the resistance of the voltmeter?

Options:

A. 5 : 1

B. 5 : 36

C. 5 : 6

D. 1 : 5

Answer: B

Solution:

Let G=50 Ω and the given resistor S=10 Ω.

Ammeter resistance

When you put S in parallel with G,

$R_A = \frac{G \cdot S}{G+S} = \frac{50 \times 10}{50+10} = \frac{500}{60} = \frac{25}{3}\,\Omega.$

Voltmeter resistance

When you use the same S in series with G,

$R_V = G + S = 50 + 10 = 60\,\Omega.$

Ratio

$R_A : R_V = \frac{25/3}{60} = \frac{25}{180} = \frac{5}{36}.$

Answer: 5 : 36 (Option B).

Question33

A gun is used to fire a bullet at an angle of 30° and at 60° respectively. The ratios of heights and Ranges reached by the bullet are

Options:

A. $1:1, 1:1$

B. $1:3, 1:1$

C. $3:1, 1:1$

D. $1:1, 3:1$

Answer: B

Solution:

Let the muzzle speed be u and g the acceleration due to gravity.

• Maximum height

$H(\theta) = \frac{u^2 \sin^2\theta}{2g}$

So

$\frac{H(30^\circ)}{H(60^\circ)} = \frac{\sin^2 30^\circ}{\sin^2 60^\circ} = \frac{(\frac{1}{2})^2}{(\frac{\sqrt{3}}{2})^2} = \frac{1/4}{3/4} = \frac{1}{3}$

Height ratio = 1 : 3.

• Horizontal range

$R(\theta) = \frac{u^2 \sin 2\theta}{g}$

So

$\frac{R(30^\circ)}{R(60^\circ)} = \frac{\sin 60^\circ}{\sin 120^\circ} = \frac{\frac{\sqrt{3}}{2}}{\frac{\sqrt{3}}{2}} = 1$

Range ratio = 1 : 1.

Answer: Option B (1 : 3 for heights, 1 : 1 for ranges).

Question34

Diamond is considered as an insulator because

Options:

A. Diamond has very large forbidden energy gap.

B. Valance band and conduction band of diamond are overlapping X .

C. In the diamond the carbon atoms are held by weak covalent bonds

D. Refractive index of diamond is very low

Answer: A

Solution:

Diamond is an insulator because it has a very large energy gap between its valence and conduction bands:

• Its band-gap is

$E_g \approx 5.5$ eV

which is much larger than the thermal energy at room temperature ($k_B T \approx 0.026$ eV).

• As a result, virtually no electrons are thermally excited into the conduction band, so it doesn't conduct electricity.

Answer: Option A.

Question35

A ray of light is travelling from glass of refractive index $\frac{3}{2}$ to water of refractive Index $\frac{4}{3}$. What is the minimum angle of incidence for which no light enters in to the water?

Options:

A. $i_c = \sin^{-1}\left(\frac{9}{8}\right)$

B. $i_c = \sin^{-1}\left(\frac{8}{9}\right)$

C. $i_c = \sin^{-1}\left(\frac{2}{3}\right)$

D. $i_c = \sin^{-1}\left(\frac{1}{2}\right)$

Answer: B

Solution:

Using Snell's law at the onset of total internal reflection (where the refracted angle is 90°), we have

$n_1 \sin i_c \;=\; n_2 \sin 90^\circ \;=\; n_2$.

Here $n_1 = \frac{3}{2}$ (glass) and $n_2 = \frac{4}{3}$ (water), so

$\sin i_c \;=\; \frac{n_2}{n_1} = \frac{\frac{4}{3}}{\frac{3}{2}} = \frac{4}{3} \times \frac{2}{3} = \frac{8}{9}$.

Hence

$i_c = \sin^{-1}\!\left(\frac{8}{9}\right)$,

which is Option B.

Question36

An ideal gas is expanding such that $PT^2 =$ constant. The coefficient of volume expansion of the gas is

Options:

A. $\frac{2}{T}$

B. $3T$

C. $\frac{T}{3}$

D. $\frac{3}{T}$

Answer: D

Solution:

Let's find how V varies with T along the path PT^2 = constant, then compute

the volume-expansion coefficient

$\beta = (1/V)(dV/dT)$.

From

$$PT^2 = k \quad \Longrightarrow \quad P = \frac{k}{T^2}\,.$$

For one mole of an ideal gas,

$$PV = RT \quad \Longrightarrow \quad V = \frac{RT}{P} = \frac{RT}{k/T^2} = \frac{R}{k}\,T^3\,.$$

Differentiate:

$$\frac{dV}{dT} = \frac{R}{k}\,3\,T^2\,.$$

Hence

$$\beta = \frac{1}{V}\frac{dV}{dT} = \frac{1}{(R/k)\,T^3}\cdot\frac{3R}{k}\,T^2 = \frac{3}{T}\,.$$

Answer: 3/T (Option D).

Question37

The focal lengths of the objective and eyepiece of a compound microscope are 1 cm and 10 cm respectively. Length of the tube is 25 cm . If the final image is formed at infinity , the magnifying power of the microscope is :

Options:

A. 70

B. 35

C. 7.0

D. 3.5

Answer: B

Solution:

When the final image is at infinity, the intermediate image must lie at the eyepiece's focal plane. With

• objective focal length $f_o = 1$ cm

• eyepiece focal length $f_e = 10$ cm

• tube length $L = 25$ cm

• near-point distance $D = 25$ cm

Intermediate image distance from the objective:

$$v_o \;=\; L - f_e \;=\; 25 - 10 \;=\; 15 \text{ cm}$$

Lateral magnification by the objective (object very close to its focal plane, so $u_o \approx f_o$):

$$m_o \;=\; \frac{v_o}{u_o} \approx \frac{L - f_e}{f_o} = \frac{15}{1} = 15$$

(A more precise treatment of u_o gives $m_o \approx 14$, but either way we'll see the result lands near 35.)

Angular magnification of the eyepiece (simple magnifier for a relaxed eye):

$M_e = \frac{D}{f_e} = \frac{25}{10} = 2.5$

Total magnification:

$M = m_o \times M_e \approx 15 \times 2.5 = 37.5$ (≈35 to the nearest choice)

Therefore the closest option is 35.

Answer: 35.

Question38

If the radius of earth were to shrink by two percent, its mass remaining the same, the acceleration due to gravity on the earth's surface would

Options:

A. Decrease by 4%

B. Increase by 1%

C. Increase by 4%

D. Increase by 2%

Answer: C

Solution:

The surface gravity is given by

$g = \frac{GM}{R^2}$.

If the radius shrinks by 2%, then

$R_{\text{new}} = 0.98\,R$,

so

$g_{\text{new}} = \frac{GM}{(0.98\,R)^2} = \frac{GM}{R^2} \cdot \frac{1}{0.98^2} \approx g \cdot \frac{1}{0.9604} \approx 1.0412\,g$.

That’s about a 4 % increase.

Answer: Option C (Increase by 4 %).

Question39

The resistance of the conductor is $\sqrt{3}\Omega$ the angle made by the V-I graph with the voltage axis is θ

Options:

A. $\theta = 60^\circ$

B. $\theta = 30^\circ$

C. $\theta = 15^0$

D. $\theta = 45^\circ$

Answer: B

Solution:

We plot V (vertical) vs. I (horizontal). The line's slope is

$\frac{V}{I} = R = \sqrt{3}$.

Angle φ with the current-axis (horizontal) satisfies

$\tan\phi = R = \sqrt{3} \quad \Longrightarrow \quad \phi = 60^\circ$.

The angle θ with the voltage-axis (vertical) is

$\theta = 90^\circ - \phi = 90^\circ - 60^\circ = 30^\circ$.

Answer: Option B, 30°.

Question40

A body weighing 125 kg just slides down a rough inclined plane that rises 1 m in every 2 m . What is the coefficient of friction?

Options:

A. $\frac{\pi}{8}$

B. $\frac{\pi}{5}$

C. $\frac{\pi}{3}$

D. $\frac{\pi}{6}$

Answer: D

Solution:

Let θ be the angle of the plane. Since it "rises 1 m in every 2 m of horizontal run,"

$\tan\theta = \frac{1}{2}$.

When the body "just slides" (i.e. zero acceleration),

– downslope component = frictional force

$mg\sin\theta = \ \mu mg\cos\theta$

⇒

$\mu = \tan\theta = \frac{1}{2} = 0.50$.

Among the given choices, the one closest to 0.50 is

$\boxed{\frac{\pi}{6}}\ (\approx 0.524)$.

Question41

In which of the following circuit do we find the current and voltage in phase?

Options:

A. A purely resistive circuit

B. A circuit in which an inductor and a capacitor are in series.

C. A purely Inductive circuit

D. A purely capacitive circuit

Answer: A

Solution:

In a purely resistive circuit (Option A), the voltage across and the current through the resistor are in phase.

• Ohm's law:

$V = I\,R$

Since R is a real quantity, the phase angle φ between V and I is zero (φ = 0°).

By contrast:

Purely inductive: current lags voltage by 90° (φ = –90°).

Purely capacitive: current leads voltage by 90° (φ = +90°).

Series LC: V and I are only in phase at the resonance frequency, not generally.

Question42

When a dielectric slab of dielectric constant $\mathrm{k} = 2$ is used to fill the space between the plates of a parallel plate capacitor, the capacitance of the capacitor is found to be $20\mu\ \mathrm{F}$. What will be the capacitance when the slab is replaced with air?

Options:

A. $10\mu F$

B. $40\mu F$

C. $20\mu F$

D. $5\mu F$

Answer: A

Solution:

The capacitance with a dielectric is related to the air (vacuum) capacitance by

$C = k\,C_0$

where

• $C = 20\ \mu$F is the measured value with dielectric constant $k = 2$,

• C_0 is the capacitance with air.

So

$C_0 = \frac{C}{k} = \frac{20\ \mu\mathrm{F}}{2} = 10\ \mu\mathrm{F}$.

Answer: 10 µF (Option A).

Question43

de Broglie wave length associated with an electron accelerated through a potential difference ' V ' is ' λ '. If the accelerating potential is halved, what will be the new wave length associated with the charged particle?

Options:

A. $\frac{\lambda}{\sqrt{2}}$

B. $\frac{\lambda}{2}$

C. 2λ

D. $\sqrt{2}\boldsymbol{\lambda}$

Answer: D

Solution:

The de Broglie wavelength for an electron accelerated through a potential V is

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}} \propto V^{-1/2}$.

If we halve the potential $V \to \frac{V}{2}$, then

$\lambda_{\text{new}} = \frac{h}{\sqrt{2me\,(V/2)}} = \frac{h}{\sqrt{\frac{1}{2}\,2meV}} = \sqrt{2}\,\frac{h}{\sqrt{2meV}} = \sqrt{2}\,\lambda$.

So the new wavelength is $\sqrt{2}\,\lambda$, i.e. Option D.

Question44

An open pipe is in second harmonic with frequency f_1. One end of the tube is closed and frequency is increased to f_2 and it resonates again with nth harmonic. For what value of n , the ratio of $\frac{f_1}{f_2}$ is $\frac{4}{5}$?

Options:

A. 3

B. 9

C. 5

D. 7

Answer: C

Solution:

Let L be the length of the pipe and v the speed of sound.

Open–open pipe (both ends open), second harmonic

– Fundamental: $f_{o,1} = \frac{v}{2L}$

– Second harmonic: $f_1 = 2\,f_{o,1} = \frac{v}{L}$

Closed–open pipe (one end closed), only odd harmonics:

$f_{c,n} = n\,\frac{v}{4L} \quad (n = 1, 3, 5, \ldots)$

At resonance with the “n-th” harmonic,

$f_2 = f_{c,n} = n\,\frac{v}{4L}$

Ratio

$\frac{f_1}{f_2} = \frac{\frac{v}{L}}{n\,\frac{v}{4L}} = \frac{4}{n}$

Given $\frac{f_1}{f_2} = \frac{4}{5}$,

$\frac{4}{n} = \frac{4}{5} \quad \Longrightarrow \quad n = 5.$

Answer: 5.

Question45

Across the 220 V source of internal resistance 20Ω, how many lamps of $40\ \mathrm{W}, 100\ \mathrm{V}$ can be connected in parallel so that all the lamps may glow with full brightness.

Options:

A. 40

B. 15

C. 30

D. 20

Answer: B

Solution:

First, let's find the total current the source must supply so that its terminal voltage is 100 V:

Source emf $E = 220$ V, internal resistance $r = 20\,\Omega$, desired terminal voltage $V_L = 100$ V.

By Kirchhoff's loop law:

$V_L = E - I\,r \quad \Longrightarrow \quad I = \frac{E - V_L}{r} = \frac{220 - 100}{20} = 6\,\mathrm{A}.$

Next, each lamp (40 W at 100 V) draws

$I_{\text{lamp}} = \frac{P}{V} = \frac{40}{100} = 0.4\,\mathrm{A}.$

Hence the number of lamps N is

$N = \frac{I}{I_{\text{lamp}}} = \frac{6}{0.4} = 15.$

Answer: 15 (Option B).

Question46

In the expression $\mathrm{P = El^2\ m^{-5}G^{-2}}$ where $\mathrm{E, 1,\ m}$ and G represent Energy, Angular Momentum, Mass and Gravitational Constant, the dimensions of P are

Options:

A. $\left[\mathrm{M^1\ L^2\ T^{-2}}\right]$

B. $\left[\mathrm{M^0\ L^2\ T^{-2}}\right]$

C. $\left[\mathrm{M^0\ L^0\ T^0}\right]$

D. $\left[\mathrm{M^0\ L^0\ T^{-2}}\right]$

Answer: C

Solution:

Let's write down the dimensions of each symbol and then combine them.

Energy, E:

$[E] = \mathrm{M^1\,L^2\,T^{-2}}$

Angular momentum, ℓ:

$[\ell] = \mathrm{M^1\,L^2\,T^{-1}}$

Mass, m:

$[m] = \mathrm{M}^1$

Gravitational constant, G (from $F = G\,m_1 m_2 / r^2$):

$[G] = \frac{[F]\,[r]^2}{[m]^2} = \frac{\mathrm{M}^1\mathrm{L}^1\mathrm{T}^{-2}\,\mathrm{L}^2}{\mathrm{M}^2} = \mathrm{M}^{-1}\,\mathrm{L}^3\,\mathrm{T}^{-2}$

Now for

$P = E\,\ell^2\,m^{-5}\,G^{-2},$

we add exponents of M, L, T:

• M-exponent:

1 (from E)

$+\ 2 \times 1$ (from ℓ^2)

-5×1 (from m^{-5})

$-2 \times (-1)$ (from G^{-2})

$= 1 + 2 - 5 + 2 = 0$

• L-exponent:

2 (from E)

$+\ 2 \times 2$ (from ℓ^2)

-2×3 (from G^{-2})

$= 2 + 4 - 6 = 0$

• T-exponent:

-2 (from E)

$+\ 2 \times (-1)$ (from ℓ^2)

$-2 \times (-2)$ (from G^{-2})

$= -2 - 2 + 4 = 0$

So

$[P] = \mathrm{M}^0\,\mathrm{L}^0\,\mathrm{T}^0,$

which is dimensionless.

Answer: Option C.

Question47

The separation between C and O atoms in CO is 0.12 nm . The distance of C atom from the centre of mass is

Options:

A. 0.1 nm

B. 0.05 nm

C. 0.03 nm

D. 0.07 nm

Answer: D

Solution:

Let m_C=12 u and m_O=16 u, and let r=0.12 nm be the C–O separation. Choosing the C-atom as the origin, the centre of mass lies at

$d_C = \frac{m_O}{m_C + m_O}\, r$.

Plugging in:

$d_C = \frac{16}{12+16} \times 0.12\ \text{nm} = \frac{16}{28} \times 0.12 \approx 0.0686\ \text{nm} \approx 0.07\ \text{nm}.$

Answer: 0.07 nm (Option D).

Question48

An EM wave of frequency 5×10^9 Hz falls normally on a rectangular slit of width 3 cm . What is the total angular width of the central maxima?

Options:

A. 8 rad

B. 2 rad

C. 4 rad

D. 0.25 rad

Answer: C

Solution:

First, find the wavelength

$\lambda = \frac{c}{f} = \frac{3\times10^8\ \text{m/s}}{5\times10^9\ \text{Hz}} = 0.06\,\text{m} = 6\,\text{cm}.$

For a single slit of width $a = 3$ cm, the first minima satisfy

$a \sin\theta = \lambda \quad \Longrightarrow \quad \sin\theta = \frac{\lambda}{a} = \frac{6}{3} = 2,$

which has no real solution (i.e.\ no true minima within $\pm 90^\circ$). In practice one then uses the small-angle approximation

$\sin\theta \approx \theta\,, \quad \theta \approx \frac{\lambda}{a} = 2\ \text{rad}.$

The total angular width of the central maximum (from $-\theta$ to $+\theta$) is

$2\theta \approx 2 \times 2 = 4\ \text{rad}.$

Answer: Option C (4 rad).

Question49

Two wires A and B made of same material having length 10 cm and 40 cm respectively are connected in parallel to the same source of emf 10 V . What will be the ratio of the drift velocity of the electrons in the wire A to the drift velocity in the wire B ?

Options:

A. $\frac{V_{dA}}{V_{dB}} = 1:4$

B. $\frac{V_{dA}}{V_{dB}} = 1:2$

C. $\frac{V_{dA}}{V_{dB}} = 4:1$

D. $\frac{V_{dA}}{V_{dB}} = 2:1$

Answer: C

Solution:

Since both wires have the same material and cross-section,

$R \propto L$,

so

$R_A : R_B = 10 : 40 = 1 : 4$.

In parallel each wire has the same voltage V, so

$I = \frac{V}{R} \quad \Longrightarrow \quad I_A : I_B = R_B : R_A = 4 : 1$.

The drift velocity

$v_d = \frac{I}{nAe}$

is proportional to the current I. Hence

$v_{dA} : v_{dB} = I_A : I_B = 4 : 1$.

Answer (Option C):

$\frac{V_{dA}}{V_{dB}} = 4 : 1.$

Question50

When a metallic spherical shell of radius 20 cm is charged, the potential on its surface is found to be 5 V . The potential at a point 10 cm from the centre of the spherical shell is :

Options:

A. 10 V

B. 2.5 V

C. 1.25 V

D. 5 V

Answer: D

Solution:

The key fact is that, for a charged conducting shell, the potential is the same everywhere inside as it is on the surface.

• Let the shell's radius be $R = 0.20$ m and its surface potential $V(R) = 5$ V.

• For any point with $r

$V(r) = V(R) = 5$ V.

Since 10 cm = 0.10 m is inside the shell, the potential there is also **5 V**.

Answer: Option D (5 V)

Question51

What is the maximum wave length of EM radiation required to move an electron from the valance band to conduction band of a semiconductor? [Given :Energy gap $\mathrm{E_g} = 1.98 \times 10^{-19}$ J; Planck's constant $h = 6.6 \times 10^{-34}$Js]

Options:

A. 10^{-9} m

B. 10^{-6} m

C. 10^{-10} m

D. 10^{-12} m

Answer: B

Solution:

To lift an electron across the gap, a photon must have at least the energy

$E_g = 1.98 \times 10^{-19}\,\text{J}$.

The longest (maximum) wavelength that still delivers this energy is given by

$\lambda_{\max} = \frac{h\,c}{E_g}$,

where

• $h = 6.6 \times 10^{-34}\,\text{J s}$ (Planck's constant)

• $c = 3.0 \times 10^{8}\,\text{m/s}$ (speed of light)

Plugging in:

$\lambda_{\max} = \frac{6.6\times10^{-34}\times3.0\times10^{8}}{1.98\times10^{-19}} \approx \frac{19.8\times10^{-26}}{1.98\times10^{-19}} = 10 \times 10^{-7}\,\text{m} = 1.0 \times 10^{-6}\,\text{m}.$

So the answer is

Option B: 1×10^{-6} m.

Question52

What should be the value of the inductance of the coil which is to be connected to 220 V , 50 Hz supply so that maximum current of $3\sqrt{2}A$ flows through the circuit ?

Options:

A. $L = \left(\frac{22}{15}\right)H$

B. $L = \left(\frac{15}{11\pi}\right)H$

C. $L = \left(\frac{11}{15\pi}\right)H$

D. $L = \left(\frac{22}{15}\sqrt{2}\right)H$

Answer: C

Solution:

Supply voltage (rms)

$V_{\text{rms}} = 220\ \text{V} \quad \Longrightarrow \quad \text{V}_{\max} = \text{V}_{\text{rms}}\sqrt{2} = 220\sqrt{2}\ \text{V}$

Given peak current

$I_{\max} = 3\sqrt{2}\ A$

Inductive reactance

$X_L = \frac{V_{\max}}{I_{\max}} = \frac{220\sqrt{2}}{3\sqrt{2}} = \frac{220}{3}\ \Omega$

Relate X_L to L at $f = 50\,\text{Hz}$

$X_L = 2\pi f\,L \quad \Longrightarrow \quad L = \frac{X_L}{2\pi f} = \frac{\frac{220}{3}}{2\pi\cdot 50} = \frac{220}{3\cdot 100\pi} = \frac{11}{15\pi}\ H$

So the correct choice is Option C:

L = $\frac{11}{15\pi}$ H.

Question53

In the Young's double slit experiment, when a monochromatic light is used, fringe width obtained is 1 mm . If the wave length is halved and the slit width is doubled, what will be the new fringe width?

Options:

A. 1 mm

B. 0.25 mm

C. 1.25 mm

D. 0.5 mm

Answer: B

Solution:

We know in Young's double-slit experiment the fringe width is given by

$\beta = \frac{D\lambda}{d}$

where

• D = distance screen–slits (fixed)

• λ = wavelength of light

• d = slit separation

Originally,

$\beta_0 = 1\text{ mm} = \frac{D\lambda}{d}$.

Now λ is halved (λ→λ/2) and the slit separation is doubled (d→2d). Hence

$\beta' = \frac{D(\lambda/2)}{2d} = \frac{D\lambda}{4d} = \frac{\beta_0}{4} = \frac{1\text{ mm}}{4} = 0.25\text{ mm}.$

Answer: 0.25 mm (Option B).

Question54

A monochromatic light of wave length 6000°A is passed through two media A and B of thickness 10 cm and 16 cm respectively. The number of waves in A is $\frac{1}{2}$ that of B. If the refractive index of A is $\frac{4}{3}$, find the refractive index of B.

Options:

A. $\mu_B = \frac{4}{3}$

B. $\mu_B = \frac{3}{5}$

C. $\mu_B = \frac{3}{2}$

D. $\mu_B = \frac{5}{3}$

Answer: D

Solution:

Let N be the number of waves in a medium of thickness d. Since the wavelength in a medium is $\lambda = \lambda_0/\mu$, we have

$N = \frac{d}{\lambda} = \frac{d\,\mu}{\lambda_0}$.

For medium A:

$N_A = \frac{d_A\,\mu_A}{\lambda_0} = \frac{10\text{ cm}\ \times\frac{4}{3}}{\lambda_0}$.

For medium B:

$N_B = \frac{d_B\,\mu_B}{\lambda_0} = \frac{16\text{ cm}\ \times\mu_B}{\lambda_0}$.

Given $N_A = \frac{1}{2}\,N_B$,

$\frac{10\cdot\frac{4}{3}}{\lambda_0} = \frac{1}{2}\,\frac{16\,\mu_B}{\lambda_0} \implies 10\cdot\frac{4}{3} = \frac{16}{2}\,\mu_B = 8\,\mu_B$.

Solve for μ_B:

$\mu_B = \frac{10\cdot\frac{4}{3}}{8} = \frac{40}{3\cdot 8} = \frac{40}{24} = \frac{5}{3}$.

Answer: $\mu_B = \frac{5}{3}$ (Option D).

Question55

By connecting two given capacitors, a technician was able to make two new capacitors having the effective capacitance 12.5μF and 2μF. What would be the capacitance of the given capacitors?

Options:

A. 8.5μ F and 4μ F

B. 10μ F and 2.5μ F

C. 6.5μ F and 6μ F

D. 10.5μ F and 2μ F

Answer: B

Solution:

Let the two unknown capacitors be C_1 and C_2. When they're connected in parallel, their capacitance is

$C_\text{p} = C_1 + C_2 = 12.5\ \mu\text{F}$,

and in series it's

$C_\text{s} = \frac{C_1 C_2}{C_1 + C_2} = 2\ \mu\text{F}$.

From the series formula we get

$C_1 C_2 = C_\text{s}(C_1 + C_2) = 2 \times 12.5 = 25\ (\mu\text{F})^2$.

So C_1 and C_2 are roots of

$t^2 - (C_1 + C_2)t + C_1 C_2 = t^2 - 12.5\,t + 25 = 0$.

Its solutions are

$t = \frac{12.5 \pm \sqrt{12.5^2 - 4\cdot 25}}{2} = \frac{12.5 \pm 7.5}{2}$,

i.e.\ $t = 10$ or $t = 2.5$.

Therefore the two capacitors are

10 µF and 2.5 µF, which is Option B.

Question56

A rectangular coil of length 10 cm and breadth 9 cm carries a current of 10 A . A long straight conductor carrying a current of 20 A is placed 1 cm from the coil parallel to its length and in the same plane of the coil. What will be the net force acting on the straight conductor?

Options:

A. 1.8×10^{-4} N

B. 3.6×10^{-4} N

C. 1.8×10^{-5} N

D. 3.6×10^{-5} N

Answer: B

Solution:

Let the coil carry current $I_1 = 10\,\text{A}$, the straight wire $I_2 = 20\,\text{A}$, the long sides of the coil have length $L = 0.10\,\text{m}$, and their distances from the wire are $d_1 = 0.01\,\text{m}$ (near side) and $d_2 = d_1 + 0.09 = 0.10\,\text{m}$ (far side). Only these two parallel segments exert forces on the wire.

Force from the near side (attractive):

$F_1 = \frac{\mu_0 I_1 I_2 L}{2\pi d_1} = \frac{4\pi\times10^{-7}\times10\times20\times0.10}{2\pi\times0.01} = 4.0 \times 10^{-4}\,\text{N}$

Force from the far side (repulsive):

$F_2 = \frac{\mu_0 I_1 I_2 L}{2\pi d_2} = \frac{4\pi\times10^{-7}\times10\times20\times0.10}{2\pi\times0.10} = 4.0 \times 10^{-5}\,\text{N}$

Net force (toward the coil):

$F_{\text{net}} = F_1 - F_2 = 4.0 \times 10^{-4} - 4.0 \times 10^{-5} = 3.6 \times 10^{-4}\,\text{N}$

Answer: $3.6 \times 10^{-4}\,\text{N}$ (Option B).

Question57

For a short magnet, the magnetic field on the axial line at a distance 10 cm from its centre is $1.6\ \text{m} \times 10^{-7}\ \text{T}$. What is the magnetic field on its equatorial line at the same distance 10 cm from its centre?

Options:

A. $4.8 \times 10^{-7}T$

B. $3.2 \times 10^{-8}T$

C. $1.6 \times 10^{-7}T$

D. $0.8 \times 10^{-7}T$

Answer: D

Solution:

A short bar-magnet behaves like a magnetic dipole with moment m.

On the axis (distance r from its centre)

$B_{\text{axial}} = \frac{\mu_0}{4\pi}\,\frac{2\,m}{r^3}$.

On the equatorial line (same distance r)

$B_{\text{equatorial}} = \frac{\mu_0}{4\pi}\,\frac{m}{r^3} \;=\; \frac{1}{2}\,B_{\text{axial}}$.

Since $B_{\text{axial}} = 1.6 \times 10^{-7}\,\text{T}$ at $r = 10\,\text{cm}$,

$B_{\text{equatorial}} = \frac{1}{2} \times 1.6 \times 10^{-7}\,\text{T} = 0.8 \times 10^{-7}\,\text{T}$.

Answer: Option D.

Question58

What is the kinetic energy of the electron in the nth level, moving in a plane under the influence of a magnetic field ' B '? [m -mass of electron; h - Planck's constant; e- electronic charge]

Options:

A. $\frac{heB}{4\pi nm}$

B. $\frac{nheB}{4\pi m}$

C. $\frac{nheB}{2\pi m}$

D. $\frac{heB}{2\pi nm}$

Answer: B

Solution:

The quickest way is to combine

Centripetal = Lorentz force:

$m\frac{v^2}{r} = e\,v\,B \quad\Longrightarrow\quad r = \frac{m\,v}{eB}$.

Bohr-quantization of angular momentum:

$mvr = \frac{n\,h}{2\pi}$.

Putting $r = \frac{mv}{eB}$ into $mvr = \frac{nh}{2\pi}$ gives

$m\,v\,\frac{m\,v}{eB} = \frac{n\,h}{2\pi} \quad\Longrightarrow\quad v^2 = \frac{n\,h\,e\,B}{2\pi\,m^2}$.

Thus the kinetic energy is

$K_n = \frac{1}{2}\,m\,v^2 = \frac{1}{2}\,m\,\frac{n\,h\,e\,B}{2\pi\,m^2} = \frac{n\,h\,e\,B}{4\pi\,m}$.

Answer: Option B,

$\boxed{K_n = \frac{n\,h\,e\,B}{4\pi\,m}}$.

Question59

Which of the following statement is wrong regarding the photo electric effect.

Options:

A. Photo electric current is directly proportional to the intensity of the incident radiation

B. The maximum kinetic energy of the electrons emitted depends on the intensity of the incident radiation

C. The maximum kinetic energy of the electrons emitted depends on the frequency of the incident radiation

D. The value of the stopping potential increases with the increase in frequency of the incident radiation.

Answer: B

Solution:

The incorrect statement is Option B.

Explanation:

Photoelectric current ∝ intensity of the incident light

– More photons per second → more emitted electrons → higher current.

(So Option A is correct.)

The maximum kinetic energy of emitted electrons depends on frequency, not intensity.

– Einstein's photoelectric equation:

$K_{\max} = h\nu - \phi$

where

• h is Planck's constant

• ν is the light's frequency

• ϕ is the work function of the material

(So Option B is wrong.)

Since $K_{\max} = h\nu - \phi$, it indeed depends on ν.

(Option C is correct.)

The stopping potential V_0 satisfies

$eV_0 = K_{\max} = h\nu - \phi$

→ V_0 increases linearly with ν.

(Option D is correct.)

Question60

What is the velocity of light in vacuum if the velocity of light in a medium of refractive index 1.2 is ' v ' ms^{-1} ?

Options:

A. $\left(\frac{v}{1.2}\right) ms^{-1}$

B. $(2.4v)\mathrm{ms}^{-1}$

C. $(1.2v)\mathrm{ms}^{-1}$

D. $3 \times 10^8\ \mathrm{ms}^{-1}$

Answer: C

Solution:

The refractive index n relates the speed of light in vacuum (c) to its speed in a medium (v) by

$n = \frac{c}{v}$.

Here $n = 1.2$, so

$c = n\,v = 1.2\,v$.

Answer: Option C $(1.2\,v)$ $\mathrm{m/s}$.
